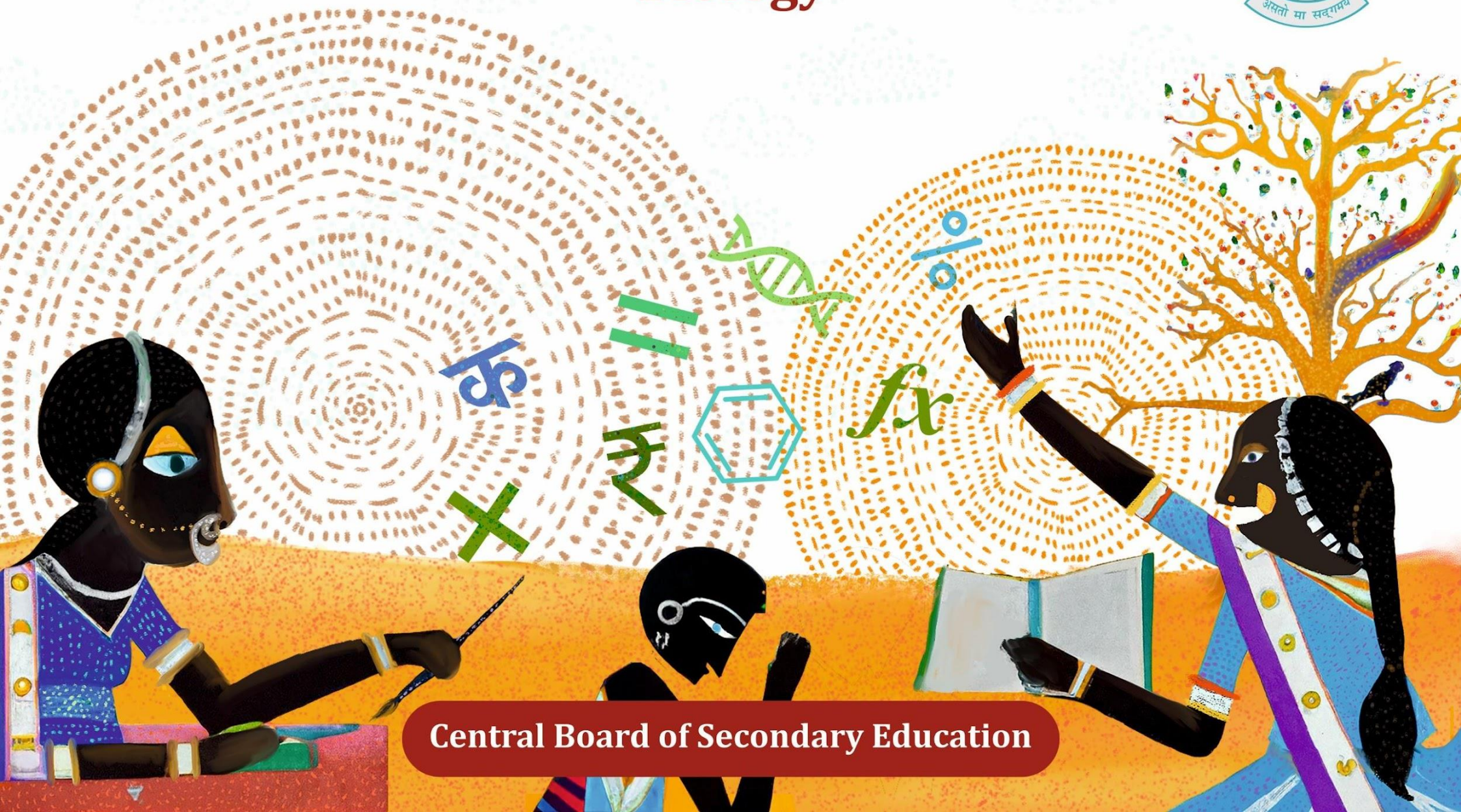


# Ei



## Learning Framework Classes 11-12 Biology



Central Board of Secondary Education





# Ei





# Learning Framework Classes 11-12

## Biology



**First Edition: July 2023**

Unpriced e-Publication, not for sale

**Co-created by  
CBSE Centre for Excellence in Assessment  
and  
Educational Initiatives**



## 1. FOREWORD

The vision of the National Education Policy (NEP) 2020, released by the Government of India, directs that children learn and, more importantly, learn how to learn. Education must move towards less content and more towards learning to think critically and solve problems, be creative and multidisciplinary, and 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-centered, discussion-based, flexible, and enjoyable. The policy mandates competency-based education (CBE) to enhance learners' acquisition of critical 21st-century skills. The first determinant for implementing CBE is a curriculum aligned to defined learning outcomes and 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 twelve subjects of Grades 11 and 12, i.e., English, Hindi, Mathematics, Physics, Chemistry, Biology, History, Geography, Economics, Accountancy, Business Studies and Computer Science. The Learning Frameworks comprise explicitly stated knowledge, skills, and dispositions that an education system should try to achieve. These frameworks will help develop a common shared understanding among teachers, students, and other stakeholders and serve as a standard benchmark for teaching, learning, and assessment nationwide.

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

We hope these frameworks not only become a reference point for competency-based education across the country but also facilitate teachers' and other stakeholders' planning and design of teaching-learning processes and assessment strategies.

The learning frameworks have been drafted based on the 2022-23 curriculum. Specific chapters and topics that have been rationalized in the 2023-24 curriculum are retained in this document. The rationalized sections are referenced under Chapter#3 - Content Domains. Please note that the unit or content marked with \* are partially rationalised.

Feedback regarding the framework is welcome. Any further input and suggestions will be incorporated in subsequent editions

*Team CBSE*

## 2. 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 emphasises developing higher-order skills such as analysis, critical thinking and problem-solving through classroom instructions and aligned assessments. These skills are important indicators to drive pedagogy and learning outcomes across schools and boards.

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, blueprints, assessment items and rubrics. 12 frameworks have been developed for English, Hindi, Mathematics, Physics, Chemistry, Biology, History, Geography, Economics, Accountancy, Business Studies and Computer Science in Grades 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 define the specific skills a learner needs to attain. A clear understanding of these Learning Outcomes (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. The 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 of Biology has emerged as one of the separate disciplines of science at the higher secondary level. Although the nature of biology and the 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".

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#### 4. 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 the human body and its function. The latter as we know, is the basis of medical practice. However, parts of biological knowledge developed independently of human application. Fundamental questions about the 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 a 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 the 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 phenomenal growth in the dominating area of molecular biology. In a sense, functional disciplines emphasizing mechanisms underlying living processes, received more attention, support, and intellectual and social recognition. Biology, unfortunately, got divided into classical and modern biology. To the majority of practising biologists, the 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 the molecular level. Physics and Chemistry dominated the public perception of science for a long time. The day-to-day life of man was influenced by developments in Physics, Chemistry and their respective manufacturing industries while Biology served its utility for human welfare. Medical practice, especially diagnostics, the 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 the political domain and the commercial value of biology became obvious.

Biology has become a distinct science discipline at the higher secondary level, with its unique philosophical, methodological, and ethical perspectives. It hence must aim at imparting conceptual clarity to learners, enabling them to develop higher-order thinking skills for a deeper understanding of biological concepts.



## 5. STAGE SPECIFIC CURRICULAR EXPECTATIONS

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

- CE1. Identify and develop an understanding of concepts, principles, theories, and laws governing the physical world around a biological entity
- CE2. Develop the 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 explanations, 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 perspective
- 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 the 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

## 6. CONTENT DOMAINS

**The content for biology for grades 11-12 in the 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.

Please note that the unit or content marked with \* are partially rationalised whereas those with \*\* are the ones deleted in full, as per the academic year 2023-24 syllabus.

**Table I. Grade 11 Content units and textbook chapters**

Content units	NCERT textbook chapters
<b>I. Diversity of Living Organisms</b>	1. The Living World*
	2. Biological Classification
	3. Plant Kingdom*
	4. Animal Kingdom
<b>II. Structural Organization in Plants and Animals</b>	5. Morphology of Flowering Plants*
	6. Anatomy of Flowering Plants*
	7. Structural Organisation in Animals*
<b>III. Cell: Structure and Functions</b>	8. Cell-The Unit of Life
	9. Biomolecules*
	10. Cell Cycle and Cell Division
<b>IV. Plant Physiology</b>	11. Photosynthesis in Higher Plants

	12. Respiration in Plants
	13. Plant - Growth and Development*
<b>V. Animal Physiology</b>	14. Breathing and Exchange of Gases
	15. Body Fluids and Circulation
	16. Excretory Products and their Elimination
	17. Locomotion and Movement
	18. Neural Control and Coordination*
	19. Chemical Coordination and Integration



**Table II. Grade 12 Content units and textbook chapters**

<b>Content units</b>	<b>NCERT textbook chapters</b>
<b>I. Reproduction</b>	1. Sexual Reproduction in Flowering Plants
	2. Human Reproduction
	3. Reproductive Health
<b>II. Genetics and Evolution</b>	4. Principles of Inheritance and Variation
	5. Molecular Basis of Inheritance
	6. Evolution
<b>III. Biology and Human Welfare</b>	7. Human Health and Diseases
	8. Microbes in Human Welfare
<b>IV. Biotechnology and its Applications</b>	9. Biotechnology - Principles and Processes
	10. Biotechnology and its Application
<b>V. Ecology and Environment</b>	11. Organisms and Populations*
	12. Ecosystem*
	13. Biodiversity and Conservation

## 7. SUBJECT SPECIFIC COGNITIVE DOMAINS

### CATEGORIES OF 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]

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.

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#### **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. Ask students to define a concept, e.g., State the law of limiting factors for photosynthesis.

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#### **Cognitive Domain – Understand**

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

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#### **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.

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### **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. Ask students to compare and explain the relationship between two physical quantities from the same content domain, e.g., Differentiate between the lifecycle of gymnosperms and that of pteridophytes and Bryophytes.

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### **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 justify their choice, e.g., Examine how temperature and amount of carbon dioxide affect the rate of photosynthesis of a plant.

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### **Cognitive Domain – Create**

‘Create’ involves combining elements 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.



## 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
<b>Remember</b> <ul style="list-style-type: none"><li>• recognising</li><li>• recalling</li></ul>	<ul style="list-style-type: none"><li>• recognising the scientific names of plants and animals, floral formulae of plant families etc.</li><li>• recalling observations made by scientists that led to the discovery of cell organelles, laws of inheritance etc.</li><li>• defining scientific terms, processes, factors, laws, etc.</li></ul>
<b>Understand</b> <ul style="list-style-type: none"><li>• interpreting</li><li>• exemplifying</li><li>• classifying</li><li>• summarizing</li><li>• inferring</li><li>• comparing</li><li>• explaining</li></ul>	<ul style="list-style-type: none"><li>• describing structure-function relationship of different parts of plants and human body</li><li>• making inferences from the given information about a phenomenon</li><li>• classifying organisms in a scientific manner</li><li>• summarizing the events of different stages of a biological process</li><li>• inferring graphs, tables to explain a biological concept</li><li>• comparing organisms, phenomena and processes based on certain characteristics</li><li>• explaining scientific concepts and biological relationships between with examples</li></ul>
<b>Apply</b> <ul style="list-style-type: none"><li>• executing</li><li>• implementing</li></ul>	<ul style="list-style-type: none"><li>• solving problems by applying the scientific concepts in daily life</li><li>• predicting outcomes based on given set information from an experiment or process</li></ul>

<b>Analyze</b> <ul style="list-style-type: none"> <li>differentiating</li> <li>organising</li> <li>attributing</li> </ul>	<ul style="list-style-type: none"> <li>differentiating between different organisms, processes and phenomena</li> <li>drawing conclusions based on the data collected in activities/experiments</li> <li>relating processes and phenomena with causes and effects</li> </ul>
<b>Evaluate</b> <ul style="list-style-type: none"> <li>checking</li> <li>critiquing</li> </ul>	<ul style="list-style-type: none"> <li>conducting an experiment to verify the scientific facts or hypotheses</li> <li>justifying effects of different factors on a process or phenomena</li> </ul>
<b>Create</b> <ul style="list-style-type: none"> <li>generating</li> <li>planning</li> <li>producing</li> </ul>	<ul style="list-style-type: none"> <li>planning investigations and experiments to verify the scientific facts or hypotheses</li> <li>producing a flow chart or diagram to represent the flow of biological phenomena or process</li> <li>a graphical representation of a given biological process or concept</li> </ul>

## SAMPLE TASKS FROM DIFFERENT COGNITIVE DOMAINS

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 15 – CLASS 11

Table IV: Chapter 15. Body Fluids and Circulations – Class 11

CHAPTER 15. BODY FLUIDS AND CIRCULATIONS – CLASS 11	
Cognitive domain	Sample tasks
<b>Remember</b>	<ul style="list-style-type: none"><li>• What instrument is used for measuring blood pressure?</li><li>• State the three formed elements of human blood.</li></ul>
<b>Understand</b>	<ul style="list-style-type: none"><li>• Describe the events of the three stages of the cardiac cycle.</li><li>• Blood exhibits coagulation or clotting in response to an injury or trauma. What is the role of calcium in clotting?</li></ul>
<b>Apply</b>	<ul style="list-style-type: none"><li>• 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.<ul style="list-style-type: none"><li>a. What could be the reason for the condition of the second child?</li><li>b. How could this condition have been avoided?</li></ul></li></ul>
<b>Analyze</b>	<ul style="list-style-type: none"><li>• How does the open circulatory system differ from the closed one? Explain with examples.</li></ul>
<b>Evaluate</b>	<ul style="list-style-type: none"><li>• The Arterial wall is thicker and more elastic than the walls of veins. What would happen if the wall thickness of arteries is the same as veins?</li><li>• Why do veins have valves but, arteries don't?</li></ul>



<b>Create</b>	<ul style="list-style-type: none"> <li>Draw a schematic flow chart of the pathway of human blood circulation highlighting how it prevents the mixing of oxygenated and deoxygenated blood.</li> </ul>
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## CHAPTER 8 – CLASS 12

**Table V: Chapter 7. Human Health and Disease – Class:12**

<b>CHAPTER 7. (HUMAN HEALTH AND DISEASE)– CLASS: 12</b>	
<b>Cognitive domain</b>	<b>Sample tasks</b>
<b>Remember</b>	<ul style="list-style-type: none"> <li>Name the four barriers of innate immunity.</li> <li>Name two bacterial diseases.</li> </ul>
<b>Understand</b>	<ul style="list-style-type: none"> <li>Describe different stages of the life cycle of Plasmodium.</li> <li>The thymus is an endocrine gland that acts as a secondary lymphoid organ. What is its role in causing immune response?</li> </ul>
<b>Apply</b>	<ul style="list-style-type: none"> <li>When exposed to grass pollen, Arjun experiences sneezing, watery eyes, and scratchy throat.               <ol style="list-style-type: none"> <li>What is this condition called?</li> <li>Suggest the drugs to reduce the symptoms.</li> </ol> </li> </ul>
<b>Analyze</b>	<ul style="list-style-type: none"> <li>How does a benign tumour differ from a malignant tumour?</li> </ul>
<b>Evaluate</b>	<ul style="list-style-type: none"> <li>Why are breastfed babies more likely to be immune to diseases than bottle-fed babies?</li> <li>It is necessary for a patient to take immunosuppressants after undertaking any graft/transplant. Justify.</li> </ul>
<b>Create</b>	<ul style="list-style-type: none"> <li>According to recent reports, MIT engineers have embedded genes from fireflies into watercress plants inducing them to give dim light for nearly four hours. To create these plants, the MIT team turned to luciferase, the enzyme that gives</li> </ul>

fireflies their glow. Luciferase acts on a molecule called luciferin, causing it to emit light. Another molecule called co-enzyme A helps the process by enhancing luciferase activity. None of these molecules are naturally produced by plants.

*[Sourced and edited from: <https://www.dailymail.co.uk/sciencetech/article-5178531/MIT-creates-bioluminescent-trees-glow-like-fireflies.html>]*

- a. Describe briefly, the step-by-step process that should be followed in creating these plants.
- b. Draw a diagram of the possible vector used in (a).

Following learning outcomes for the senior secondary stage developed by the 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

“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]

- (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, bisymmetrical 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 breathe? 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.

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### **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.

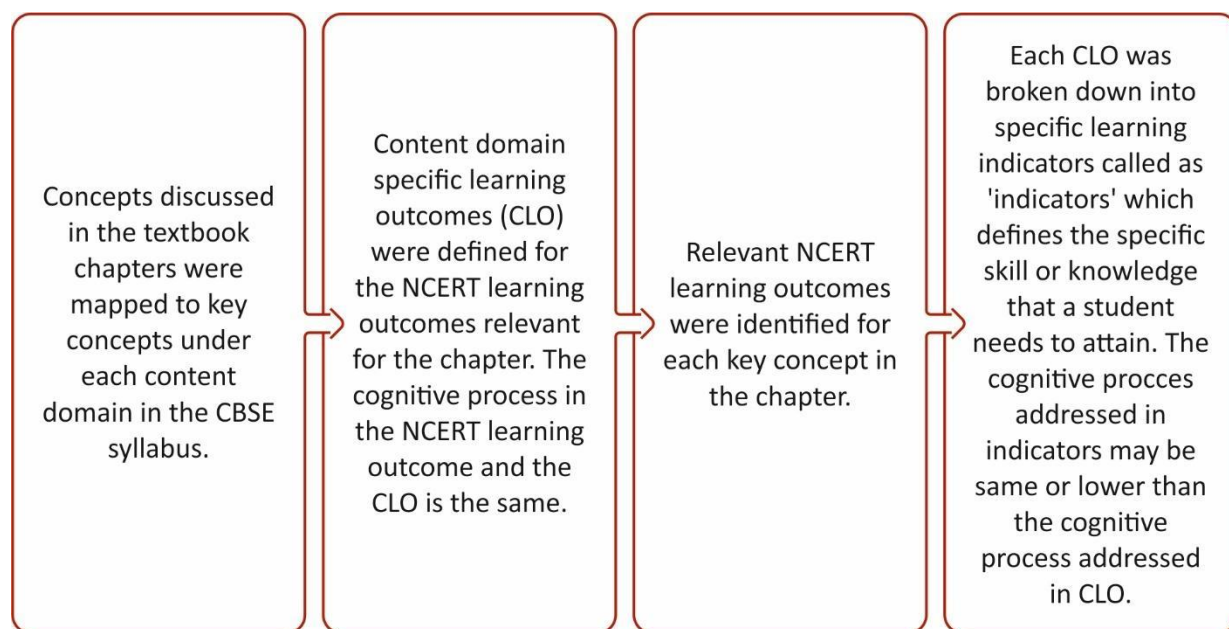
- (4) explains efficiently systems, relationships, processes and phenomena, such as; double fertilisation, flower is a modified shoot, process of embryonic development in mammals, adaptations in animals living in xeric and hydric conditions, sexually transmitted infections, mendelian and chromosomal 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 an independent assortment of alleles important from the point of view of variation? Which type of soil has poor nutrient status and high leaching? How can the 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) exhibits 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 the environment by realizing the interdependency and inter-relationship in the biotic and abiotic factors of the environment, such as, by appreciating the 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.

## 8. 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 with in the NCERT textbook chapters will be very helpful for both teachers and students in planning to teach 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.



## CLASS 11 CONTENT DOMAIN SPECIFIC LEARNING OUTCOMES AND INDICATORS

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
<b>I: Diversity of Living Organisms</b>  1. The Living World	<b>Diversity in the Living World</b>	LO21. Makes efforts to conserve the environment realizing the inter-dependency and inter-relationship in the biotic and abiotic factors of environment	CLO1. Relates the concept of "Biodiversity "to 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
				C3. Summarizes universal rules of the binomial system of nomenclature of plants and animals with examples
				C4. Identifies the scientific names of organisms as per the binomial system of nomenclature based on the distinct similarities and differences



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  1. The Living World		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO3. Differentiates generic and scientific systems of nomenclature of organisms	C5. Differentiates generic name and specific epithet
				C6. Infers the importance of universally accepted principles to provide scientific names to organisms
			CLO4. Differentiates between the basic methods of taxonomic study	C7. Compares classification and identification with examples
				C8. Explains the branch of study called taxonomy
		LO6. Describes the contribution of scientists/researchers all over the world in the 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

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  1. The Living World	<b>Taxonomic categories</b>	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. Explain the characteristics of different taxonomical categories and show the hierarchical arrangement between them	C11. Explain 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 the 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 provides 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

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  1. The Living World		LO10. Prepares slides for study of the structural intricacies of life forms and structural organisations	CLO9. Categorise the collected plant and animal specimens to group 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, apparatuses, instruments and devices properly for performing activities/ experiments/ investigations		C15. Observe planktons under the microscope to analyze their characters
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, and phenomena, or to seek answers to queries on their own		C16.Describes and groups collected plant specimens and organisms into specific taxa based on similarities and dissimilarities
<b>I: Diversity of Living Organisms</b>  2. Biological Classification	<b>Classification system</b>	LO6. Describes the contribution of scientists/researchers all over the world in systematic evolution of	CLO10. Describes the contribution of scientists in the evolution of different classifications systems developed over	C17.Explains observations made by scientists to develop and improve and change the classification systems of living organisms when the scientific

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification		concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	time	criteria of classification change
			CLO11. Describes the recently proposed three-domain system of classification	C18. Explain the three-domain classification
		L08. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO12. Explains the characteristics of the five-kingdom classification	C19. Describes the characteristics of the proposed Five Kingdom classification of R.H. Whittaker in the form of a table
		L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient features		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
		L02. Classifies organisms, phenomena and processes, based on certain	CLO13. Classifies organisms using 5-kingdom classification	C21. Compares the different classification systems listing the advantages of five Kingdom

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification	<b>Kingdom Monera</b>	characteristics / salient features systematically in a more scientific and organized manner	system based on certain characteristics in a more scientific manner	classification
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO14. Describes the organisms of kingdom Monera	C22.Explains the criteria used to classify organisms into kingdom Monera
			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
			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



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification		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
	<b>Kingdom Protista</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO20. Describes characteristic features of the organisms of the kingdom Protista	C28. Explain the criteria used to classify organisms into the kingdom Protista
				C29. Describes the characteristics of different groups of protists with examples
				C30. Describes the applications of protists in everyday life
		LO1. Differentiates organisms, phenomena and	CLO21. Differentiates between different types of	C31. Differentiates between

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification		processes based on certain characteristics and salient features	protistan	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. Draw a well-labelled diagram of Euglena and Paramecium
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO24. Describes the organisms of the kingdom Protista in daily life and solving problems	C34. Explain 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 the sea often appear red in colour?

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification	<b>Kingdom Fungi</b>	L02. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO25. Describes the organisms of kingdom Fungi	C35. Explains the criteria used to classify organisms into kingdom Fungi
				C36. Classifies fungi based on certain characteristics
				C37. Illustrates fruitification in Fungi
				C38. Describes the applications of fungi in everyday life
		L05. Explains efficiently systems, relationships, processes and phenomena	CLO25. Describes the organisms of the kingdom Fungi	C39.Explains the process of formation of basidiocarp in the edible mushroom (Agaricus).
		L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO26. Differentiates between various classes of kingdom fungi on the basis of the morphology of mycelium, mode of spore formation, and fruiting bodies	C40.Distinguishes between various types of spores and fruiting bodies in fungi

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification	<b>Kingdom Fungi</b>	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 ( <i>Rhizopus</i> ) 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	C45. Collects a pond water sample and a rotting food sample to explore and analyze the categories of different

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification			solving problems	microscopic organisms
	<b>Kingdom Plantae</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO32. Describes the organisms of the 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 the lifecycle of angiosperms	C47. Draw a flow chart of the reproduction of angiosperm
	<b>Kingdom Animalia</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO34. Describes the organisms of kingdom Animalia	C48.Explains the criteria used to classify organisms into kingdom Animalia
	<b>Viruses, Viroids,</b>	LO2. Classifies organisms, phenomena and processes,	CLO35. Describes features of viruses and their	C49.Explains the criteria used to classify organisms as virus or



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification	<b>Prions and Lichens</b>	based on certain characteristics / salient features systematically in a more scientific and organized manner	discovery	viroid
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO35. Describes features of viruses and their discovery	C50.Explains the observations by scientists that led to the discovery of virus
				C51.Describes the structural features of viruses that help in infection
				C52. Enlists new examples of RNA and DNA viruses
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO36. Draws a well-labelled diagram of a few common viruses	C53.Explain the structure of the Tobacco Mosaic Virus and Bacteriophage with the help of labelled diagram
		LO2. Classifies organisms, phenomena and processes, based on certain	CLO37. Describes structure of viroid, prions and lichens	C54. Explain the criteria used to classify viroid, prions and lichens

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  2. Biological Classification		characteristics / salient features systematically in a more scientific and organized manner		
		L03. Relates processes and phenomena with causes and effects	CLO38. Relates viral diseases with their causes	C55.Relates the viral diseases in humans with their causes
		L03. 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
		L019. 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
<b>I: Diversity of Living Organisms</b>  3. Plant Kingdom	<b>Classification systems of Plants</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CLO40. Explains the process used to classify organisms	C58.Explains the factors that affect the classification system
		L02. Classifies organisms,	CLO41. Describes the	C59.Classifies the organisms of

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 3. Plant Kingdom	<b>Algae</b>	phenomena and processes, based on certain characteristics/salient features systematically in a more scientific and organized manner	features of organisms of the kingdom Plantae	kingdom Plantae based on certain characteristics
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a 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 are useful to humans with examples
		LO2. Classifies organisms, phenomena and processes, based on certain	CLO44. Classifies the organisms of division Algae	C62.Classifies algae into different classes—red, green, and brown algae—based on certain

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 3. Plant Kingdom	<b>Algae</b>	characteristics / salient features systematically in more scientific and organized manner		characteristics
			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 the study of the structural intricacies of life forms and structural organisations	CLO47. Prepares slides and identifies different types of algae under the microscope	C65.Prepare a slide of pond water and identify different types of algae under a compound microscope
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO48. Observe permanent slides of algae	C66. Observe permanent slides of various algae to study their features
		LO2. Classifies organisms,	CLO49. Describes the	C67.Classifies the organisms into

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 3. Plant Kingdom	<b>Bryophytes</b>	phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	features of organisms of division Bryophytes	the division Bryophytes based on their salient features
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CL050. Draws labelled diagrams of 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 a more scientific and organized manner	CL051. 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	CL052. Explains the use of organisms of bryophytes	C70. Explain how some mosses are of great economic importance to us and Sphagnum is used in moss stick by a gardener

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 3. Plant Kingdom	<b>Bryophytes</b>	sustainable development		
		LO3. Relates processes and phenomena with causes and effects	CL053. 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	CL054. Draws flow charts to explain the life cycle of bryophytes	C72. Draw a flow chart to explain the life cycle of moss
		LO11. Handles laboratory tools, apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CL055. Observe permanent slides of liverworts and moss	C73. Observe permanent slides of liverworts and moss capsules to explain their structure
	<b>Pteridophytes</b> <b>Pteridophytes</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a	CL056. Describes the features of organisms of division Pteridophytes	C74.Explain the criteria used to classify organisms into division Pteridophytes
				C75.Classifies Pteridophytes into



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  3. Plant Kingdom		more scientific and organized manner		different classes based on certain characteristics
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO57. Draws labelled diagrams of different types of pteridophytes (ferns)	C76. Draw well-labelled diagrams of pteridophytes (ferns) and highlight their distinguishing morphological characteristics
		LO10. Prepares slides for study of 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
	<b>Gymnosperms</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a 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	CLO60. Differentiates the lifecycles of different division of plants	C79. Differentiates between the lifecycle of Gymnosperms with that of Pteridophytes and Bryophytes

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b>  3. Plant Kingdom	<b>Gymnosperms</b>	features		
		LO12. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, and 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, and Cycas/seeds of Chilgoza (Pinus gerardiana)
		LO11. Handles laboratory tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	CLO62. Observe permanent slides of a longitudinal section of cones and pollens of Pinus	C81. Observe permanent slides of a longitudinal section of a male and female cone, as well as the 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.Explain 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	C83. Observes characters of ten different plant specimens on a field trip to a botanical garden or

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
			field trips	unmaintained outdoor places and classifies them into appropriate divisions of Kingdom Plantae.
<b>I: Diversity of Living Organisms</b> 4. Animal Kingdom	<b>Basis of Classification of Animals Kingdom</b>	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 a well-labelled diagram of 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 the kingdom Animalia	C86. Draws a flowchart illustrating the broad classification of the kingdom Animalia based on common

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 4. Animal Kingdom				fundamental features
	<b>Phylum Porifera</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO68. Identifies the common structural and organisational characteristics of phylum Porifera	C87.Describes the characteristic features of Phylum Porifera
	<b>Phylum Coelenterata</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CLO69. Identifies the common structural and organisational characteristics of phylum Coelenterate	C88.Explains the characteristic features of Phylum Coelenterate
	<b>Phylum Ctenophora</b>		CLO70. Identifies the common structural and organisational characteristics of phylum Ctenophora	C89.Explains the characteristic features of Phylum Ctenophora
	<b>Phylum Platyhelminthes</b>		CLO71. Identifies the common structural and organisational	C90.Explains the characteristic features of Phylum Platyhelminthes

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 4. Animal Kingdom			characteristics of phylum Platyhelminthes	
	<b>Phylum Aschelminths</b>		CL072. Identifies the common structural and organisational characteristics of phylum Aschelminths	C91.Explains the characteristic features of Aschelminths
	<b>Phylum Annelida</b>		CL073. Identifies the common structural and organisational characteristics of phylum Annelida	C92.Explains the characteristic features of Annelida
	<b>Phylum Arthropoda</b>	L02. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a more scientific and organized manner	CL074. Identifies the common structural and organisational characteristics of phylum Arthropoda	C93.Describes the distinguishing characteristics of organisms in Phylum Arthropoda
	<b>Phylum Mollusca</b>		CL075. Identifies the common structural and organisational characteristics of the	C94.Explains the characteristic features of the Mollusca

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 4. Animal Kingdom			phylum Mollusca	
	<b>Phylum Echinodermata</b>		CL076. Identifies the common structural and organisational characteristics of the phylum Echinodermata	C95. Explains the characteristic features of Echinodermata
	<b>Phylum Hemichordata</b>		CL077. Identifies the common structural and organisational characteristics of phylum Hemichordata	C96.Explains the characteristic features of Hemichordates
	<b>Phylum Chordata</b>		CL078. Describes the criteria used to classify organisms into Phylum Chordata and into subphylum Vertebrata	C97.Explain the distinguishing characteristics of organisms of Phylum Chordata and subphylum Vertebrata
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL079. Describes the distinguishing characteristics of organisms in Phylum Chordata and non-	C98.Distinguishes chordates from non-chordates

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<b>I: Diversity of Living Organisms</b>  4. Animal Kingdom			chordates	
		LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a 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
			CLO82. Differentiates based on a 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, and phenomena,	CLO83. Conducts investigations to study the diversity in animal kingdom	C102. Studies and explores animal diversity as types of insects/birds/amphibians /birds present in your neighbourhood garden/pond / lake / river/home



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>I: Diversity of Living Organisms</b> 4. Animal Kingdom		or seek answers to queries on their own		garden
		LO20. Exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while making decisions	CL084. Reasons to debunk some misunderstandings to fully grasp the criteria to classify Kingdom Animalia	C103. Explain the reasoning and clarify the misconceptions using different questions using the 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	CL085. Interprets the characteristics of each phylum/class to support the theory of evolution (Increase in size of cerebrum, chamber of the heart)	C104. Analyses the characteristics of different classes/phyla and understand their evolutionary complexities
<b>II: Structural Organization in Plants and Animals</b> 5. Morphology of	<b>The Root</b>	LO3. Relates processes and phenomena with causes and effects	CL086. Explains the structure and function of the root	C105. Explains and relates the structure and function of different parts of the root system
		LO1. Differentiates organisms, phenomena and	CL087. Illustrates the distinguishing	C106. Compares taproot and fibrous root system

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
Flowering Plants  <b>II: Structural Organization in Plants and Animals</b>  5. Morphology of Flowering Plants		processes based on certain characteristics and salient features	characteristics of fibrous root and taproot	
	<b>The Stem</b>	LO3. Relates processes and phenomena with causes and effects	CL088. Explains the structure and function of stem	C107. Relates the structure of stem to its function
	<b>The leaf</b>	LO3. Relates processes and phenomena with causes and effects	CL089. Explains the 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 a more scientific and organized manner	CL090. Explain the different types of leaves based on their features	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 modifications of leaves
	<b>The flower</b>	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CL091. States the definition of terms associated with flowers	C110. Defines the term inflorescence, staminode and aestivation

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<b>II: Structural Organization in Plants and Animals</b>  5. Morphology of Flowering Plants	<b>Parts of flower</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL092. 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	CL093. Compares flowers based on different salient characteristics	C112. Differentiates flowers based on different salient characteristics such as the 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
			CL094. Describes the parts of the gynoecium of a flower	C113. Differentiates parts of gynoecium and different types of carpels
		LO4. Applies scientific	CL095. Identifies the	C114. Describes different types of

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>II: Structural Organization in Plants and Animals</b>  5. Morphology of Flowering Plants		terminology for organisms, processes, and phenomena based on internationally accepted conventions	different types of placentation in plants	placentation – marginal, axile, parietal, free central and basal – with examples
	<b>The Fruit</b>	L05. 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
	<b>The Seed</b>	L01. 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
	<b>Semi-Technical Description of a Typical Flowering Plant</b>	L013. Analyzes and interprets graphs and figures	CLO98. Illustrates the parts of a flower and floral diagram of different plants	C117. Draws and interprets figures- position of flower parts on the thalamus and floral diagram of plants
		L08. 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

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<b>II: Structural Organization in Plants and Animals</b>  5. Morphology of Flowering Plants			CLO99. Draws labelled diagrams of morphological features and modifications of different parts of plants	C119. Draw a floral diagram describing the 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. Observe the characteristics of commonly available flowering plants	C122. Describes the structural/morphological details of various commonly available angiosperms on a field visit to a garden/park
	<b>Permanent Tissues</b>	LO3. Relates processes and phenomena with causes	CLO102. Describes the function and structure of	C123. Explains the formation of permanent tissues and relates the structure of different permanent

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>II: Structural Organization in Plants and Animals</b>  6. Anatomy of Flowering Plants		and effects	permanent tissues	tissues with its function
	<b>Complex Tissues</b>	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
	<b>The plant tissue system</b>	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 systems – 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
	<b>The Root Tissue System</b>	LO5. Explains efficiently systems, relationships,	CLO107. Explain different regions of T.S of root	C128. Explains and differentiates the different regions of T.S of

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>II: Structural Organization in Plants and Animals</b>  6. Anatomy of Flowering Plants		processes and phenomena		dicot and monocot root
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO108. Draws figures of the transverse section of dicot and monocot root	C129. Draws labelled figures of the transverse section of dicot and monocot root
	<b>The Stem Tissue System</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO109. Explain different regions of T.S of stem	C130. Explain and differentiate 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
	<b>The Leaf Tissue System</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO111. Explains different regions of a leaf with figures	C132. Analyze the different regions of T. S of the 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	CLO112. Prepare slides of	C134. Dissects T.S. of dicot and



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<b>II: Structural Organization in Plants and Animals</b>  6. Anatomy of Flowering Plants		tools, and apparatuses, instruments and devices properly for performing activities/ experiments/ investigations	T.S of dicot and monocot root/stem /leaf	monocot root/stem /leaf and prepares temporary mount to observe under a microscope
		LO15. Draws conclusion on the basis of data collected in activities/experiments and investigatory projects conducted by them	CLO113. Observe 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

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<b>II: Structural Organization in Plants and Animals</b>  7. Structural Organisation in Animals	<b>Organ and Organ System</b>	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 multicellular organisms.
	<b>Frog</b>	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
				C141. Explains the importance of frog in environment
<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life	<b>Cell theory</b>	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 the contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based	CLO119. Illustrates the observations by scientists that led to the discovery of cell	C143. Describes the contribution of scientists/researchers for the scientific discoveries of cell and tools to study it

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life		on historical scientific events/ timelines etc.		
	<b>Cell</b>	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.
	<b>Cell Envelope and its Modifications</b>	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 the systematic evolution of concepts, scientific	CLO123. Describes role and the relevance of fluid mosaic theory	C147. Explains the fluid mosaic theory and relates transport of materials through the plasma membrane with its structure

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life		discoveries and inventions in the field of biology based on historical scientific events/ timelines etc		
		L07. 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
	<b>Endomembrane System</b>	L05. 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
	<b>Mitochondria</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CLO126. Explains mitochondria	C150. Describes the features and diagrammatically illustrates the mitochondria
	<b>Plastids</b>	L03. 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

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<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL0128. 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	CL0129. Explains plastids	C153. Describes the features of plastids
	<b>Chloroplast</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL0130. Explains chloroplasts	C154. Describes the features and diagrammatically illustrates the chloroplast
	<b>Eukaryotic and prokaryotic ribosomes</b>	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL0131. Explains ribosomes	C155. Differentiates between prokaryotic and eukaryotic ribosomes
	<b>Cytoskeleton</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL0132. Explains cytoskeleton	C156. Describes the features of cytoskeletons

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<b>III: Cell: Structure and Functions</b> 8. Cell: The Unit of Life	<b>Cilia and Flagella</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL0133. Explains cilia and flagella	C157. Describes the features and diagrammatically illustrates the cilia and flagella
	<b>Centrosome and Centrioles</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL0134. Explains centrosome and centrioles	C158. Describes the features of centrosome and centrioles
	<b>Nucleus</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CL0135. Explains nucleus	C159. Describes the features and diagrammatically illustrates the nucleus
		LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL0136. Explain the features of chromosomes	C160. Describes, compares and diagrammatically illustrates the chromosomes and indicates the position of the centromere in its types
	<b>Cell and its Organelles</b>	LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CL0137. Draws labelled diagrams of different cell organelles	C161. Draws labelled diagrams of different cell organelles such as cell plasma, mitochondria, chloroplast, and chromosomes to show their parts
		LO12. Plans and conducts	CL0138. Conducts an	C162. Investigates the sizes of

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<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life		investigations and experiments to arrive at and verify the facts, principles, and phenomena, or to seek answers to queries on their own	experiment to investigate the arrangement of organelles in a cell	different organelles and their location in the cell based on their functions
		L015. 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
		L019. 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 animal and plant cell models showing cell organelles to appropriate size scale using sustainable materials such as clay, sticks, wool threads etc.
		L016. Communicates the findings and conclusions effectively	CLO141. Communicates the conclusions about cell organelle sizes and their function in cell	C165. Presents the cell models of plants and animals to the class describing the relation between location, structure and function



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<b>III: Cell: Structure and Functions</b>  8. Cell: The Unit of Life	<b>Organic compounds in the body</b>	L07. 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
	<b>Proteins</b>	L014. 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
<b>III: Cell: Structure and Functions</b>  9. Biomolecules	<b>Fatty acid</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CLO144. Describes phospholipids and fatty acid	C168. Explains phospholipids and general chemical structure of fatty acids
			CLO145. Describes phospholipids and fatty acid	C169. Differentiates between different types of fatty acid
	<b>Nitrogen bases, nucleosides and nucleotides</b>	L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient	CLO146. Compares different genetic materials	C170. Differentiates DNA and RNA; nucleosides and nucleotides

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<b>III: Cell: Structure and Functions</b> 9. Biomolecules		features		
		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
	<b>Primary and secondary metabolites</b>	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
	<b>Biomacromolecules</b>	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO149. Explains macromolecules and micromolecules	C173. Investigate the composition of macromolecules and micro molecules in living cells
	<b>Structure of Polysaccharides</b>	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

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<b>III: Cell: Structure and Functions</b> 9. Biomolecules	<b>Structure of DNA and RNA</b>	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. Draw the diagram of DNA showing its composition
	<b>Structure of proteins</b>	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 structures with examples – primary, secondary, tertiary and quaternary structure
	<b>Enzymes</b>	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	CLO155. Explains cofactors in an enzyme	C179. Explains enzymes and cofactors and classifies them

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>III: Cell: Structure and Functions</b> 9. Biomolecules		characteristics / salient features systematically in more scientific and organized manner	and classify enzymes	based on their nature
		LO5. Explains efficiently systems, relationships, processes and phenomena	CL0156. Explains the mechanism of enzyme action	C180. Explains the concept of activation energy and the nature of enzyme action
		LO13. Analyzes and interprets graphs and figures	CL0157. Draws and interprets graphs related to enzyme activity	C181. Draws and interprets graphs showing the concept of activation energy, and the 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	CL0158. 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, apparatuses,	CL0159. Uses laboratory tools, apparatuses and	C183. Demonstrates the proper usage of thermometer, Bunsen

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<b>III: Cell: Structure and Functions</b> 9. Biomolecules		instruments and devices properly for performing activities/ experiments/ investigations	instruments to experiment with the activity of an enzyme	burner etc. to investigate the effect of different temperatures / pH on the activity of salivary amylase on starch
		L015. Draws conclusion on the basis of data collected in activities/experiments and investigatory projects conducted by them	CLO160. Collects data in tabular format in the investigation for the activity of salivary amylase	C184. Create a data table showing the time taken for colour change in a reaction (reaction time) by salivary amylase at different temperatures and pH
		L016. Communicates the findings and conclusions effectively	CLO161. Communicates the data about the nature of enzyme activity to the class	C185. Presents the charts and graphs of collected data from the investigation of the effects of pH and temperature on an enzyme
		L03. Relates processes and phenomena with causes and effects	CLO162. Explains thermal stability	C186. Explains thermal stability in thermoplastic organisms
		L017. Applies scientific concepts of Biology in daily life and solving problems	CLO163. Explains the application of the mechanism of enzyme activity in daily life	C187. Explain how refrigeration increases the shelf-life of fruits and vegetables

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		L017. Applies scientific concepts of Biology in daily life and solving problems	CLO163. Explains the application of the mechanism of enzyme activity in daily life	C188. Explains how competitive inhibitors are often used in the control of bacterial pathogens
<b>III: Cell: Structure and Functions</b> 10. Cell Cycle and Cell Division	<b>Cell cycle</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CLO164. Explains cell cycle and its different phases	C189. Explain the importance of cell division
		L03. Relates processes and phenomena with causes and effects	CLO165. Describes the function of different cells in different phases	C190. Co-relates and explains the different phases of the cell cycle with their function and duration and represents it pictographically through pie chart
		L04. 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. Explain the terms used for various stages of cell division
		L07. Makes linkages at the interface of Biology with other disciplines by relating various	CLO167. Represents stages of cell division pictorially	C192. Represents stages of cell division pictorially

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>III: Cell: Structure and Functions</b>  10. Cell Cycle and Cell Division		interdisciplinary concepts		
	<b>M Phase</b>	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
				C194. Explains the importance of mitosis and relate 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
	<b>Meiosis</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO171. Explain meiosis in cells	C197. Explains changes in cells in the different phases of meiosis
				C198. Explain the importance of



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<b>III: Cell: Structure and Functions</b> 10. Cell Cycle and Cell Division				meiosis
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CL0172. Illustrates the meiosis in cells showing the changes in cells in the different phases	C199. Draws the events of the different stages of meiosis
	<b>Mitosis and meiosis</b>	LO1. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL0173. Differentiates between various stages of mitosis and meiosis	C200. Compares metaphase, anaphase and telophase of mitosis with meiosis 1 & 2
				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	CL0174. Creates models depicting various stages of cell division	C202. Draw charts/prepare models depicting various stages of mitosis/meiosis
		LO12. Plans and conducts investigations and experiments to arrive at	CL0175. Observe different stages of mitosis through an experiment	C203. Conducts investigation to observe the features of chromosomes at different stages

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<b>III: Cell: Structure and Functions</b>  10. Cell Cycle and Cell Division		and verify the facts, principles, phenomena, or to seek answers to queries on their own		of mitosis of an onion root tip cells
		LO10. Prepares slides for study of the structural intricacies of life forms and structural organisations	CL0176. 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	CL0177. Observe the cell division on the slides of cells	C205. Identifies the 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	CL0178. 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	CL0179. Communicates	C207. Represents and explains

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		findings and conclusions effectively	features of different stages of a cell division after observing the stages in slides under microscope	the characteristics of different phases of a cell division after correct identification of stages of cell division under microscope
<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants	<b>Early Experiments of Photosynthesis</b>	LO6. Describes the contribution of scientists/researchers all over the world in the 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. Explain the observations made by the different scientists that led to the discovery of requirements for photosynthesis
	<b>Chloroplasts and Light Reaction of Photosynthesis</b>	L05. 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
		L05. Explains efficiently systems, relationships,	CLO182. Describes the role of chloroplast in	C210. Describes the role of chloroplast pigments in light

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<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants		processes and phenomena	photosynthesis	absorption in thylakoids
		L013. 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
		L012. 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 experiments to show the evolution of oxygen in photosynthesis
		L05. 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
	<b>Electron Transport System</b>	L07. Makes linkages at the interface of Biology with other disciplines by relating various	CLO185. Describes the role of excitation of an electron in light reaction	C214. Explains the mechanism of the electron transport scheme in a light reaction involving the excitation of electrons and its

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants		interdisciplinary concepts		transfer to an acceptor.
		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. Draw a flow chart of the cyclic and non-cyclic photo-phosphorylation
	<b>Chemiosmotic Hypothesis</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO188. Describes the mechanism of chemiosmotic hypothesis	C217. Describes how the difference in the proton gradient across a membrane is linked to ATP synthesis
	<b>Fate of ATP and NADPH produced in light phase</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO189. Explains the fate of ATP and NADPH produced in the light phase of photosynthesis and describe the study by scientists for the discovery of 5-carbon	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

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<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants	Calvin cycle		RuBP	
		LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO190. Describes the process of the Calvin cycle	C219. Explain the Calvin pathway and calculate 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
	C4 pathway	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO192. Explain the anatomy of C4 plants and their pathway	C221. Describes the Kranz anatomy of the leaves of C4 plants with the help of a diagram and understands the significance of dimorphic chloroplast
				C222. Explain the process of the Hatch and Slack Pathway cycle with illustrations
		LO3. Relates processes and phenomena with causes	CLO193. Explains physiological adaptation	C223. Gives reasons why the C4 pathway is seen in plants adapted

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<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants		and effects	in plants in a dry tropical region	to dry tropical regions
		L08. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CL0194. Draws the pathway of C4 cycle	C224. Draws the cyclic representation of C4 cycle
	<b>Photorespiration</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CL0195. Explains photorespiration	C225. Describes the process of photorespiration in plants
		L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CL0195. Compares C3 and C4 plants	C226. Differentiates C3 and C4 plants and their pathways
	<b>Factors Affecting Photosynthesis</b>	L03. Relates processes and phenomena with causes and effects	CL0196. Explains the factors that affect photosynthesis	C227. Describes the internal factors that affect the rate of photosynthesis
				C228. Describes the external factors that affect the rate of photosynthesis in plants

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<b>IV: Plant Physiology</b>  11. Photosynthesis in Higher Plants				C229. States the Blackman's law of limiting factors
				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, and phenomena, or to seek answers to queries on their own	CL0197. 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	CL0198. 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	CL0199. Evaluate how different factors affect	C233. Analyzes the results of various experiments about



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		in activities/experiments and investigatory projects conducted by them	photosynthesis	factors affecting photosynthesis
<b>IV: Plant Physiology</b>  12. Respiration in Plants	<b>Breathing and Respiration in plants</b>	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 respire
	<b>Metabolic Pathways</b>	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 being liberated as heat

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<b>IV: Plant Physiology</b> 12. Respiration in Plants	<b>Glycolysis</b>	LO7. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO204. Describes the process of glycolysis	C238. Explain the reactions involved in glycolysis
		LO8. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO205. Illustrates the process of glycolysis	C239. Draw 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
	<b>Fermentation</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO207. Describes the process of anaerobic respiration	C241. Explains steps of different anaerobic respiration
	<b>Krebs Cycle</b>	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

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<b>IV: Plant Physiology</b> 12. Respiration in Plants	<b>Electron Transport System</b>	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
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO209. Describes the process of electron transport system	C244. Explains the steps of electron transport system
				C245. Explains ATPs produced in electron transport system
	<b>Chemiosmotic Hypothesis</b>	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	CLO212. Draw the diagram of the process of	C248. Relates and appreciates the structure of mitochondria with its role in ATP synthesis using

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<b>IV: Plant Physiology</b>  12. Respiration in Plants		floral diagrams	ATP synthesis	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
	<b>The Respiratory Balance Sheet</b>	LO14. Uses scientific conventions, symbols, and equations to represent various quantities, elements, and units	CLO213. Calculates the total ATP generated in the metabolism of one glucose molecule in respiration	C250. Calculates the total net number of ATP 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. Evaluate and draw a conclusion about why the energy yield from respiration in aerobic conditions is much greater than the energy yield from respiration in anaerobic conditions
	<b>Amphibolic Pathway</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO215. Explains amphibolic pathway	C252. Justify why the respiratory pathway is an amphibolic pathway rather than catabolic

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<b>IV: Plant Physiology</b> 12. Respiration in Plants	<b>Respiratory Quotient</b>	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—vary
	<b>Plant Growth</b>	LO3. Relates processes and phenomena with causes and effects	CLO217. Explain the distinguishing feature of plant growth	C254. Explains that plant growth is indeterminate and the role of meristem
	<b>Phases of growth</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO218. Explain the different phases of growth	C255. Names and explains the phases of growth for a plant – Meristematic, Elongation, Maturation
<b>IV: Plant Physiology</b> 13. Plant Growth and Development	<b>Growth Rates</b>	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
			CLO220. Differentiates between absolute and growth rates	C257. Calculates surface area to differentiate between the absolute and relative growth

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<b>IV: Plant Physiology</b> 13. Plant Growth and Development				rates of leaves in plants
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO221. Describes the conditions for plant growth	C258. Explain the conditions needed for plant growth
	<b>Differentiation, Dedifferentiation and Redifferentiation</b>	LO4. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO222. Explains differentiation, dedifferentiation, and redifferentiation in plants	C259. Explain the structural changes in a cell during differentiation, dedifferentiation and redifferentiation
	<b>Plant Development</b>	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. Explain the process of plant development	C261. Explains the intrinsic and extrinsic factors in plant growth and development
	<b>Plant Growth Regulators</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features systematically in a	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

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<b>IV: Plant Physiology</b>  13. Plant Growth and Development		more scientific and organized manner		
		LO6. Describes the contribution of scientists/researchers all over the world in the 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

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		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
	<b>Respiratory Organs</b>	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 depending mainly on their habitats and levels of organisation
<b>V: Human Physiology</b> 14. Breathing and Exchange of Gases	<b>Human Respiratory System</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO230. Describes the structure and role of different parts of the human respiratory system	C268. Explains the parts of the human respiratory system
				C269. Describes the process of respiration
		LO8. Draws labelled	CLO231. Draw a labelled	C270. Correlates the structure of the parts of the human respiratory system to its functions C271. Illustrates the parts of the



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<b>V: Human Physiology</b> 14. Breathing and Exchange of Gases		diagrams, flow charts, concept maps, graphs and floral diagrams	diagram of the human respiratory system	human respiratory system
		L03. Relates processes and phenomena with causes and effects	CLO232. Explain the process of breathing	C272. Illustrates the mechanism of inspiration and expiration by the coordinate movement of the diaphragm and internal intercostal muscles
	<b>Mechanism of Breathing</b>	L07. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO233. Relates difference in pressure for explaining the mechanism of breathing	C273. Relates pressure and volume to explain breathing mechanism
	<b>Respiratory Volumes and Capacities</b>	L04. Applies scientific terminology for organisms, processes, and phenomena	CLO234. Describes respiratory volumes and capacities	C274. Defines the meaning of different respiratory volumes and capacities
		L014. 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

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<b>V: Human Physiology</b>  14. Breathing and Exchange of Gases	<b>Exchange of Gases</b>	LO13. Analyzes and interprets graphs and figures	CLO236. Analyzes and interprets the data of lung volumes from device	C276. Analyzes of pneumotachographs generated by spirometer
		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 the 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

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<b>V: Human Physiology</b>  14. Breathing and Exchange of Gases		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 the diffusion membrane between the alveolus with a pulmonary capillary
			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
				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
	<b>Transport of Oxygen</b>	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	C284. Plot the oxygen dissociation curve by relating the percentage saturation of haemoglobin with oxygen against

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<b>V: Human Physiology</b> 14. Breathing and Exchange of Gases			haemoglobin in blood	the partial pressure of oxygen
		L03. 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 CO <sub>2</sub> , H <sup>+</sup> concentration, temperature, etc. on binding and dissociation of O <sub>2</sub> with haemoglobin using the oxygen dissociation curve
	<b>Transport of Carbon dioxide</b>	L03. Relates processes and phenomena with causes and effects	CLO245. Describes the role of CO <sub>2</sub> in respiration	C286. Appreciates the role of carbon dioxide in the process of respiration
		L05. Explains efficiently systems, relationships, processes and phenomena	CLO246. Explains the transport of CO <sub>2</sub> in blood	C287. Describes the mechanism of diffusion of carbon dioxide between lungs, body tissues and blood
		L05. 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 centre in the brain responsible for the regulation of respiration
	<b>Regulation of</b>	L017. Applies scientific	CLO248. Infers different	C289. Identifies the real-life

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	<b>Respiration</b>	concepts of Biology in daily life and solving problems	day-to-day activities that affect the regulation of respiration	situation or variables in action and hypothesises the response of the respiratory centre, chemo-sensitive area, and pneumotaxic area in the brain
		L018. 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
	<b>Disorders of Respiratory System</b>	L03. Relates processes and phenomena with causes and effects	CLO251. Summarises the disorders associated with the respiratory system	C291. Explain the causes and symptoms of common disorders related to the respiratory system
<b>V: Human Physiology</b> 15. Body Fluids and Circulation	<b>Blood</b>	L02. 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
		L05. Explains efficiently systems, relationships,	CLO253. Explains the components of human	C293. States different components of the blood—

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<b>V: Human Physiology</b> 15. Body Fluids and Circulation		processes and phenomena	blood	plasma and formed elements
	<b>Plasma</b>	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.
	<b>Formed Elements</b>	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. Evaluate 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
	<b>Blood Groups</b>	LO3. Relates processes and phenomena with causes	CLO258. Explains different ABO, Rh positive	C298. Explains how different antigens and antibodies on RBC

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<b>V: Human Physiology</b>  15. Body Fluids and Circulation		and effects	and negative blood group types and establishes blood donor compatibility	form different blood groups along with Rh grouping and predicts outcomes of different combinations in blood transfusion/ reasons for erythroblastosis fetalis
		L03. 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
	<b>Coagulation of Blood</b>	L05. 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
	<b>Lymph</b>	L05. 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

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<b>V: Human Physiology</b> 15. Body Fluids and Circulation	<b>Circulatory Pathways</b>	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 hearts.
	<b>Human Circulatory System</b>	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 the human heart	C304. Explains the significance of thicker walls 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 the septum in atrial and/or ventricular region; pacemakers)
	<b>Cardiac Cycle</b>	LO5. Explains efficiently systems, relationships,	CLO266. Summarises the different stages of a	C306. Defines scientific terminologies- systole, diastole, cardiac cycle, stroke volume,



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<b>V: Human Physiology</b> 15. Body Fluids and Circulation		processes and phenomena	cardiac cycle	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 the number of heartbeats, duration of cardiac cycle, stroke volume, and cardiac output
	<b>Electrocardiograph</b>	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 the cardiac cycle with different waves in the presentation of a standard ECG
			CLO269. Describes the role of pacemaker in heart	C309. Explains the role of a pacemaker to control the heartbeat.
	<b>Double Circulation</b>	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	CLO271. Explains the	C311. Describes how oxygenated

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		systems, relationships, processes and phenomena	double circulatory pathway	and deoxygenated blood is circulated in the system to prevent mixing
	<b>Regulation of Cardiac Activity</b>	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
	<b>Disorders of Circulatory System</b>		CLO273. Enlists and analyzes the disorders caused by the circulatory system	C313. Explain the causes and symptoms of common disorders related to the circulatory system
<b>V: Human Physiology</b> 16. Excretory Products and their Elimination	<b>Human Excretory System</b>	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 ammonotelic, ureotelic, and uricotelic animals with examples
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO275. Describes the parts of the human excretory system	C315. Explains the structure and function of a human kidney – Cortex and Medulla

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b>  16. Excretory Products and their Elimination				C316. Explain the structure of different parts of a nephron: Bowman's capsule, distal convoluted tubule, proximal convoluted tubule, Henle's loop, and collecting duct
		L08. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO276. Draw neat and labelled figures of the human urinary system and associated structures	C317. Draws neat and labelled figures of the human urinary system and L.S. kidneys
				C318. Illustrates the structure of the nephron, renal corpuscle, countercurrent system, urine formation, etc.
	<b>Urine Formation</b>	L05. Explains efficiently systems, relationships, processes and phenomena	CLO277. Explain 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
	<b>Function of PCT</b>	L03. Relates processes and phenomena with causes	CLO278. Summarises the function and structure of	C320. Explains the structural features of PCT responsible for reabsorption and secretion of

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 16. Excretory Products and their Elimination		and effects	PCT	electrolytes, liquids, and nutrients
	<b>Function of Henle's Loop</b>	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. Analyze 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 the osmolarity
	<b>Function of DCT</b>	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
	<b>Function of</b>	LO3. Relates processes and phenomena with causes	CLO283. Summarises the structure and function of	C325. Describes the secretion and reabsorption by collecting duct

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 16. Excretory Products and their Elimination	<b>Collecting Duct</b>	and effects	collecting duct	that regulates the osmolarity of medullary interstitial fluid
		L08. Draws labelled diagrams, flow charts, concept maps, graphs and floral diagrams	CLO284. Draws a 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
	<b>Mechanism of Concentration of the Filtrate</b>	L05. 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
	<b>Regulation of Kidney Function</b>	L03. 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.
	<b>Micturition</b>	L03. Relates processes and	CLO287. Summarises how	C329. Explains the neural signals

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 16. Excretory Products and their Elimination		phenomena with causes and effects	the release of urine from the urinary bladder is regulated	by CNS that regulate the release the urine from the urinary bladder
	<b>Role of Other Organs in Excretion</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO288. Enlists other organs of the body involved in the excretion of wastes	C330. Illustrates the different waste excreted by the organs other than kidneys – lungs, liver and skin
	<b>Disorders of the Excretory System</b>	LO3. Relates processes and phenomena with causes and effects	CLO289. Summarises the disorder associated with the excretory system	C331. Explain the causes and symptoms of common disorders related to the excretory system
			CLO290. Summarises the disorder - diabetes insipidus	C332. Explain the causes and symptoms of the 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 reports to predict metabolic disorders
		LO18. Appreciates technological applications	CLO292. Explains dialysis	C334. Describes the mechanism of dialysis used to remove wastes

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
		and processes in Biology towards the improvement in the quality of life and sustainable development,		from the blood
V: Human Physiology  17. 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
			CLO294. Differentiates between locomotion and movements	C336. Justifies that all locomotion are movements, but all movements are not locomotion
	Muscle		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

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 17. Locomotion and Movement		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
	<b>Structure of Contractile Proteins</b>	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
	<b>Mechanism of Muscle Contraction</b>	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 $\text{Ca}^{2+}$ in the process of contraction and relation of muscles
		LO1. Differentiates organisms, phenomena and processes based on certain	CLO301. Compares white and red fibres	C343. Differentiates between white and red fibres and their



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 17. Locomotion and Movement	<b>Skeletal System</b>	characteristics and salient features		importance
		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 the skull and their arrangement
				C346. Describes the different bones present in ribs and vertebral column and their arrangement
				C347. Describes the different bones present in the pectoral girdle and pelvic girdle and their arrangement
		LO7. Makes linkages at the interface of Biology with	CLO304. Explains the composition and function	C348. Relates the composition of the matrix of bones and cartilage

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 17. Locomotion and Movement	<b>Joints</b>	other disciplines by relating various interdisciplinary concepts	of bones and cartilages	with their structure and function
		L05. Explains efficiently systems, relationships, processes and phenomena	CLO305. Defines the function of joints	C349. Explains the role of bone joints
		L07. 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
		L01. 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
	<b>Disorders of Muscular and</b>			C352. Categorizes synovial joints into different kinds based on articulation with examples
		L03. Relates processes and phenomena with causes	CLO308. Explains the disorder associated with	C353. Explains the causes and symptoms of common disorders

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 17. Locomotion and Movement	<b>Skeletal System</b>	and effects	the muscular system	related to the muscular system
			CLO309. Explains the disorder associated with the skeletal system	C354. Explain the causes and symptoms of common disorders related to the skeletal system
<b>V: Human Physiology</b> 18. Neural Control and Coordination	<b>Neural System</b>	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
	<b>Human Neural System</b>	LO2. Classifies organisms, phenomena and processes, based on certain characteristics / salient features	CLO311. Classifies the human nervous system	C356. Classifies the human neural system into central (CNS) and peripheral neural system (PNS) based on information processing and control
	<b>Neuron as Structural and Functional Unit of Neural System</b>	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	CLO313. Illustrates the structure of neuron	C358. Draws neat and labelled figures of the structure of neuron

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b>  18. Neural Control and Coordination		floral diagrams		
		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
			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

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b>  18. Neural Control and Coordination		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
	<b>Central Neural System</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO319. Describes different parts of the human nervous system	C364. Explains the different parts of CNS
				C365. Explains the different parts of the human brain
<b>V: Human Physiology</b>  19. Chemical Coordination and Integration	<b>Endocrine Glands</b>	LO3. Relates processes and phenomena with causes and effects	CLO320. Analyzes the relation between endocrine and neural system	C366. Explains how the neural system and the endocrine system coordinate together to function
	<b>Human Endocrine System and Hormones</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO321. Explains endocrine gland and hormones	C367. Defines key terms like hormones; identifies the position of endocrine glands, illustrates their structure and enumerates their features
		LO8. Draws labelled diagrams, flow charts,	CLO322. Illustrates the location of different	C368. Draw a figure to show the position of various endocrine

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 19. Chemical Coordination and Integration		concept maps, graphs and floral diagrams	endocrine glands	glands
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO323. Explains hypothalamus and its hormones	C369. Summarises the functions of hormones released by the hypothalamus
			CLO324. Explains pituitary gland and its hormones	C370. Summarises the functions of hormones released by pituitary gland
			CLO325. Explains the pineal gland and its hormones	C371. Summarises the functions of hormones released by pineal gland
			CLO326. Explains the thyroid gland and its hormones	C372. Summarises the functions of hormones released by the thyroid gland
		LO17. Applies scientific concepts of Biology in daily life and solving problems	CLO327. Explains the role of iodine in thyroid functioning	C373. Justify the significance of an iodine-rich diet and its effect on thyroid gland
		LO5. Explains efficiently systems, relationships,	CLO328. Explains the parathyroid gland and its	C374. Summarises the functions of hormones released by

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b>  19. Chemical Coordination and Integration		processes and phenomena	hormones	parathyroid gland
		LO3. Relates processes and phenomena with causes and effects	CLO329. Explains how hormones of the thyroid and parathyroid gland together regulate calcium levels	C375. Discusses the interaction of TCT and PTH in regulating $\text{Ca}^{2+}$ ions in the body
		LO5. Explains efficiently systems, relationships, processes and phenomena	CLO330. Explains the 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. Explain the 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 a diagrammatic representation of a section of the adrenaline gland

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b> 19. Chemical Coordination and Integration		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 an 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
	<b>Hormones of Heart, Kidney and Gastrointestinal Tract</b>	LO5. Explains efficiently systems, relationships, processes and phenomena	CLO338. Explains hormones secreted by some non-endocrine glands	C384. Explains the organs other than the endocrine organ that releases hormones
	<b>Mechanism of</b>	LO3. Relates processes and phenomena with causes	CLO339. Explains the mechanism of receptor	C385. Describes the mechanism of hormone action involving the



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>V: Human Physiology</b>  19. Chemical Coordination and Integration	<b>Hormone Action</b>	and effects	action	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 hormones 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 mechanisms 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 a flow chart to explain the 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
<b>VI: Reproduction</b> 1. Sexual Reproduction in Flowering Plants	<b>Stamen, Microsporangium, and Pollen Grain</b>	L04. Explains efficiently systems, relationships, processes and phenomena	CLO1. Explain the structure of the male reproductive part of the flower	C1. Illustrates a typical stamen, transverse section of an anther and structure of a microsporangium
		L04. explains efficiently systems, relationships, processes and phenomena	CLO1. Explain the structure of the male reproductive part of the flower	C2. Explains the structure of pollen of flower
		L08. Prepares slides for the study of the structural intricacies of life forms and structural organisations	CLO2. Prepare a slide to show the structure of pollen grain	C3. Examines the structure of pollen grain under the microscope
		L04. explains efficiently systems, relationships, processes and phenomena	CLO3. Describes the process of microsporogenesis	C4. Outlines the process of microsporogenesis
		L07. draws labelled diagrams, flow charts, concept maps, and graphs	CLO4. Illustrates the structure of the anther, the sporangium, and the stages of microspore development	C5. Draws neat labelled diagram of the transverse section of an anther, sporangium and stages of microspore development

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b>  1. Sexual Reproduction in Flowering Plants	<b>Stamen, Microsporangium, and Pollen Grain</b>	L01. 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
		L04. explains efficiently systems, relationships, processes and phenomena	CLO6. Describes the role of pollen	C7. Describes the process of pollen formation in flowers and its importance for humans
		L016. 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
		L02. 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
		L02. relates processes and phenomena with causes and effects	CLO9. Explain the allergies caused by pollen grain	C10. Applies the cause of asthma and bronchitis to pollen dehiscence and pollen release

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b>  1. Sexual Reproduction in Flowering Plants		L09. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, and 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
		L020. calculates using the data given	CLO11. Calculates the percentage of pollen grains germinated in the experiments conducted	C12. Calculates the percentage of pollens germinated in the experiment conducted
	<b>The Pistil, Megasporangium, and Embryo Sac Pollination</b>	L01. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO12. Explain the structure of the female reproductive part of the flower	C13. Explain the structure of the pistil and ovule and differentiate between different types of carpels
		L04. explains efficiently systems, relationships, processes and phenomena, such as	CLO13. Describes the process of megasporogenesis	C14. Illustrates the development of megaspores from the megaspores
		L01. differentiates organisms, phenomena and processes based on certain characteristics	CLO14. Differentiates between pollen grain and embryo sac	C15. Compares between a pollen grain and mature embryo sac

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b> 1. Sexual Reproduction in Flowering Plants	<b>The Pistil, Megasporangium, and Embryo Sac Pollination</b>	and salient features		
		L04. explains efficiently systems, relationships, processes and phenomena	CLO15. Describes the role of pollination	C16. Explains and evaluates different types of pollination
		L02. relates processes and phenomena with causes and effects	CLO16. Analyzes differences between the seeds formed by xenogamy and geitonogamy	C17. Summarises outbreeding devices and the pollen-pistil interaction after pollination
		L01. differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO17. Correlates the adaptation of flowers and floral parts to achieve pollination	C18. Gives the reason why variations are seen in seeds formed by xenogamy and not from geitonogamy
		L03. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO18. Applies scientific terminology to describe the pistil	C19. Understands and correlates the modified floral part to the agent of pollination
				C20. Applies scientific terminology to describe the pistil and other parts of the flower and embryonic development in plants

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b>  1. Sexual Reproduction in Flowering Plants		L016. 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
		L04. explains efficiently systems, relationships, processes and phenomena	CLO20. Summarises outbreeding devices	C22. Elaborates on inbuilt mechanisms to prevent self-pollination and inbreeding depression
		L07. draws labelled diagrams, flow charts, concept maps, and graphs	CLO21. Draws labelled diagrams of reproductive parts of flowers	C23. Draws neat, labelled diagrams of an ovule, and nucleate stages of embryo sac
		L09. plans and conducts investigations and experiments to arrive at and verify the facts, principles, and 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
	<b>Double Fertilization</b>	L04. explains efficiently systems, relationships,	CLO23. Describes the process of double	C25. Justifies that fertilization in flowering

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b> 1. Sexual Reproduction in Flowering Plants		processes and phenomena	fertilisation	plants involve double fertilization and triple fusion
		L013. draws conclusions 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 are necessary for double fertilization
	<b>Post-Fertilization: Structures and Events</b>	L04. 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
			CLO26. Describes the characteristics of fruits and seeds	C28. Explains the role and structure of seed and fruits
		L01. 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
		L07. draws labelled diagrams, flow charts, concept maps, and	CLO28. Illustrates of reproductive structures of	C30. Draws neat, labelled diagram of stages of embryo

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
		graphs	flowers in the post-fertilization stages	development, structure of dicot and monocot embryo dicot seed, monocot seed and false fruits
	<b>Apomixis and polyembryony</b>	L016. 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
<b>VI: Reproduction</b>  2. Human Reproduction	<b>The Male Reproductive System</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO30. Describes different parts of the male reproductive system	C32. Enlists the names and explains the structure of different parts of the male reproductive system
				C33. Explain and correlate the parts of the male reproductive system with their function
		L07. draws labelled diagrams, flow charts, concept maps, and graphs	CLO31. Illustrates different parts of the male reproductive system	C34. Draws neat, labelled diagram of the reproductive system of human male and observes the duct system of



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b>  2. Human Reproduction				human males
	<b>The Female Reproductive System</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO32. Describes different parts of the female reproductive system	C35. Enlists the names, explains and correlates the functions of different parts of the female reproductive system
		L07. draws labelled diagrams, flow charts, concept maps, and graphs	CLO33. Illustrates different parts of the female reproductive system	C36. Draws neat, labelled diagram of the reproductive of a human female and observes the duct system of human female
		L04. 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
		L09. 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 the form of sperm and ova

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b>  2. Human Reproduction	<b>Gametogenesis</b>	L04. 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
		L01. 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
		L04. 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
		L07. 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.
		L015. 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
		L015. applies scientific	CLO40. Applies knowledge	C44. Clears myths associated

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VI: Reproduction</b> 2. Human Reproduction	<b>Fertilization and Implantation</b>	concepts in daily life and solving problems	of the menstrual cycle for better reproductive health	with women not being allowed to offer prayers during menstruation
		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
				C46. Distinguishes between Graafian follicle and corpus luteum to 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  C48. Illustrates the process of implantation

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	<b>Pregnancy and Embryonic Development</b>	L04. 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
		L015. 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
	<b>Parturition and Lactation</b>	L04. Explains efficiently systems, relationships, processes and phenomena	CLO45. Describes the process of parturition and lactation	C51. Illustrates the mechanism of parturition and breastfeeding with the role of oxytocin
<b>VI: Reproduction</b> 3. Reproductive Health	<b>Reproductive Health – Problems and Strategies</b>	L015. 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.
				C53. States and compares the indicators of improved reproductive health in a society

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
VI: Reproduction 3. Reproductive Health			CLO47. Analyzes the importance of the 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.
				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
C58. Describes the different kinds of natural contraceptive methods and barriers used for contraceptives with examples				

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<b>VI: Reproduction</b> 3. Reproductive Health		L04. 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
				C60. Defines and illustrates the processes of tubectomy and vasectomy
		L03. 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
	<b>Medical Termination of Pregnancy (MTP)</b>	L03. 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.
	<b>Sexually Transmitted Infections (STIs)</b>	L02. 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

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<b>VI: Reproduction</b> 3. Reproductive Health		L018. 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
	<b>Infertility</b>	L04. Explains efficiently systems, relationships, processes and phenomena	CLO54. Describes the cause of infertility	C65. Enlist and summarise some reasons for infertility
		L016. 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
		L015. 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 the different anomalies in infertile couples
	<b>Mendel's law of</b>	L05. Describes contribution of	CLO57. Analyzes the	C68. Summarizes Mendel's

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VII: Genetic and Evolution</b>  4. Principles of Inheritance and Variation	<b>Inheritance</b>	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	observations and conclusions made by Mendel in the pea plant experiment	experiments with the pea plant, covering the method, phenotypes, observation, and inference.
			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
		L06. 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
		L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO60. Compares different natures of protein expression by an allele	C71. Differentiates between dominance, incomplete dominance, and co-dominance with examples
		L04. Explains efficiently	CLO61. Describes the nature	C72. Describes how



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<b>VII: Genetic and Evolution</b>  4. Principles of Inheritance and Variation		systems, relationships, processes and phenomena	of protein expression by an allele	dominance occurs at the molecular (gene-enzyme) level
		L01. 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
		L07. 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
		L09. 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
	<b>Inheritance of Two Genes</b>	L05. Describes the contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific	CLO65. Analyzes the observations and conclusions made in Morgan's experiment	C76. Explains the chromosomal theory of inheritance involving and independent segregation of

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VII: Genetic and Evolution</b>  4. Principles of Inheritance and Variation		discoveries and inventions in the field of biology based on historical scientific events/ timelines		chromosomes.
		L04. Explains efficiently systems, relationships, processes and phenomena	CLO66. Explains the role of recombination in genetics	C77. Describes linkage and recombination using a cross.
		L020. 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
	<b>Polygenic traits</b>	L03. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	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.
		L09. Plans and conducts investigations and experiments to arrive at and verify the facts, principles, and phenomena, or	CLO69. Interprets alleles of multiple genes exhibiting a single phenotypic expression in a population	C80. Analyze the population to observe the prevalence of polygenic traits

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<b>VII: Genetic and Evolution</b> 4. Principles of Inheritance and Variation		to seek answers to queries on their own		
		L013. 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
	<b>Pleiotropy</b>	L03. Applies scientific terminology for organisms, processes, phenomena based on internationally accepted conventions	CLO71. Explains pleiotropy	C82. Describes pleiotropy with an example.
		L02. Relates processes and phenomena with causes and effects	CLO72. Explains how a single gene exhibits multiple phenotypic expression	C83. Examines the effect of genes towards different phenotypes
		L015. 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 to laws of inheritance to understand how recessive traits get expressed in F2 generation

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<b>VII: Genetic and Evolution</b> 4. Principles of Inheritance and Variation		L05. 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
	<b>Sex Determination</b>	L01. Differentiates organisms, phenomena and processes based on certain characteristics and salient features	CLO75. Differentiates the mechanism of sex determination in different organisms	C86. Differentiates between sex determination between humans and birds and how sex determination is different between honeybees and other organisms
		L018. 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
		L03. Applies scientific terminology for organisms,	CLO77. Illustrates with the help of a flowchart and	C88. Interprets the sex of the progeny in birds, insects and

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<b>VII: Genetic and Evolution</b>  4. Principles of Inheritance and Variation		processes, and phenomena based on internationally accepted conventions	predicts the probability of the sex of an individual in the progeny	humans
	<b>Mutations</b>	L02. Relates processes and phenomena with causes and effects	CLO78. Explains mutation and their importance	C89. Elaborates on the role of mutation in the inheritance
	<b>Genetic Disorders</b>	L02. 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
		L04. 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
		L01. 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

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<b>VII: Genetic and Evolution</b> 4. Principles of Inheritance and Variation		L03. Applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO82. Differentiates between Klinefelter's syndrome and Turner's syndrome	C93. Examines the karyotype and distinguishes Klinefelter's syndrome and Turner's syndrome
		L02. 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
		L011. 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 disorders, dominant or recessive etc.
<b>VII: Genetic and Evolution</b> 5. Molecular Basis of Inheritance	<b>The DNA</b>	L06. Makes linkages at the interface of Biology with other disciplines by relating various interdisciplinary concepts	CLO84. Describes the salient features of the DNA of double helix	C96. Explains the structure of DNA and summarise the observations that led to the discovery of the double helix structure of DNA
		L07. Draws labelled diagrams, flow charts, concept maps,	CLO85. Illustrates the	C97. Draws the figure of

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<b>VII: Genetic and Evolution</b>  5. Molecular Basis of Inheritance		graphs	structure of DNA	DNA, showing its structure
		L01. 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
		L06. 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)
		L04. Explains efficiently systems, relationships, processes and phenomena	CLO88. Describes the structure of nucleosomes and packing of DNA into chromosome	C100. Summarizes the structure of nucleosomes and how a long nucleotide chain is observed as chromosomes in eukaryotes
		L07. Draws labelled diagrams, flow charts, concept maps, graphs	CLO89. Illustrates the structure of nucleosome	C101. Creates a neat and labelled figure highlighting the structure of nucleosomes
	<b>The Search for Genetic Material</b>	L05. Describes contribution of scientists/researchers all over	CLO90. Explains the characteristic of genetic	C102. Summarizes the methods, observation, and

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<b>VII: Genetic and Evolution</b>  5. Molecular Basis of Inheritance		the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.	material and the experiments and observations made by various scientists to discover them	inferences for experiments performed by Frederick Griffith, by Avery, MacLeod, McCarty, and by Hershey and Chase
	<b>Replication</b>	L05. Describes the contribution of scientists/researchers all over the world in the systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	CLO91. Explains the characteristic of genetic material and the experiments and observations made by various scientist to discover them	C103. Summarizes the method, observation, and inferences of the experiments performed by Matthew Meselson and Franklin Stahl
		L04. 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
	<b>Transcription</b>	L04. 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



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<b>VII: Genetic and Evolution</b>  5. Molecular Basis of Inheritance				a new molecule of messenger RNA (mRNA)
		L01. 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
	<b>Genetic Code</b>	L012. 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
		L06. 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
	<b>Translation</b>	L04. 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

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<b>VII: Genetic and Evolution</b>  5. Molecular Basis of Inheritance	<b>Regulation of Gene Expression</b>	L04. 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
	<b>Human Genome Project</b>	L04. 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
	<b>DNA fingerprinting</b>	L016. Appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable development	CLO100. Explains DNA fingerprinting	C112. Describes the principle underlying DNA fingerprinting using VNTRs, the steps involved, and its importance
	<b>Origin of Life</b>	L04. 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
		L05. Describes contribution of scientists/researchers all over	CLO102. Explains biogenesis and the	C114. Describes the observations and conclusion

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<b>VII: Genetic and Evolution</b> 6. Evolution		the world in systematic evolution of concepts, scientific discoveries and inventions in the field of biology based on historical scientific events/ timelines	experiments done by scientists to support its theory	made by Pasteur about the generation of life on earth
				C115. Explains observations and conclusion of Miller's experiment and why it led to the acceptance of chemical evolution
	<b>Evolution of Life Forms – A theory</b>	L05. 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
	<b>Evidence for Evolution</b>	L02. 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
		L01. Differentiates organisms, phenomena and processes based on certain characteristics	CLO105. Differentiates between divergent and convergent evolution	C118. Describes divergent and convergent evolution and homologous and

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<b>VII: Genetic and Evolution</b>  6. Evolution		and salient features		analogous structures with examples
		L04. Explains efficiently systems, relationships, processes and phenomena	CLO106. Explains evolution by anthropogenic action	C119. Describes evolution by anthropogenic action with the help of examples
		L04. 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
	<b>Adaptive Radiation</b>	L04. 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
	<b>Biological Evolution</b>	L05. 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/	CLO109. Explain how the origin of life is dependent on life span	C122. Explains how the rate of appearance of new forms is dependent on life span with examples
			CLO110. Describes the theory of the origin of life	C123. Outlines the theory proposed by Lamarck and

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VII: Genetic and Evolution</b> 6. Evolution		timelines	proposed by Lamarck about the origin of life with evidence	how it differed from Darwin's theory
	<b>Mechanism of Evolution</b>	L05. 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 the origin of life proposed by Hugo DeVries about the origin of life with evidence	C124. Describes saltation proposed by Hugo DeVries and how it differed from Darwin's conclusions
	<b>Hardy-Weinberg Principle</b>	L06. 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.
		L02. 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
		L07. 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

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<b>VII: Genetic and Evolution</b> 6. Evolution	<b>A Brief Account of Evolution</b>	L04. 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)
	<b>Origin and Evolution of Man</b>		CLO116. Traces the timeline and features of the evolution of human	C129. Explains a characteristic feature and timelines of Ramapithecus, Dryopithecus, Australopithecus, Homo habilis, Homo erectus, Neanderthal man, and Homo sapiens
	<b>Health</b>		CLO117. Define health, disease, and immunity	C130. Explains the meaning of health and diseases stating factors that affect health and ways to maintain general health
	<b>Common Diseases in Humans</b>		CLO118. Describes different common pathogenic infection	C131. Summarises the causes, major symptoms, spread and control measures of various pathogenic diseases

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			CLO119. Explains the lifecycle of plasmodium	C132. Describes the life cycle of the malarial parasite with a diagram
<b>VIII: Biology in Human Welfare</b>  7. Human Health and Disease	<b>Immunity</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO120. Describes features of different types of immunity	C133. Describes the barriers involved in innate 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.
		L01. 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
			CLO121. Explains immunization using vaccination	C136. Explains the different kinds of vaccination based on the molecules introduced in the body.

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<b>VIII: Biology in Human Welfare</b>  7. Human Health and Disease		L02. relates processes and phenomena with causes and effects	CLO122. Explains immune memory	C137. Identifies “immune memory” to be the basis of vaccination and immunisation
		L016. 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 processes in biology towards improvement in quality of life by the technique of vaccination
		L02. relates processes and phenomena with causes and effects	CLO124. Explains allergy	C139. Describes the cause, symptoms and control measures of allergy
		L04. explains efficiently systems, relationships, processes and phenomena	CLO125. Explains auto-immunity	C140. Correlates the occurrence of autoimmune diseases to immune cells attacking “self” with examples such as rheumatoid arthritis
			CLO126. Describes lymphoid system and its	C141. Describes the role of lymphoid organs in



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<b>VIII: Biology in Human Welfare</b> 7. Human Health and Disease			role	immunity
	<b>AIDS</b>	L03. 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
	<b>Cancer</b>	L02. 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
				C144. Explains the features of different cancerous tumours and the treatments available
	<b>Drugs and Alcohol Abuse</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO129. Describes drug and alcohol addiction	C145. Differentiates between the source, action and effect of different drugs
				C146. Explains the effects of drug abuse and addiction and its preventive measures

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<b>VIII: Biology in Human Welfare</b> 7. Human Health and Disease		L015. applies scientific concepts in daily life and solving problems	CLO130. Spreads the awareness for drugs and alcohol abuse	C147. Applies the awareness about drug and alcohol abuse for prevention of such habits in young adults
<b>VIII: Biology in Human Welfare</b> 8. Microbes in Human Welfare	<b>Microbes in Household Products</b>	L016. 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
	<b>Microbes in Industries</b>	L016. 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
		in systematic evolution of concepts, scientific discoveries and inventions in the field of	CLO133. Describes how antibiotics were discovered	C150. Explains how Alexander Fleming discovered penicillin

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<b>VIII: Biology in Human Welfare</b>  8. Microbes in Human Welfare		biology based on historical scientific events/ timelines		
		L02. relates processes and phenomena with causes and effects	CLO134. Summarises antibiotics for treating bacterial diseases	C151. Describes antibiotics and explain how it works
		L03. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO135. Enlist the diseases cured by antibiotics	C152. Names some diseases treated with antibiotics
		L015. 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
				C154. Enlists the basic classification of antibiotics
				C155. Explains the disadvantages of antibiotics
				C156. Describes use and misuse of antibiotics in treatment of diseases for human

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<b>VIII: Biology in Human Welfare</b>  8. Microbes in Human Welfare		L016. 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
				C158. States the uses of lipases, pectinases, proteases, streptokinase, cyclosporine A, and statins
		L03. applies scientific terminology for organisms, processes, and phenomena based on internationally accepted conventions	CLO138. Describes BOD	C159. Explain biochemical oxygen demand or BOD
		L011. analyzes and interprets graphs and figures	CLO139. Understand the role of BOD in studying pollution	C160. Analyzes and interprets data of BOD of water samples to know their pollution level
		L016. appreciates technological applications and processes in Biology towards the improvement in the quality of	CLO139. Understand the role of BOD in studying pollution	C161. Uses the BOD of water samples to spread awareness about the prevention of water

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VIII: Biology in Human Welfare</b>  8. Microbes in Human Welfare		life and sustainable development		pollution at the source
		L016. 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
				C163. Summarises the role of sewage treatment plants for humankind
		L018. 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 borewells or handpump directly
	<b>Microbes in Production of Biogas</b>	L04. 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
		L016. appreciates technological applications and processes in	CLO143. Reasons for the importance of biogas to	C166. Justifies the use of biogas as compared to

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<b>VIII: Biology in Human Welfare</b>  8. Microbes in Human Welfare	<b>Microbes as Biocontrol Agents</b>	Biology towards the improvement in the quality of life and sustainable development	humankind	burning of wood as fuel in villages
		L01. 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
		L016. 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. Evaluate the need for Biocontrol agents in modern farming
				C169. Justifies how Bioherbicides help in the reduction of weeds in cropland
			CLO146. Determines the role of microbes in pest control with examples	C170. Explain how <i>Bacillus thuringiensis</i> and baculoviruses help in pest control as a biocontrol agent
				C171. Explains how Integrated Pest Management

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>VIII: Biology in Human Welfare</b>  8. Microbes in Human Welfare	<b>Microbes as Biofertilizers</b>			helps in reducing agro-chemical pollution
		L02. 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
		L01. 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
		L01. 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
		L016. 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

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<b>IX: Biotechnology</b> 9. Biotechnology: Principles and Processes	<b>Biotechnology</b>	L03. 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 the European Federation of Biotechnology (EFB) and two core techniques of modern biotechnology
		L05. Describes the contribution of scientists/researchers all over the world in the 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
	<b>Principles of Biotechnology</b>	L06. 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
				C179. Mentions the basic techniques of genetic engineering
				C180. Describes the method



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<b>IX: Biotechnology</b> 9. Biotechnology: Principles and Processes				of gene cloning and transfer
				C181. Describes the role of DNA replication in genetic engineering
		L05. describes the contribution of scientists/researchers all over the world in the 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
		L06. 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
	<b>Tools of Recombinant DNA Technology</b>	L016. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable	CLO155. Describes the tools used in genetic engineering	C184. Enumerates the tools of rDNA
				C185. Describes in detail the naming and functioning of restriction enzymes for the

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>IX: Biotechnology</b>  9. Biotechnology: Principles and Processes		development		cutting of DNA at a specific location
				C186. Describes restriction enzymes and their functioning using examples.
		L016. 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
				C188. Compares and contrasts the roles of these enzymes (molecular scissors and molecular glue) during cell division
				C189. Describes the functioning of DNA ligase in producing recombinant DNA
		L016. appreciates technological applications and processes in Biology towards the	CLO157. Summarises the use of gel electrophoresis in rDNA technology	C190. Describes the uses of gel electrophoresis in producing recombinant DNA

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<b>IX: Biotechnology</b>  9. Biotechnology: Principles and Processes		improvement in the quality of life and sustainable development		C191. Describes and explains how gel electrophoresis is used to separate desired DNA fragments of different lengths
		L016. 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
				C193. Analyses/Discusses the role of bacteria in biotechnology and genetic engineering
		L016. appreciates technological applications and processes in Biology onwards the improvement in the quality of life and sustainable development	CLO159. Summarises the ways to identify transformants	C194. Explains methods to identify transformants
				C195. Emphasises the role of selectable markers in identifying transformants
			CLO160. Describes the methods to make cells	C196. Describes the process to make cells competent

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<b>IX:Biotechnology</b> 9. Biotechnology: Principles and Processes	<b>Processes of Recombinant DNA Technology</b>	L04. explains efficiently systems, relationships, processes and phenomena	competent	C197. Explains the need for a competent host and the methods to introduce it into the host
			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
		L015. applies scientific concepts in daily life and solving problems	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
			CLO163. Calculate 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 $2n$

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<b>IX: Biotechnology</b> 9. Biotechnology : Principles and Processes				copies of the original
		L04. 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
				C202. Explains the steps and the need for downstream processing
		L02. 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
<b>IX: Biotechnology</b> 10. Biotechnology and its Applications	<b>Biotechnological Applications in Agriculture</b>	L016. 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 GMOs and discusses their advantages and disadvantages.
			CLO167. Explains the application of biotechnology	C205. Enlists the critical research areas of biotechnology

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<b>IX: Biotechnology</b> 10. Biotechnology and its Applications			CLO168. Describes the application of biotechnology to increase the yield in agriculture	C206. Previews the biotechnological applications in agriculture
		L015. 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
		L016. 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
				C209. Explains the generation of pest-resistant tobacco plants using iRNA
	<b>Biotechnological Applications in Medicine</b>	L016. appreciates technological applications and processes in Biology towards the	CLO169. Describes the application of biotechnology to manufacture medicines	C210. Summarises the method of producing recombinant insulin

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<b>IX:</b> <b>Biotechnology</b> 10. Biotechnology and its Applications		improvement in the quality of life and sustainable development		C211. Outlines how genetic diseases can be treated with gene therapy, using the example of severe combined immunodeficiency (SCID)
				C212. Explains the process and importance of gene therapy
				C213. Describes the usage of biotechnological methods for molecular diagnosis of diseases
				C214. Analyzes and interpret the results of banding from gel electrophoresis, autoradiography and ELISA diagnostic test
		L05. describes contribution of scientists/researchers all over the world in systematic evolution of concepts, scientific	CLO170. Describe the discovery of stem cell technology	C215. Explains the discovery of different types of stem cells and their applications

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<b>IX: Biotechnology</b>  10. Biotechnology and its Applications		discoveries and inventions in the field of biology based on historical scientific events/ timelines etc.		
		L015. 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  C217. Outlines the advantages of using recombinant human proteins to treat disease, using the examples of insulin, clotting factor VIII, and adenosine deaminase
		L016. appreciates technological applications and processes in Biology towards the improvement in the quality of life and sustainable	CLO172. Describes the tools for the application of biotechnology	C218. Emphasises identifying biotechnological tools and principles employed in creating various GM resources for



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<b>IX: Biotechnology</b> 10. Biotechnology and its Applications		development		medical and agricultural advancements
	<b>Transgenic Animals</b>	L016. 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
	<b>Ethical Issues Regarding Transgenic Animals</b>	L018. exhibits ethics and values of honesty, objectivity, rational thinking and freedom from myth and superstitious beliefs while taking decisions, respect for life, etc.	CLO174. Evaluates the ethical question regarding genetic modification of organisms	C220. Analyze the serious ethical questions raised about the manipulation of microbes, plants, and animals with examples
			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
				C222. Understand that all therapeutic approaches are not successful; analyze the risk involved

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		L04. 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
		L04. explains efficiently systems, relationships, processes and phenomena	CLO177. Evaluate the role of biopiracy and bio-patent	C224. Explains the meaning of Biopiracy
				C225. Explains and discusses bio-patent and biopiracy with reference to safeguarding traditional indigenous knowledge
<b>X: Ecology</b> 11. Organisms and Populations	<b>Attributes of Population</b>	L03. 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
		L010. handles laboratory/ agricultural tools, and apparatuses, instruments and devices properly for performing	CLO178. Defines population and calculates its attributes	C227. Conducts an investigation of the difference in species composition in the different

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<b>X: Ecology</b> 11. Organisms and Populations		activities/ experiments/ investigations		quadrats in the school garden
		L020. 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
		L011. analyzes and interprets graphs and figures	CLO179. Interprets data into graphs to show variation in population density and frequency	C229. Prepare graphs to show the variations in population density and population frequency in different quadrants of the experiment
		L07. draws labelled diagrams, flow charts, concept maps, graphs	CLO180. Represents age pyramid	C230. Draws age pyramids for the human population
		L011. 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

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<b>X: Ecology</b> 11. Organisms and Populations	<b>Population Growth</b>	L06. 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
		L02. 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
		L011. analyzes and interprets graphs and figures	CLO184. Presents the data of the 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
		L06. 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
		L011. analyzes and interprets	CLO186. Studies population	C236. Interprets the graphical representation of

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<b>X: Ecology</b> 11. Organisms and Populations		graphs and figures	growth curve	growth curve
		L09. 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 in a culture of yeast cells
		L011. 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
		L015. 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
		L014. 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

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<b>X: Ecology</b> 11. Organisms and Populations				growth of yeast culture in front of peer groups
	<b>Life History Variation</b>	L02. relates processes and phenomena with causes and effects	CLO191. Evaluate the role of Darwinian fitness	C241. Explains the importance of Darwinian fitness with examples
	<b>Population Interactions</b>	L04. 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
		L09. 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. Conduct 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
		L019. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and	CLO194. Applies the concept of different population interactions in daily life and solves	C244. Carefully analyses the population interactions of the samples in the research and makes an effort to

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		abiotic factors of environment	problems relating to conservation	conserve organism
		L018. 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
		L05. 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 the fitness of one species is influenced by the presence of other species	C246. Interprets laboratory experiments conducted by ecologists like the Gause-competitive exclusion principle and Connell's elegant field experiments
		L014. 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
		L01. differentiates organisms,	CLO198. Compares different	C248. Differentiates

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		phenomena and processes based on certain characteristics and salient features,	types of population interaction	between different population interaction
<b>X: Ecology</b> 12. Ecosystem	<b>Ecosystem- Structure and Function</b>	L019. 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
			CLO200. Explains vertical stratification of a forest	C250. Explain the different levels of vertical stratification
		L07. 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
		L04. 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
	<b>Productivity</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO203. Explains productivity in terms of an ecosystem	C253. Explains primary and secondary productivity



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<b>X: Ecology</b> 12. Ecosystem		L020 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
			CLO205. Calculates gross and net primary productivity	C255. Explains and calculates gross and net primary productivity
		L015. applies scientific concepts in daily life and solving problems	CLO206. Compares productivity of different ecosystems	C256. Analyzes the productivity of different ecosystem
	<b>Decomposition</b>	L04. 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
		L015. applies scientific concepts in daily life and solving problems	CLO208. Observe the steps of the decomposition process in nature	C258. Studies the different steps of the decomposition process with the help of a simple experiment using fallen leaves
		L07. draws labelled diagrams, flow charts, concept maps,	CLO209. Illustrates the	C259. Explains the decomposition process in a

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<b>X: Ecology</b> 12. Ecosystem		graphs	process of decomposition	terrestrial system diagrammatically
	<b>Energy Flow</b>	L04. explains efficiently systems, relationships, processes and phenomena	CLO210. Illustrates energy flow in an ecosystem	C260. Explains the energy flow in an ecosystem through the food chain and food web
		L01. 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. Explain the grazing food chain (GFC) and detritus food chain (DFC) with examples
		L07. draws labelled diagrams, charts, concept maps, graphs	CLO212. Illustrates the flow chart of different types of food chain	C262. Draw a flow chart to illustrate the grazing food chain (GFC) and the detritus food chain (DFC)
	<b>Ecological Pyramids</b>	L01. 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
		L019. applies/ makes efforts to conserve environment realizing the interdependency and inter-	CLO214. Creates awareness about the conservation of organisms, keeping their	C264. Makes conscious efforts to conserve organisms of all trophic

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<b>X: Ecology</b> 12. Ecosystem		relationship in the biotic and abiotic factors of environment	trophic levels in mind	levels for balance in ecosystem
		L020. 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
		L07. draws labelled diagrams, flow charts, concept maps, graphs	CLO216. Illustrates different ecological pyramids	C266. Draws ecological pyramid of number, biomass, and energy
		L011. analyzes and interprets graphs and figures	CLO217. Draws conclusion from different ecological pyramids	C267. Analyses ecological pyramid on the basis of shape and draws conclusions about its stability
		L07 draws labelled diagrams, flow charts, concept maps, graphs	CLO218. Understand ecological balance and inverted pyramids	C268. Collects data and prepares pyramids figures of the population data of developed and developing countries
		L021 applies learning to	CLO219. Analyses the	C269. Compares and

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<b>X: Ecology</b> 12. Ecosystem		hypothetical situations	pyramids of a developed country and a developing country	contrasts the age pyramids in hypothetical data for a developed country and a developing country
		L09. 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
		L015. 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 affect the human population
		L014. 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
		L04. explains efficiently	CLO223. Describes	C273. Explains biodiversity

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<b>X: Ecology</b> 12. Biodiversity and Conservation	<b>Biodiversity</b>	systems, relationships, processes and phenomena	biodiversity	and its significance
				C274. Explains biodiversity at different levels—genetic, species, and ecological diversity
	<b>Biodiversity on Earth and India</b>	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
				C276. Reads data and justifies that a large fraction of species faces the threat of becoming extinct
	<b>Patterns of Biodiversity</b>	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
				C278. Summarises the relation between species richness with an area in a region using an equation of Z value by Alexander von

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<b>X: Ecology</b> 12. Biodiversity and Conservation				Humboldt
	<b>Importance of Species Diversity to the Ecosystem</b>	L04. 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 in long-term ecosystem experiments to explain the importance of species diversity
	<b>Loss of biodiversity</b>	L019. 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
		L09. 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 invasive species in the locality	C281. Prepare a list of invasive or alien species in the area that are threatening and competing for resources with the native species
		L015. applies scientific concepts in daily life and solving	CLO229. Justifies solutions to solve the problem of the	C282. Provides possible solutions to solve the

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<b>X: Ecology</b> 12. Biodiversity and Conservation		problems	invasion of alien species in the locality	problem of invasion of alien species in the locality
		L02. relates processes and phenomena with causes and effects	CLO230. Describes the causes of biodiversity loss	C283. Enlists the causes of biodiversity loss
		L09 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
		L018. 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
	<b>Biodiversity Conservation</b>	L019. applies/ makes efforts to conserve environment realizing the interdependency and inter-relationship in the biotic and	CLO232. Argues to justify the conservation of biodiversity	C286. Justifies the need to conserve biodiversity using narrowly, broadly utilitarian and ethical arguments with

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<b>X: Ecology</b> 12. Biodiversity and Conservation	<b>Ways to conserve the biodiversity</b>	abiotic factors of environment		examples
		L019. 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	C287. Describes the in-situ and ex-situ approach to conserve biodiversity with examples
				C288. Explain endemism and hotspots with examples
				C289. Explains the role of 'The Earth Summit' in reducing the rate of biodiversity loss
		L03. 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
		L09. plans and conducts investigations and experiments to arrive at and verify the facts, principles, phenomena, or to seek answers to queries on	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



Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>X: Ecology</b> 12. Biodiversity and Conservation		their own		anthropogenic activities
		L013. 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
		L014. 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
		L013. 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. Find out the recent amendments in the environmental policies of India and major international policies to preserve our biodiversity and global environmental issues
		L014. 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

Unit and chapter	Key concept	NCERT Learning Outcomes (LOs)	Content domain specific Learning Outcomes (CLOs)	Indicators
<b>X: Ecology</b> 12. Biodiversity and Conservation				India and major international policies in the form of a presentation to the peer group
		L015. 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
		L018. 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

## 9. SAMPLE PEDAGOGICAL PROCESSES AND ASSESSMENT STRATEGIES

“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]

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 processes 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 a 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 with 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 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, and written and oral assignments should be used to reflect the 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 the 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. Explain enzymatic reactions and the factors that affect the enzyme activity with examples	<ul style="list-style-type: none"><li>• Create a 3-D model of the tertiary structure of an enzyme with an active site and substrate using waste materials.</li><li>• Demonstrate the lock-and-key using the created model.</li><li>• Select and use appropriate devices for understanding of structural intricacies of enzymes.</li></ul>	<ul style="list-style-type: none"><li>• Assess if students apply that since most enzymes are proteins, they have secondary and primary structures</li><li>• Ask questions to students to infer the nature of active sites on enzymes.</li></ul>
		<ul style="list-style-type: none"><li>• Design and carry out activities/experiments/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.</li><li>• Instruct students to note the change in colour after adding iodine in the activity of salivary amylase on starch at different temperatures.</li><li>• Instruct students to note the change in</li></ul>	<ul style="list-style-type: none"><li>• Assess the understanding of students about variables and constants in each experiment.</li><li>• Ask: What should we do to include a positive control condition to confirm enzyme activity?</li></ul> <p>Ask them: What happened to the rate of reaction (intensity of colour change) at different temperatures? What did you observe about the activity of salivary amylase at different pH?</p>

Learning outcomes	Indicators	Pedagogical Processes	Assessment Strategies
		colour after adding iodine in the activity of salivary amylase on starch at different pH.	<ul style="list-style-type: none"> <li>Ask them to infer the effect of temperature and pH on enzyme activity.</li> </ul>
		<ul style="list-style-type: none"> <li>Design and carry out activities/experiments/investigations to find the answer to their queries</li> <li>Instruct students to note the change in colour after adding iodine in the activity of salivary amylase on starch at three different concentrations of starch.</li> </ul>	<ul style="list-style-type: none"> <li>Ask: What should we have for positive control conditions to confirm enzyme activity in this experiment?</li> <li>Ask them: What happened to the enzymatic activity (intensity of colour after adding iodine) at different concentrations of substrate?</li> <li>Ask them to infer the effect of an increased level of substrate on the enzyme activity.</li> </ul>
		<ul style="list-style-type: none"> <li>Present their observations through different graphs showing the effect of salivary amylase activity due to changes in pH, temperature and concentration of substrate</li> </ul>	<ul style="list-style-type: none"> <li>Ask questions such as what you infer from the curve of each graph.</li> <li>Remind students that most enzymes are made up of protein, which justifies the effect on enzyme activity due to changes in these parameters.</li> <li>Encourage them to infer the optimum temperature, pH and concentration of substrate when the activity of salivary amylase was maximum.</li> </ul> <p>Instruct them to find the value of <math>V_{max}</math> for the curve of substrate concentration and enzyme</p>

Learning outcomes	Indicators	Pedagogical Processes	Assessment Strategies
			<p>activity. Ask: What do you think is the significance of <math>V_{max}</math>?</p> <ul style="list-style-type: none"> <li>• Ask questions to students regarding the impact of duplicate key/ compound similar to the substrate of enzyme action with reason</li> <li>• How can the DNA be separated from cell proteins from the lysed cells?</li> <li>• Will DNA be suspended in water or alcohol?</li> </ul>

## 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	<ul style="list-style-type: none"> <li>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.</li> </ul>	<ul style="list-style-type: none"> <li>Encourage students to justify the order of steps of recombinant DNA.</li> <li>Ask: What would happen if host cells were not competent before the recombinant DNA is transferred into them?</li> </ul>
		<ul style="list-style-type: none"> <li>Design and carry out activities/experiments/ investigations: Isolate DNA from available plant material such as spinach, green pea seeds, papaya, etc.</li> <li>Students will conduct the experiments in groups and will note their observations.</li> </ul>	<ul style="list-style-type: none"> <li>Ask questions about the observations made in the experiment: What chemical is used to break the cell wall of the plant cells?</li> <li>What is the role of alcohol (ethanol) in extracting the DNA from the lysed cell?</li> </ul>
		<ul style="list-style-type: none"> <li>Collect information from books, e-books, magazines, journals, libraries, the internet, etc., to appreciate the efforts scientists made over time to discover the restriction enzymes and discuss it with the class.</li> <li>Encourage students to realize how</li> <li>restriction enzymes know where to make the cut in DNA.</li> </ul>	<ul style="list-style-type: none"> <li>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?</li> <li>Why is important to use the same restriction enzyme on vector and target DNA?</li> </ul>



**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
<b>Total</b>	<b>70</b>

**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
<b>Total</b>	<b>70</b>

**Other details of the test paper:**

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

## 11. 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 studying 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; using foldscope/microscope for observing the internal structure of a 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, and 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 breathe? 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, and 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 making decisions, such as reports and recording 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
<b>Total</b>	<b>30</b>

## SUGGESTED PROJECTS/ACTIVITIES/ PRACTICAL – CLASS 11

### Part A: List of Experiments

1. Study and describe locally available common flowering plants, from the 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 the 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 the presence of urea in urine.
11. Test for the presence of sugar in urine.
12. Test for the presence of albumin in urine.
13. Test for the 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, liver fluke, 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**

1. Prepare a temporary mount to observe pollen germination.
2. Study the plant population density by quadrat method.
3. Study the plant population frequency by quadrat method.
4. Prepare a temporary mount of onion root tip to study mitosis.
5. 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 cells or grasshopper testis through permanent slides.
5. T.S. of blastula through permanent slides (Mammalian).
6. Mendelian inheritance using seeds of different colours/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, and 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 symbiotic association in root modules of leguminous plants, Lichens, parasitic interaction of cuscuta with host
11. Flashcard models showing examples of homologous and analogous organs.

## 12. SAMPLE ASSESSMENT IDEAS

### 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 the 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 understand that blue and red regions of the light spectrum are the most effective in photosynthesis.

<b>Distractor 1</b>	The plant with grow at a slower rate	Explanation: This will test what regions of the light spectrum are important for photosynthesis.
<b>Distractor 2</b>	The plant with grow at a faster rate	Explanation: This will test what regions of the light spectrum are important for photosynthesis.
<b>Distractor 3</b>	The plant growth will remain constant	Explanation: This will test what regions of the light spectrum are important for photosynthesis.

## 2. Free Response Question / Subjective Question

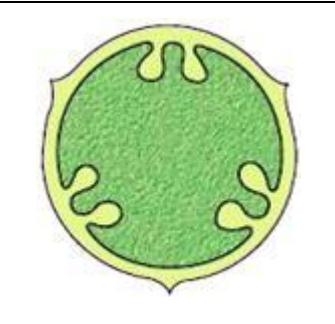
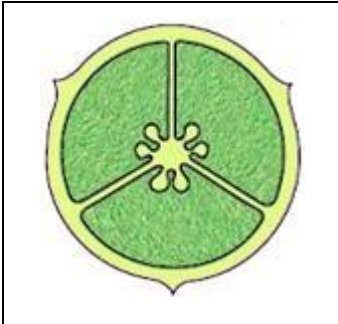
<b>Content domain (Chapter name)</b>	<b>The Living World</b>
<b>Content Domain Learning outcome</b>	CLO4. Differentiates between the basic methods of taxonomic study
<b>Indicator</b>	C8. Explain the branch of study called taxonomy
<b>Cognitive level</b>	Understand
<b>Thinking Process</b>	Explain
<b>Difficulty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



	modern taxonomical studies. Explain with examples.	
Marking Scheme		
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. Free Response Question / Subjective Question

<b>Content domain (Chapter name)</b>	<b>Morphology of Flowering Plants</b>
<b>Content Domain Learning outcome</b>	CL095. Identifies the different types of placentation in plants
<b>Indicator</b>	C114. Describe different types of placentation – marginal, axile, parietal, free central and basal – with examples
<b>Cognitive level</b>	Remember

Thinking Process	Inferring and comparing	
Difficulty level	Medium	
Marks	3 marks	
Time	4-5 minutes	
Item stem	<div>Look at the picture showing different types of placentation.</div> <div><div></div><div>Placentation GPlacentation H</div><div>A. Identify the type of placentation for both</div><div>B. How the placentation G is different from placentation H? Support with one example of each.</div></div>	
Marking Scheme		
Part	Mark	Answer
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
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#### 4. Free Response Question / Subjective Question

<b>Content domain (Chapter name)</b>	<b>Cell Cycle and Cell Division</b>			
<b>Content Domain Learning outcome</b>	CLO168. Explain the process of mitosis			
<b>Indicator</b>	C194. Explain the importance of mitosis and relate mitosis to types of growth patterns in living organisms			
<b>Cognitive level</b>	Apply			
<b>Thinking Process</b>	Applying and interpreting			
<b>Difficulty level</b>	Hard			
<b>Marks</b>	3 marks			
<b>Time</b>	6-8 minutes			
<b>Item stem</b>	Colchicine is an alkaloid drug. Study the data collected when different amount of colchicine is added to the cell culture.			
	<b>After 45 min</b>	<b>25 ml of cell culture without colchicine</b>	<b>25 ml of cell culture with 0.1 ml of colchicine</b>	<b>25 ml of cell culture 0.0001 ml of colchicine</b>

		2% cells are in prophase 5% cells are in metaphase 13% cells are in anaphase 80% cells are in telophase	90% cells are in metaphase, 10% cells are in prophase	75% cells are in metaphase, 25% cells are in prophase.
	<p>A. What is the effect of colchicine on cell division—decreases or increases cell division?</p> <p>B. Which stage of mitosis is influenced by colchicine? Why?</p> <p>C. Based on characteristics of that stage, how do you think colchicine influences that stage of mitosis?</p>			

### 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. Free Response Question / Subjective Question

Content domain (Chapter name)	Respiration in plants	
Content Domain Learning outcome	CLO213. Calculates the total ATP generated in the metabolism of one glucose molecule in respiration	
Indicator	C250. Calculates the total net number of ATP generated by respiration of one molecule of glucose in aerobic and anaerobic respiration	
Cognitive level	Analyze	
Thinking Process	Examining, interpreting, 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		
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 the absence of oxygen and aerobic is complete and occurs in the presence of oxygen	Answer may vary

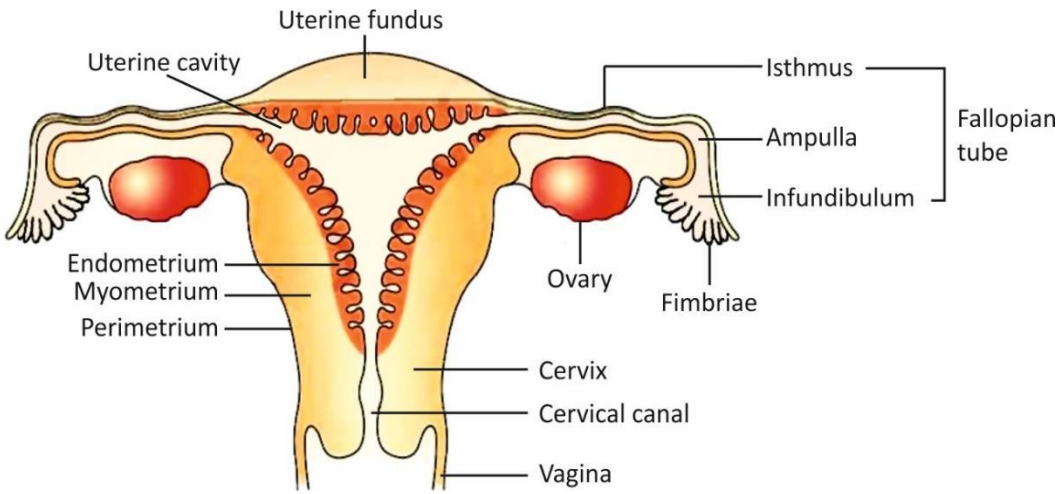
## 6. Multiple Choice Question (MCQ)

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 bougainvillaea and tendrils of cucurbits	Reason: This shows students understand that homologous modification as same structures with different functions
Distractor 1	Eye of octopus and mammals	Explanation: Students may misunderstand homologous modification as structures with the same function
Distractor 2	Wings of butterfly and bird	Explanation: Students may misunderstand homologous modification as structures with same function
Distractor 3	Thorns of bougainvillaea 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	<p>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 a patient who has no symptoms of the infection.</p> <p>Which of these methods you can use to diagnose the infection in the patient?</p>	
Correct answer	Enzyme Linked Immuno-Sorbent Assay (ELISA)	This checks if the student understands that ELISA can be used to detect low viral loads
Distractor 1	Analysis of urine	This checks if the 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	Chromatography	This checks if student lacks the understanding and making a random guess

## 8. Free Response Question / Subjective Question

<b>Content domain (Chapter name)</b>	<b>Human Reproduction</b>
<b>Content Domain Learning outcome</b>	CLO38. Describes the reproductive cycle in females
<b>Indicator</b>	C41. Explain and predict the different changes in the uterus during the different stages of the menstrual cycle
<b>Cognitive level</b>	Create
<b>Thinking Process</b>	Construct, assemble
<b>Difficulty level</b>	Medium
<b>Marks</b>	5
<b>Time</b>	10-12 minutes
<b>Item stem</b>	<p>Given below is a diagram of the female reproductive tract.</p> 



Create 4 diagrams 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
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. Free Response Question / Subjective Question

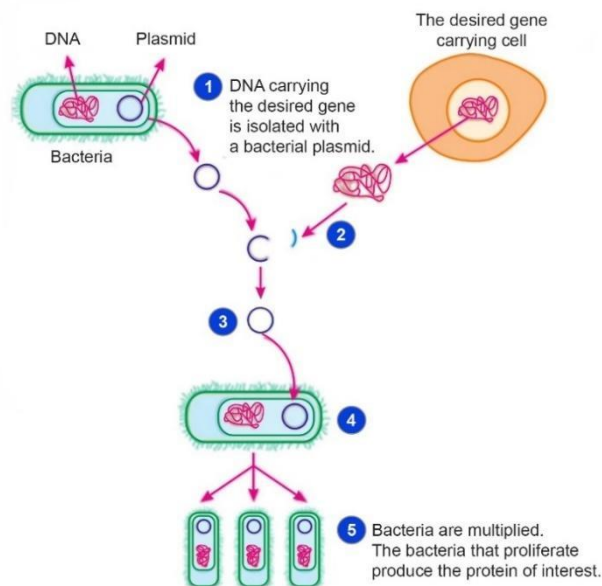
Content domain (Chapter name)		Sexual Reproduction in Flowering Plants
Content Domain Learning outcome		CLO15. Describes the role of pollination
Indicator		C17. Summarises outbreeding devices and the pollen-pistil interaction after pollination
Cognitive level		Apply
Thinking Process		Interpret, Relate
Difficulty level		Hard
Marks		3 marks
Time		5-7 minutes
Item stem		<p>Set up: An area with different species of plants. A colour tracer is added to the pollen of one species.</p> <p>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.</p> <p>A. Name and explain the phenomenon underlying this finding.</p> <p>B. How can a plant breeder avoid fertilization by unwanted pollen?</p>
Marking Scheme		
Part	Mark	Answer
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. Free Response Question / Subjective Question

<b>Content domain (Chapter name)</b>	<b>Biotechnology: Principles and Processes</b>
<b>Content Domain Learning outcome</b>	CL0156. Explains the use and functioning of restriction enzymes in rDNA technology
<b>Indicator</b>	C186. Describes restriction enzymes and their functioning C189. Describes the functioning of DNA ligase in producing recombinant DNA
<b>Cognitive level</b>	Understand
<b>Thinking Process</b>	Infer and explain
<b>Difficulty level</b>	Medium
<b>Marks</b>	3
<b>Time</b>	4-5 minutes

Study the given chart showing the process of Recombinant DNA technology.



- Complete the explanation of steps 2, 3 and 4.
- In which step restriction enzymes are used? What is their purpose?
- In which step DNA ligase is used? What is its purpose?

### Marking Scheme

Part	Mark	Answer
A	1.5	<p>Completes steps 2, 3 and 4 as</p> <p>Step 2- Cutting of target DNA and vector at a specific location</p> <p>Step 3- Joining of vector and target foreign DNA to form recombinant DNA</p> <p>Step 4 – Transfer of recombinant DNA into the host</p>
B	1	Mentions that restriction enzymes are used step 2 to cut the vector and target DNA at the restriction site.

C	0.5	Mentions that restriction enzymes are used in step 3 to join the end fragments of vector and target DNA.
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### CLASS 11 – ASSESSMENT 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 the 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 of 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 the 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 the family of the organism	Student understands that the order of the taxonomic hierarchy
Distractor 1	Taxonomic category is A to G all together in order	Student misunderstands the 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 the 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 classifications based on an 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 provides no knowledge about the 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 the 5-kingdom classification	1

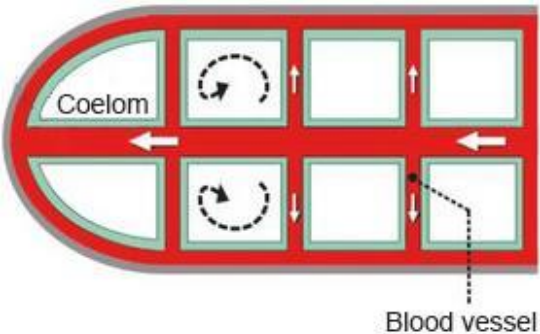
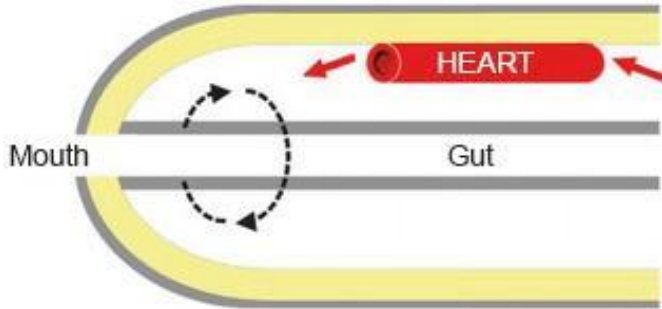


Chapter name	Biological Classification	
<b>Essential Idea</b>	The main criteria of the five-kingdom classification are cell structure, body organisation, mode of nutrition and reproduction, and phylogenetic relationships.	
<b>Item stem</b>	Choose the correct statement regarding on five-kingdom classification.	
<b>Correct answer</b>	Mushrooms and green plants are not in the same kingdom because mushrooms are heterotrophs and plants are autotrophs.	The student understands that mode of nutrition is one of the criteria of the five-kingdom classification system.
<b>Distractor 1</b>	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.
<b>Distractor 2</b>	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.
<b>Distractor 3</b>	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 the flora of an inhabited island. They found two unidentified plants—plant X and plant Y. Here are the observed features of these plants:	
	Features	Plant X
		Plant Y
	Vascular tissue	Absent
	Seeds	Absent
	Pollen	Absent
	Roots	Present
	True leaves	Present
	Fruits and flower	Absent
Identify the division of Plantae Kingdom to which each of the plant most likely belongs. Give a reason for your answer.		
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 the identification of the division (0.5 marks for each)	1

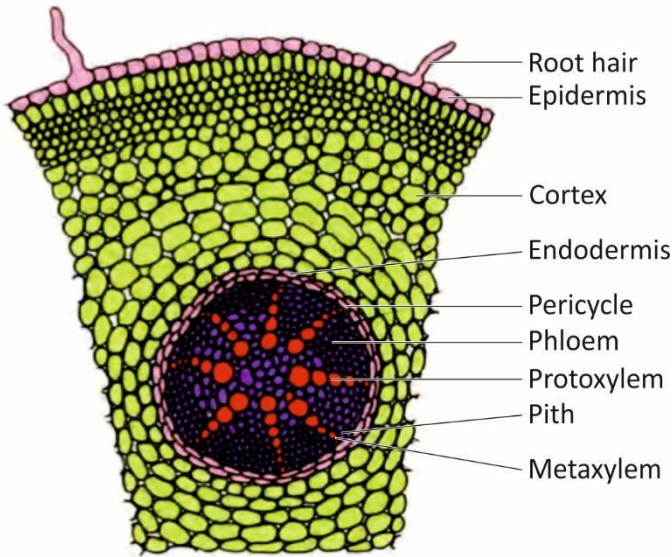
Chapter name	Plant Kingdom	
Essential Idea	We use numerical taxonomy, cytotaxonomy and chemotaxonomy information from many other sources to help resolve difficulties in plant classification.	
Item stem	<p>Read the examples of three different ways to resolve difficulties in classification.</p> <p>X: Umbelliferae and Apiaceae secrete volatile oils but Solanaceae secrete tropane alkaloids.</p> <p>Y: Taxonomical work on bacteria is done by collecting morphological, physiological, and antigenic data of the strain, processing it applying statistics to estimate the percentage of similarities and dissimilarities.</p> <p>Z: Monotropa hypopitys and Monotropa hypophegea are two morphologically similar organisms but separated since M. hypopitys is a hexaploid: (<math>2n = 48</math>) and M. hypophegea is a diploid (<math>2n = 16</math>).</p> <p>Which of these statements is correct?</p>	
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 the level of cellular organization, body symmetry, nature of coelom, patterns of digestive, circulatory or reproductive systems, and presence of notochord.	
Item stem	<p>A. Look at these animals.</p> <div data-bbox="430 363 763 724" data-label="Image"> </div> <div data-bbox="425 758 515 831" data-label="Caption">Liver Fluke</div> <div data-bbox="649 758 761 791" data-label="Caption">Ascaris</div> <p>Identify the phylum of each – Liver Fluke and Ascaris.</p> <p>What are the two common features for both these phyla? And what are the two distinguishing characteristics of each phylum?</p> <p>B.</p>	
		

	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 an example of another phylum that has these types of circulatory systems.		
Marking Rubric			
Part	Description	Marks	
Sample answer	<p>A. Liver fluke belongs to Phylum Platyhelminthes and Ascaris belongs to Phylum Aschelelminthes.</p> <p>Two common features:</p> <ol style="list-style-type: none"><li>1. Platyhelminthes and Aschelminthes have a bilaterally symmetrical body.</li><li>2. Both have organ system levels of organisation. Two differences:</li><li>3. Platyhelminthes are acoelomates and Aschelminthes are pseudocoelomates.</li><li>4. Platyhelminthes have an incomplete alimentary canal with a single opening, and Aschelminthes have a complete alimentary canal with a separate opening for the mouth and anus.</li></ol> <p>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.</p> <p>The closed circulatory system is found in chordates like aves and mammals and the open circulatory system is found in Phylum Echinoderm except cephalochordates.</p>		
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 requires 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:	Canna Lily flower Symmetry:	Butterfly Pea flower Symmetry:

	Actinomorphic	Asymmetric	Zygomorphic
	Based on the symmetry of the flower, how flowers 1, 2 and 3 are different from each other? Explain with names of their types based on symmetry.		
Marking Rubric			
Part	Description		Marks
Sample answer	The Mustard flower is actinomorphic and it can be divided into two equal radial halves in any radial plane passing through the centre. The Canna Lily flower is asymmetric (irregular) if it cannot be divided into two similar halves by any vertical plane passing through the centre. But the Butterfly Pea flower is zygomorphic and it can be divided into two similar halves only in one particular vertical plane.		
	Explain 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 the 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.	

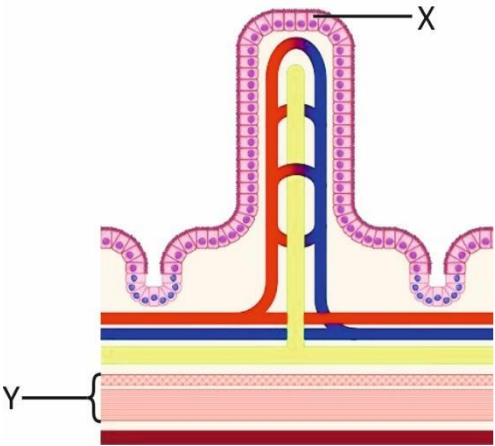
Chapter name	Anatomy of Flowering Plants
<b>Essential Idea</b>	Apical meristem tissues are the dividing cells responsible for the primary growth of plants, and permanent tissues are non-dividing cells that constitute the epidermal, ground, and vascular tissue systems.
<b>Item stem</b>	<p data-bbox="421 339 1480 371">Study the transverse section of the monocot root with different labelled parts.</p> <div data-bbox="434 467 1104 1026">  </div> <p data-bbox="421 1134 2096 1382"> A. Endodermal cells present opposite to xylem bundles are called passage cells. 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 of the morphology of the root? </p>



### Marking Rubric

Part	Description	Marks
<b>Sample answer</b>	<p>A. Their function is to transfer water and dissolved salts from the cortex into the xylem.</p> <ol style="list-style-type: none"> <li>1. Monocot root vascular bundles are radially arranged. There are equal bundles of each of the xylem and phloem and this is called polyarch.</li> <li>2. The xylem in the monocot root is exarch as the protoxylem is directed towards the periphery and the metaxylem is directed towards the centre.</li> </ol> <p>B. There is no vascular cambium i.e. lateral meristem in monocots so it does not result in the development of secondary roots</p>	
<b>Part A</b>	Writes a relevant function of endodermal cells opposite to the xylem.	1
<b>Part B</b>	Writes two relevant reasons supporting the statement (0.5 marks for each)	1
<b>Part C</b>	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	<p>Shayam is studying the roots of two new plant specimens collected on the fieldwork. Here is the data collected</p> <p>Sample A: Narrower cortex. Endodermis is less thickened and Casparian strips are more prominent. The xylem and phloem bundles vary from 2 to 5. The pith is absent or very small.</p> <p>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.</p> <p>Which of these is the plant sample most likely to be?</p>	
Correct answer	Sample A is a dicot plant	Student understands the characteristic features of the dicot root
Distractor 1	Sample B is a dicot plant	Student misunderstands characteristic features of dicot root
Distractor 2	Sample A is a 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	<p>There are four different levels of cellular organisation in a multicellular organism.</p> <p>Look at the image showing two of the different levels of cellular organisation in a section of one of the villi.</p> <div></div> <p>A. Label X, and Y in terms of the levels of cellular organization.</p> <p>B. Name the other two levels of organisation (other than X and Y) of villi.</p>		
Marking Rubric			
Part	Description	Marks	
Sample answer	A. X. epidermal cell Y. smooth muscle tissue		

	B. Organ: Small intestine; Organ system: Digestive system	
<b>Part A</b>	Identifies the name of layers (0.5 marks for each)	1
<b>Part B</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	

<b>Distractor 3</b>	N: Open circulatory system; O: Kidneys	Student misunderstands that frogs have an open circulatory system
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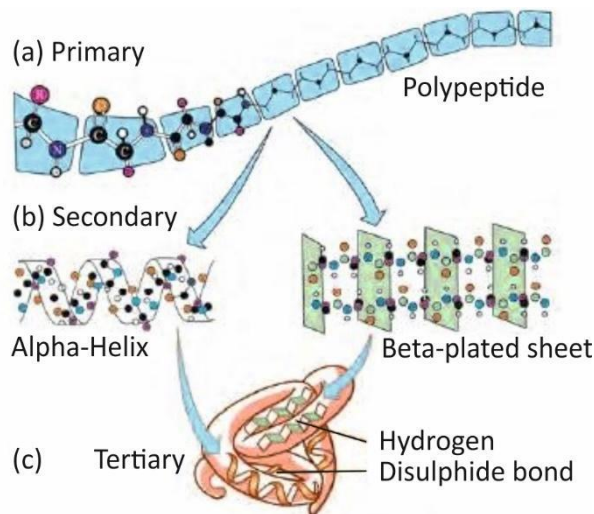
Chapter name	Cell-The Unit of Life	
Essential Idea	All living organisms, prokaryotic and eukaryotic, are made of cells that have at least a plasma membrane, genetic material, ribosomes, and cytoplasm.	
Item stem	Antibiotics are medicines used to treat bacterial infections in humans. These medicines kill 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	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	<p>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</p> <p>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?</p>	
<b>Correct answer</b>	Organelle A: Mitochondria Organelle B: Chloroplast	Student understands the function of mitochondria and chloroplast
<b>Distractor 1</b>	Organelle A: Ribosomes Organelle B: Nuclei	Student misunderstands that ribosomes play an important role in respiration
<b>Distractor 2</b>	Organelle A: Endoplasmic reticulum Organelle B: Chloroplast	Student misunderstands that the endoplasmic reticulum plays an important role in respiration
<b>Distractor 3</b>	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	<table border="1"> <thead> <tr> <th rowspan="2">Element</th><th colspan="2">% of Weight of</th></tr> <tr> <th>Earth's crust</th><th>Human body</th></tr> </thead> <tbody> <tr> <td>Hydrogen (H)</td><td>0.14</td><td>0.5</td></tr> <tr> <td>Carbon (C)</td><td>0.03</td><td>18.5</td></tr> <tr> <td>Oxygen (O)</td><td>46.6</td><td>65.0</td></tr> <tr> <td>Nitrogen (N)</td><td>very little</td><td>3.3</td></tr> <tr> <td>Sulphur (S)</td><td>0.03</td><td>0.3</td></tr> <tr> <td>Sodium (Na)</td><td>2.8</td><td>0.2</td></tr> <tr> <td>Calcium (Ca)</td><td>3.6</td><td>1.5</td></tr> <tr> <td>Magnesium (Mg)</td><td>2.1</td><td>0.1</td></tr> <tr> <td>Silicon (Si)</td><td>27.7</td><td>negligible</td></tr> <tr> <td colspan="3"><i>Adapted from CNR Rao. Understanding Chemistry, Universities Press, Hyderabad.</i></td></tr> </tbody> </table> <p>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?</p>		Element	% of 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	<i>Adapted from CNR Rao. Understanding Chemistry, Universities Press, Hyderabad.</i>		
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Marking Rubric																																					
Correct answer	The cell membrane selectively allows certain molecules to enter human cells.	Student understands that in 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.
<b>Distractor 1</b>	Human beings get their carbon from the atmosphere.	Student misunderstands humans get carbon from the atmosphere.
<b>Distractor 2</b>	Mitochondria produce their own nitrogen as there is very little in the Earth's crust.	Student misunderstands the role of mitochondria.
<b>Distractor 3</b>	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	<p>The image shows two different structures of the same protein:</p>  <p>(a) Primary Polypeptide</p> <p>(b) Secondary Alpha-Helix Beta-pleated sheet</p> <p>(c) Tertiary Hydrogen Disulphide bond</p> <p>Given in the image are the primary, secondary and tertiary structures of proteins.</p> <p>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.</p>	
Marking Rubric		
Part	Description	Marks
Sample answer	Tertiary structure is three-dimensional folding 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 the	

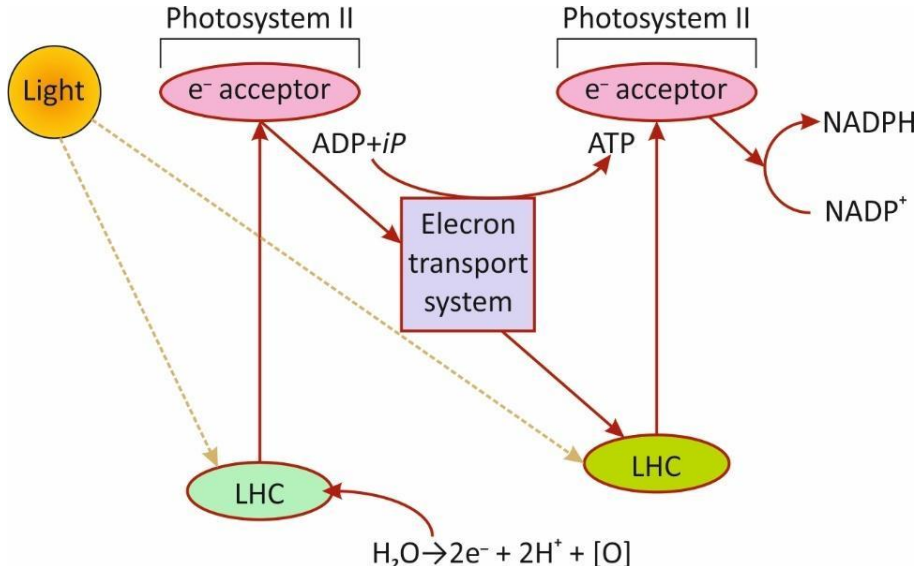
	primary structure of the protein.	
<b>Marking scheme</b>	Writes the presence of active sites in tertiary protein structure but not in primary structure	1
	Supports the answer with the difference in the structure of primary and secondary structures	1

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 what would happen if these molecules were 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 degrades 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 the 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 the 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 degrades centrioles that	

	form spindle fibres that move all chromosomes to lie at the equator during cell division.	
<b>Part A</b>	Predicts the effect of chemical A on mitosis	0.5
<b>Part A</b>	Describes the reason for the effect of chemical A	0.5
<b>Part B</b>	Predicts the effect of chemical B on mitosis	0.5
<b>Part B</b>	Describes the reason for the effect of chemical B	0.5
<b>Part C</b>	Predicts the effect of chemical C on mitosis	0.5
<b>Part C</b>	Describes the reason for the effect of chemical C	0.5

Chapter name	Cell Cycle and Cell Division	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	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?	
<b>Correct answer</b>	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.
<b>Distractor 1</b>	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.
<b>Distractor 2</b>	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.

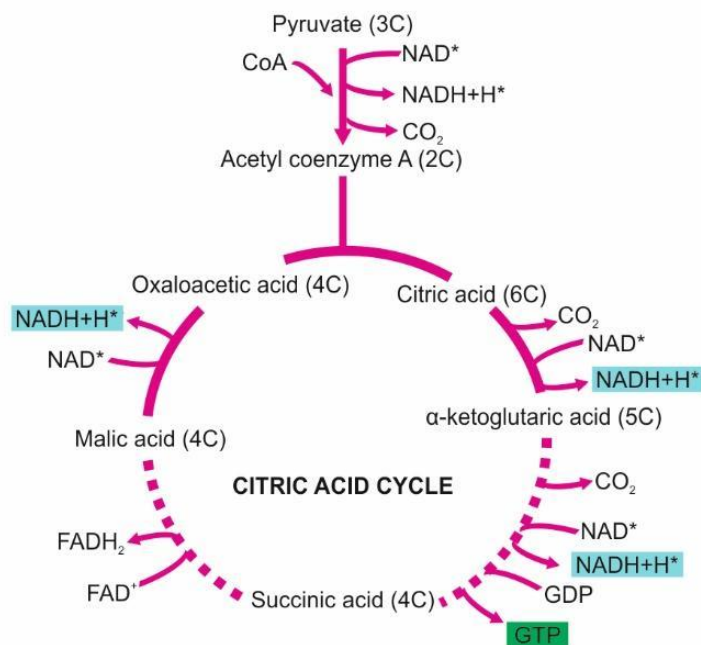
<b>Distractor 3</b>	240000 skin cells with 23 chromosomes each and 60000 gametes with 46 chromosomes each.	Student misunderstands that in mitosis four haploid cells are formed and in meiosis two diploid cells are produced.
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Chapter name	Photosynthesis 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	<p>Study the diagram shown in the Z scheme of light-dependent reaction.</p> <div><p>1. Based on the Z-scheme, list the products formed in a light-dependent reaction of photosynthesis.</p><p>2. How are the products formed in the above reactions used in the further reactions of photosynthesis?</p></div>
Marking Rubric	

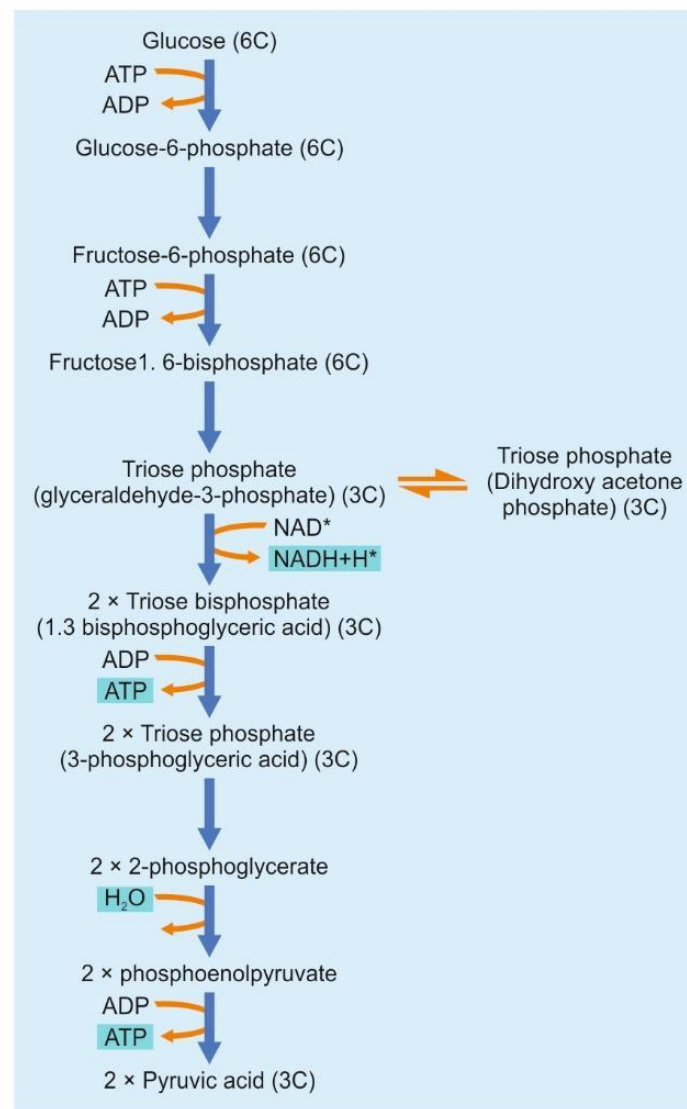
Part	Description	Marks
Sample answer	<p>A. The products formed in the light-dependent reaction of photosynthesis are ATP, NADPH, electrons, hydrogen ions (H<sup>+</sup>) and oxygen atoms.</p> <p>B. Production of hydrogen ions (H<sup>+</sup>) creates a proton gradient in the lumen, whose flow across the photosynthetic membrane provides ATP.</p> <p>The oxygen atoms combine to form molecular oxygen (O<sub>2</sub>), which is released into the atmosphere.</p>	
	<p>High-energy electrons, which are released as photosystem I absorbs light energy, are used to drive the synthesis of nicotinic adenine dinucleotide phosphate (NADPH).</p> <p>ATP and NADPH produced are used to make glucose using carbon dioxide in the Calvin cycle.</p>	
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 the Calvin Cycle of the light-independent reaction and electrons to produce NADPH.	1
	Describes how hydrogen is used to create proton gradient, and 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 <sub>4</sub> pathway that lacks photorespiration and has a tolerance to higher temperatures.
Item stem	<p>C<sub>3</sub> and C<sub>4</sub> are the two major CO<sub>2</sub> fixing pathways present in plants. Here are a few statements regarding the pathways:</p> <p>(1) These plants are most common in dry tropical climates.</p> <p>(2) The Calvin cycle in plants takes place in the mesophyll cells.</p> <p>(3) Plants have several layers of bundle sheath cells around the vascular bundles with many chloroplasts, thick walls</p>

	<p>impervious to gaseous exchange, and no intercellular spaces.</p> <p>(4) The primary CO<sub>2</sub> acceptor is phosphoenolpyruvate (PEP).</p> <p>Choose which of these is correctly assigned to the correct pathway for each statement.</p>	
<b>Correct answer</b>	(1)C <sub>4</sub> ; (2) C <sub>3</sub> ; (3) C <sub>4</sub> ; (4) C <sub>4</sub>	Student understands that in C <sub>4</sub> plants, the main photosynthetic function occurs in bundle sheath cells, and they lack photorespiration, which adapts them to high temperatures.
<b>Distractor 1</b>	(1)C <sub>3</sub> ; (2) C <sub>3</sub> ; (3) C <sub>4</sub> ; (4) C <sub>4</sub>	Student misunderstands that C <sub>3</sub> plants are adapted to higher temperatures.
<b>Distractor 2</b>	(1)C <sub>4</sub> ; (2) C <sub>3</sub> ; (3) C <sub>3</sub> ; (4) C <sub>4</sub>	Student misunderstands that C <sub>3</sub> plants have special Kranz anatomy.
<b>Distractor 3</b>	(1)C <sub>4</sub> ; (2) C <sub>4</sub> ; (3) C <sub>4</sub> ; (4) C <sub>3</sub>	Student misunderstands that in C <sub>4</sub> plants, the main photosynthetic function occurs in mesophyll cells.
<b>Chapter name</b>	Respiration in plants	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	Study the pathways of cellular respiration.	



**Pathway A**



**Pathway B**

Justify each of the statements made about these pathways with one reason.

- Pathway B is a common pathway between aerobic and anaerobic respiration.
- Pathway A in eukaryotes occurs in the matrix of mitochondria which leads to the generation of ATP.

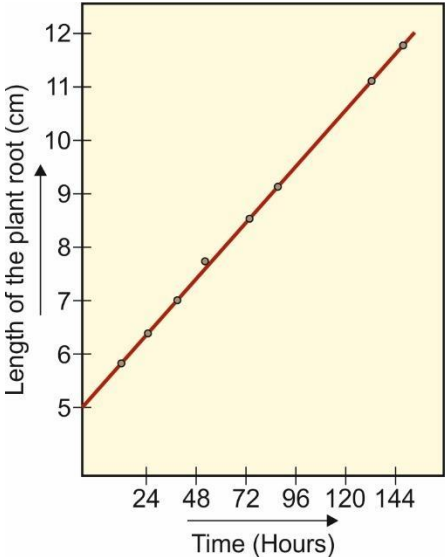
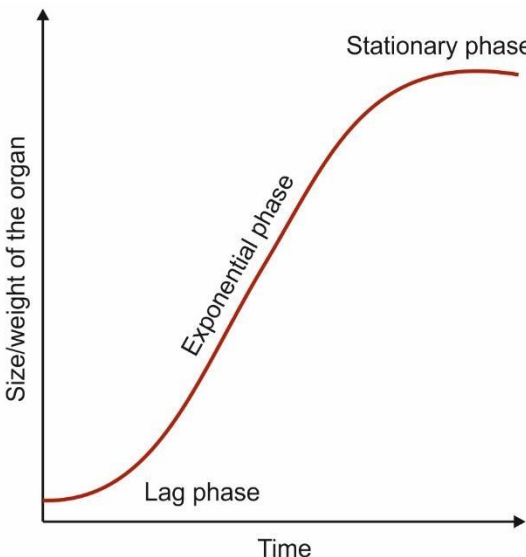
### Marking Rubric

Part	Description	Marks
<b>Sample answer</b>	<p>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.</p> <p>B. The reactions of the 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 mitochondria. 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.</p>	
<b>Part A</b>	Provides a relevant reason to support that glycolysis occurs in both aerobic and anaerobic respiration.	1
<b>Part B</b>	Provides a relevant reason to support how energy currencies generated in the TCA cycle are used to create proton gradient in mitochondria through ETS.	1

Chapter name	Respiration in plants	
<b>Essential Idea</b>	The cellular respiratory pathway is amphibolic in nature since it involves catabolic (breakdown) pathways of cellular respiration intersecting with anabolic (biosynthetic) pathways.	
<b>Item stem</b>	Choose the statement that supports that cellular respiration is an amphibolic process.	
<b>Correct answer</b>	Fatty acids are formed in the body by using acetyl CoA produced from the breakdown of glucose.	The student understands that anabolic reactions use energy to synthesise complex molecules (fatty acids) from simpler molecules (acetyl CoA) produced from catabolic glycolysis.
<b>Distractor 1</b>	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.



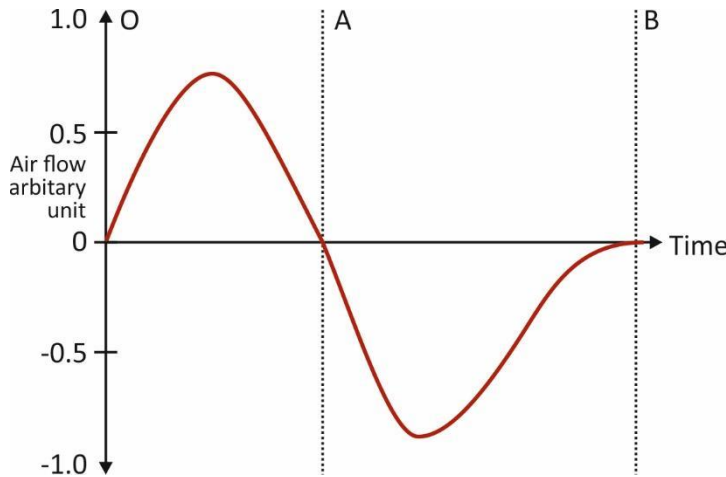
<b>Distractor 2</b>	One molecule of glucose undergoes glycolysis to produce two molecules of pyruvic acid.	Student misunderstands that the conversion of glucose to pyruvic acid is an anabolic reaction.
<b>Distractor 3</b>	Fats are hydrolysed into fatty acids and glycerol that subsequently yield acetyl CoA.	Student misunderstands that the conversion of fats to acetyl CoA is an anabolic reaction.

<b>Chapter name</b>	<b>Plant - Growth and Development</b>	
<b>Essential Idea</b>	Following cell division in root and shoot apical meristem cells, the growth could be arithmetic or geometrical.	
<b>Item stem</b>	<p>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.</p> <div style="display: flex; justify-content: space-around; align-items: flex-start;"> <div style="text-align: center;">  <p><b>Growth graph 1</b></p> </div> <div style="text-align: center;">  <p><b>Growth graph 2</b></p> </div> </div> <p>Based on the two graphs given above name two differences in the organs in which these types of growth may occur.</p>	

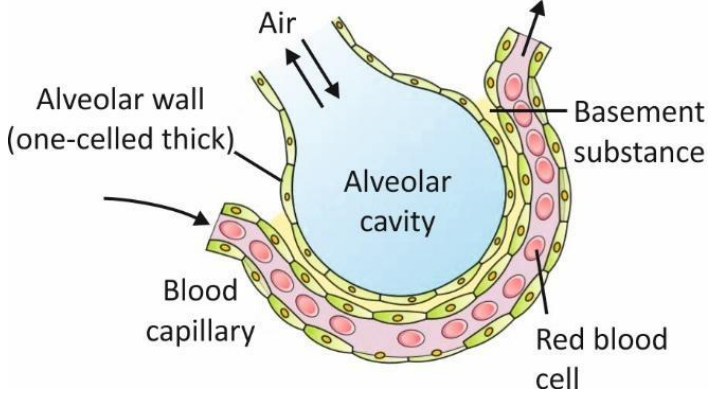
### Marking Rubric

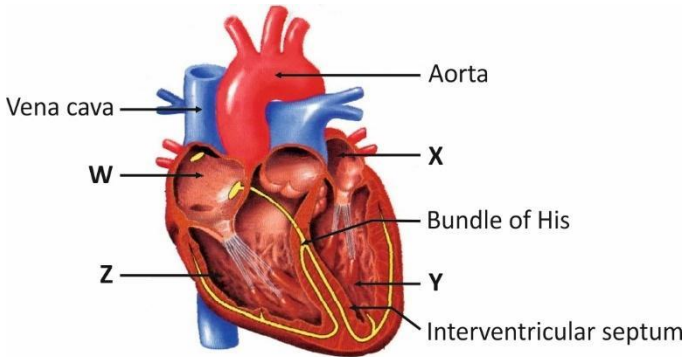
Part	Description	Marks
<b>Sample answer</b>	<p>A long, narrow organ like a root is likely to show growth as shown in Graph 1, while an organ like a leaf or stem is likely to show growth as shown in Graph 2.</p> <p><b>The probable differences:</b></p> <ol style="list-style-type: none"> <li>Graph 1 type growth happens in linear, narrow organs, while graph 2 type growth happens in creating two- or three-dimensional structures.</li> <li>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.</li> </ol>	
	Explains that functional and structural differences	2

Chapter name	Plant - Growth and Development	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	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?	
<b>Correct answer</b>	Cutting the growing root tips	Students understand that root tip produces cytokinin responsible for delaying senescence.
<b>Distractor 1</b>	Removing the flowers	Student misunderstands that the growth regulator released in flowers is responsible for delaying senescence.
<b>Distractor 2</b>	Cutting the young buds	Student misunderstands that the growth regulator released in young buds is responsible for delaying senescence.
<b>Distractor 3</b>	Cutting the mature fruits	Student misunderstands that the growth regulator released in mature fruits is 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	<p>The graph represents airflow in and out of the lungs during a normal breath.</p>  <p>A. Which parts of the graph represent inspiration and expiration?</p> <p>B. How does the relationship between the pressure in the lungs and the atmospheric pressure vary between phases OA and AB?</p> <p>C. How is the pressure gradient generated in different phases of breathing?</p>		
Marking Rubric			
Part	Description		Marks
Sample answer	<p>A. OA represents inspiration and AB represents expiration.</p> <p>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</p>		

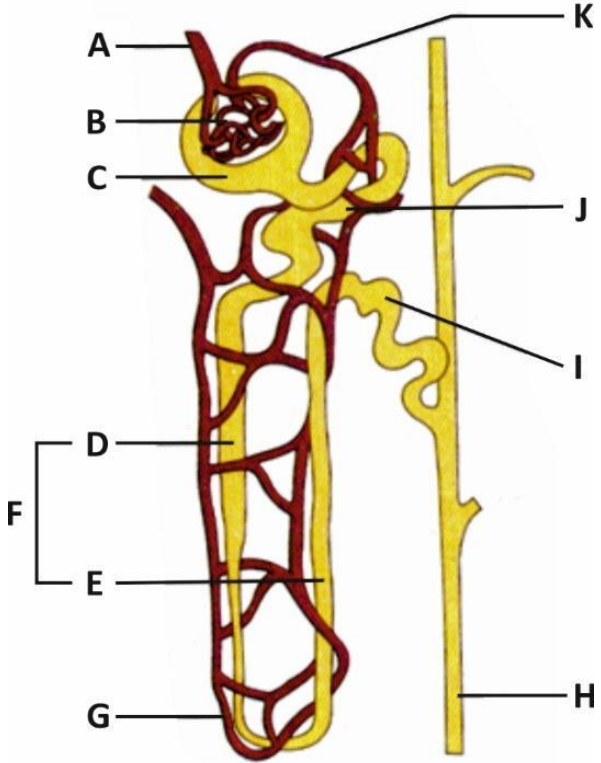
	<p>atmospheric pressure.</p> <p>C. During inspiration, the diaphragm and the external intercostal muscles contract, lifting the ribs and the sternum. This increases the volume of the thoracic chamber and, thereby, the pulmonary volume and leads to a decrease in intra-pulmonary pressure.</p> <p>During expiration, the diaphragm and the intercostal 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.</p>	
<b>Part A</b>	Identifies the phases of breathing in the graph (0.5 mark for each)	1
<b>Part B</b>	Explains the pressure gradient during expiration and inspiration	1
<b>Part C</b>	Explains how the diaphragm and the external intercostal muscles regulate inspiration	1
<b>Part C</b>	Explains how the 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 <sub>2</sub> (pO <sub>2</sub> ) and CO <sub>2</sub> (pCO <sub>2</sub> ), their solubility, and the thickness of the diffusion surface.	
Item stem	<p>The diagram below shows a structure involved in gas exchange.</p> 	
Correct answer	pO <sub>2</sub> in the alveolar cavity = 104 mmHg pO <sub>2</sub> in the 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 <sub>2</sub> in alveolar cavity = 104 mmHg pO <sub>2</sub> 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 <sub>2</sub> in alveolar cavity = 40 mmHg pCO <sub>2</sub> 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 <sub>2</sub> in alveolar cavity = 40 mmHg pCO <sub>2</sub> 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 regulated by neural and hormonal mechanisms.	
Item stem	<p>Look at the diagram:</p> <div></div> <p>1. Name the structures labelled W--Z.</p> <p>2. Explain the sequence of 3 events in a cardiac cycle of the heart.</p> <p>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?</p>	
Marking Rubric		
Part	Description	Marks
Sample answer	<p>A. W-Right Atrium X- Left Atrium Y- Left Ventricle Z- Right Ventricle</p> <p>A. Atrial and Ventricular diastole: chambers are relaxed and atria are filling in with blood</p> <p>a. Atrial systole: atria contract and remaining blood is pushed into ventricles</p> <p>b. Ventricular systole: ventricles contract and push blood out through the aorta and pulmonary artery</p> <p>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.</p>	

<b>Part A</b>	Identifies each label correctly (0.5 mark for each)	2
<b>Part B</b>	Names each of the 3 events of the cardiac cycle correctly (0.5 mark for each)	1.5
<b>Part B</b>	Explains each of the 3 events of the cardiac cycle correctly (0.5 mark for each)	1.5
<b>Part C</b>	Predicts a logical effect due to hole on the wall	1

Chapter name	Body Fluids and Circulation	
<b>Essential Idea</b>	The normal activities of the heart are regulated autonomously by specialised muscles called nodal tissues- sinoatrial node (SA node) and atrioventricular node (AV node).	
<b>Item stem</b>	Choose the correct route through which action potential passes in the heart for the contraction of the heart muscle.	
<b>Correct answer</b>	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 the heart muscles.
<b>Distractor 1</b>	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.
<b>Distractor 2</b>	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.
<b>Distractor 3</b>	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 <sup>+</sup> and toxins into the filtrate.
Item stem	<p>Study the diagram and answer the questions:</p>  <p>A. Explain how an increase in blood pressure in area (B) would affect the functioning of the nephron.</p> <p>B. Explain why proteins and blood cells are found in area (B) but not in area (J).</p> <p>C. Write the steps of urine formation in the nephron. Write in 7 steps.</p>

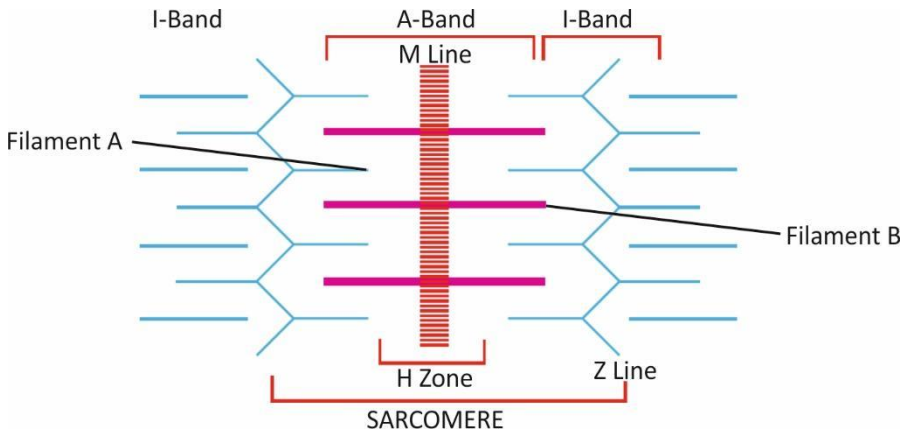


### Marking Rubric

Part	Description	Marks
<b>Sample answer</b>	<p>A. Area (B) is the glomerular capillary. The increase in blood pressure caused 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.</p> <p>B. Blood is filtered so finely when passing through the 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, the glomerular capillary (Area B) has protein and blood cells, but PCT (Area J) doesn't.</p> <p>C.</p> <ol style="list-style-type: none"> <li>1. Blood moves through the afferent arteriole into the glomerulus.</li> <li>2. Molecules except plasma protein and blood cells don't enter the nephron.-</li> <li>3. In PCT, Na<sup>+</sup> is actively transported out of the nephron, followed by Cl<sup>-</sup> and HCO<sub>3</sub>, and water moves from the nephron.</li> <li>4. Water moves out of the filtrate by osmosis, concentrating salt in the filtrate.</li> <li>5. Salt diffuses out from the filtrate into the interstitial fluid.</li> <li>6. Nitrogen-containing wastes, excess H<sup>+</sup> ions, and minerals such as K<sup>+</sup> ions are secreted into the filtrate in DCT.</li> <li>7. Water, salt, and minerals in the collecting duct.</li> </ol>	
<b>Part A</b>	Explains the effect of an increase in blood pressure caused by glomerular capillary	1
<b>Part B</b>	Provides a relevant justification of how protein is filtered in glomerular capillary	0.5
<b>Part C</b>	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.		
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.
<b>Distractor 3</b>	<b>D</b>	Student understands that the main excretory product of reptiles is ammonia. For adult amphibians, it is uric acid.

<b>Chapter name</b>	<b>Locomotion and Movement</b>
<b>Essential Idea</b>	In humans, locomotion and many other movements are facilitated by the coordinated excitability and contractility of the muscle tissues.
<b>Item stem</b>	<p>Look at the diagram of the sarcomere of a muscle and answer the questions:</p>  <p>The diagram illustrates a sarcomere, the basic contractile unit of muscle. It shows thick filaments (red) and thin filaments (blue). The thick filaments are labeled 'Filament A' and 'Filament B'. The thin filaments are labeled 'Filament B'. The sarcomere is bounded by two vertical lines labeled 'Z Line'. The central region is labeled 'H Zone'. The top and bottom regions are labeled 'I-Band'. The middle region is labeled 'A-Band'. The center is labeled 'M Line'. The entire unit is labeled 'SARCOMERE'.</p> <p>A. Identify filaments A and B.</p> <p>B. What happens to each type of filament during contraction?</p> <p>C. Which of these substances would make the best muscle relaxant, and why? Chemical A: Blocks acetylcholine receptors on muscle cells.</p> <p>Chemical B: Floods the cytoplasm of muscle cells with calcium ions</p>
<b>Marking Rubric</b>	

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 $\text{Ca}^{2+}$ 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.


<b>Distractor 2</b>	Pectoral girdle, skull, hind limbs, forelimbs	Student misunderstands that girdles and limbs are parts of the axial skeleton.
<b>Distractor 3</b>	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 backwards?		
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 it possesses 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.		

	<ol style="list-style-type: none"> <li>2. A rapid inflow of sodium ions happens.</li> <li>3. The membrane of the nerve end depolarises as it becomes a positive charge inside and a negative charge outside the nerve fibre.</li> <li>4. At the peak action potential, permeability to sodium ions decreases and that to potassium ions increases.</li> <li>5. A rapid outflow of potassium ions happens.</li> <li>6. The first part of the membrane repolarises</li> <li>7. The depolarization spreads down the axon as opened Na<sup>+</sup> gates stimulate neighbouring Na<sup>+</sup> gates to open.</li> </ol> <p>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.</p>	
<b>Part A</b>	Explains what exactly "generation of action potential" means, such as	0.5
<b>Part B</b>	Writes the nerve signal transmission in 8 steps (0.5 marks for each)	3.5
<b>Part C</b>	Provides a correct reason why nerve signal cannot travel backwards	1

Chapter name	Neural Control and Coordination	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	<p>Ram is thrilled today as he learned and understood a chapter in biology that he thought was difficult. Now, he is motivated and aspires to study like this to become a life scientist.</p> <p>Which part of his brain is responsible for these responses?</p>	
<b>Correct answer</b>	Limbic system of forebrain	Student understands that limbic system of fore brain is involved in emotional and motivational response

<b>Distractor 1</b>	Midbrain	Student misunderstands that midbrain is involved in emotional and motivational response
<b>Distractor 2</b>	Medulla of hindbrain	Student misunderstands that hind brain is involved in emotional and motivational response
<b>Distractor 3</b>	Spinal cord	Student misunderstands that spinal cord is involved emotional and motivational response

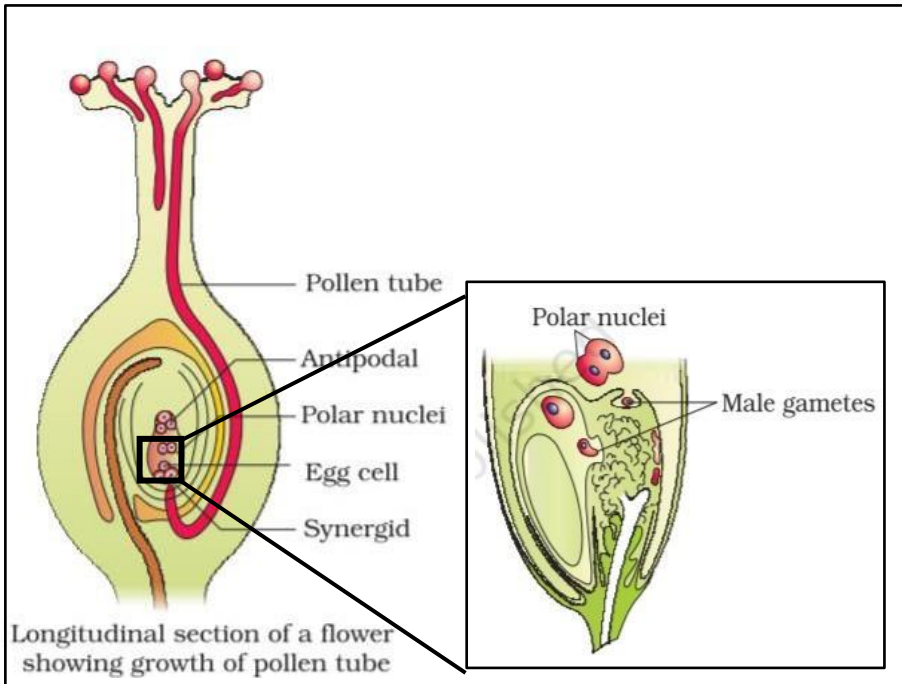
<b>Chapter name</b>	<b>Chemical Coordination and Integration</b>
<b>Essential Idea</b>	In humans, the hypothalamus exerts master control by sending signals directly to the pituitary gland, which in turn secretes hormones that influence numerous body functions.
<b>Item stem</b>	<p>Look at the flow chart showing some hormones and their target organs.</p>  <pre> graph LR     Hypo[Hypothalamus] -- TRH --&gt; Pit[Pituitary]     Pit -- CRH --&gt; TSH[TSH]     Pit -- CRH --&gt; ACTH[ACTH]     TSH --&gt; Thyroid[Thyroid]     ACTH --&gt; Adrenal[Adrenal cortex] </pre> <p>A. Name one hormone secreted by the thyroid and adrenal cortex and their function.</p> <p>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?</p> <p>C. Growth hormone is secreted by the anterior pituitary gland.</p> <p>A dwarfism disease called Laron dwarfism does not respond to growth hormone treatments (growth hormone injected into the body externally).</p>

	What could be a possible reason for this type of dwarfism?	
Marking Rubric		
Part	Description	Marks
Sample answer	<p>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.</p> <p>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.</p> <p>C. There can be a deficiency in growth hormone receptors. So, even when the growth hormone is supplied externally, no action can be observed.</p>	
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

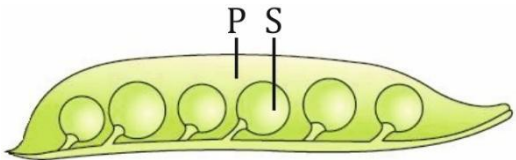


Chapter name	Chemical Coordination and Integration	
Essential Idea	Hormones affect cells using two distinct mechanisms – water-soluble hormones bind to plasma membrane receptors and steroid hormones bind to intracellular receptors.	
Item stem	Hormone X is a newly discovered hormone that regulates protein metabolism. Scientists found 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.	Students 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.

## CLASS 12 – ASSESSMENT BASED ON ESSENTIAL IDEAS

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	<p>Look at the image inset showing the discharge of male gametes in the embryo sac.</p> <div><p>Longitudinal section of a flower showing growth of pollen tube</p></div> <p>Based on the diagram, explain how sexual reproduction in flowering plants involves double fertilisation and triple fusion.</p>		
Marking Rubric			
Part	Description	Marks	
Sample	The pollen tube releases the two male gametes into the cytoplasm of the synergid. One of the male gametes		

<b>answer</b>	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	
<b>Essential Idea</b>	After fertilisation, the ovary develops into a 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.	
<b>Item stem</b>	<p>Look at the image of a fruit –pea—showing seeds (S) and pericarp (P).</p>  <p>Which of these correctly shows the structure that each part of the pea had before fertilisation?</p>	
<b>Correct answer</b>	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	
<b>Distractor 1</b>	S: Ovary	Student misunderstands that after fertilisation, the ovary develops into a seed.

	P: Ovary wall Fruit: Ovule	
<b>Distractor 2</b>	S: Ovule P: Zygote Fruit: Ovary	Student misunderstands that after fertilisation, the zygote develops into a pericarp.
<b>Distractor 3</b>	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	<p>Look at the image showing the process of gametogenesis in both males and females.</p> <div><div><p>Spermatogonia</p><p>At Puberty</p><p>Primary spermatocytes</p><p>Secondary spermatocytes</p><p>Spermatids</p><p>Spermatozoa</p><p><b>Spermatogenesis</b></p></div><div><p>Chromosome Number Per Cell</p><p>46</p><p>23</p><p>23</p></div><div><p>Fetal life</p><p>Birth</p><p>Childhood</p><p>Puberty</p><p>Adult reproductive life</p><p>Oogonia</p><p>Primary oocyte</p><p>Secondary oocyte</p><p>Ovum</p><p>First polar body</p><p>Second polar body</p><p><b>Oogenesis</b></p></div></div>		
	<p>A. What types of division happen when spermatogonia produce primary spermatocytes and oogonia produce primary oocytes? When in the lifetime of a male and female does this division happen?</p> <p>B. When and what cells undergo the first and second meiotic division in spermatogenesis and oogenesis?</p>		
Marking Rubric			
Part	Description	Marks	

<b>Sample answer</b>	<p>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.</p> <p>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.</p> <p>In oogenesis, the first meiotic division occurs in primary oocytes starting at childbirth to produce secondary oocytes at puberty, and the second meiotic division occurs in secondary oocytes to produce an ovum just before fertilisation.</p>	
<b>Part A</b>	Mentions the type of division in males and its time of occurrence (0.5 marks for each)	1
<b>Part A</b>	Mentions the type of division in females and its time of occurrence (0.5 marks for each)	1
<b>Part B</b>	Defines the stages and cells that undergo meiotic divisions in spermatogenesis (0.5 marks for each)	1
<b>Part B</b>	Defines the stages and cells that undergo meiotic divisions in oogenesis (0.5 marks for each)	1

Chapter name	Human Reproduction	
<b>Essential Idea</b>	The human reproductive cycle and events that occur after puberty are regulated by the secretion of different reproductive hormones.	
<b>Item stem</b>	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?	
<b>Correct answer</b>	End of the follicular phase	Student understands that LH and FSH peaks happen during ovulation at the end of the follicular phase.

<b>Distractor 1</b>	Luteal phase	Student does not know that the level of progesterone remains considerably high in the luteal phase.
<b>Distractor 2</b>	Start of the menstruation phase	Student does not know that the level of oestrogen remains considerably low in the menstruation phase.
<b>Distractor 3</b>	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, and 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 or 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 the fertilising capacity of sperm.	
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 a valid reason for each answer (0.5 marks for each)	1.5 marks



Chapter name	Reproductive Health	
Essential Idea	Reproductive health refers to total well-being in all aspects of reproduction, i.e., physical, emotional, behavioural and social.	
Item stem	Which of 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 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	<p>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.</p> <p>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.</p> <p>In rose plants, when F1 is self-crossed, the ratio of F2 phenotypes was 1 red tall: 2 pink tall: 1 white short.</p>	

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?

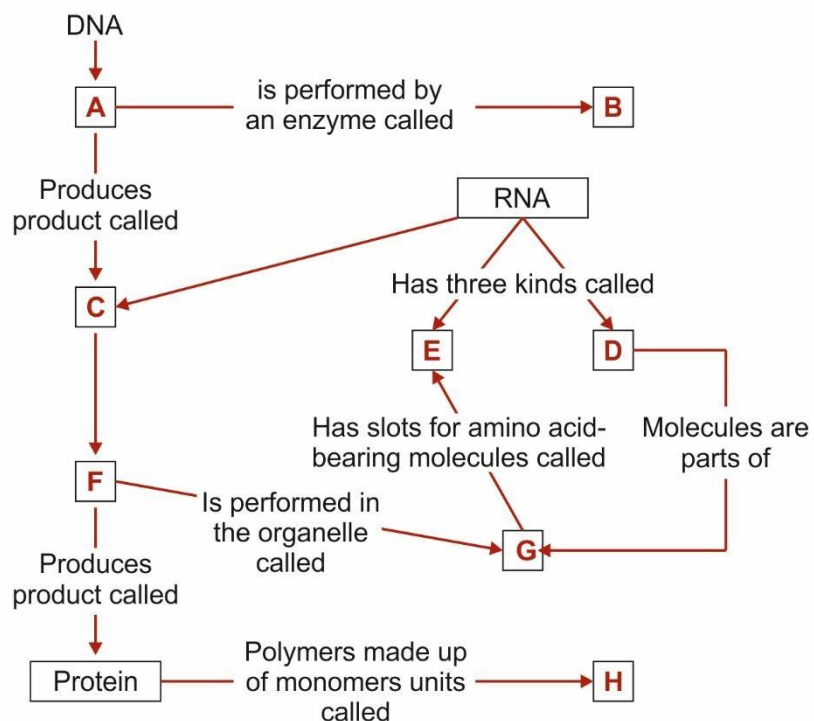
### Marking Rubric

Part	Description	Marks																									
Sample answer	<p>In snapdragon plants, the flower colour gene and plant height gene are unlinked and assort independently.</p> <p>Dihybrid cross of snapdragon plants:</p> <p>Parents</p> <div><div>RRTT</div><div>rrtt</div><div></div></div> <p>F1 generation</p> <p>RrTt (Pink and tall)</p> <p>F2 generation</p> <table><tr><td>Gametes</td><td>RT</td><td>Rt</td><td>rT</td><td>rt</td></tr><tr><td>RT</td><td>RRTT Red and tall</td><td>RRTt Red and tall</td><td>RrTT Pink and tall</td><td>RrTt Pink and tall</td></tr><tr><td>Rt</td><td>RRTt Red and tall</td><td>RRtt Red and short</td><td>RrTt Pink and tall</td><td>Rrtt Pink and short</td></tr><tr><td>rT</td><td>RrTT Pink and tall</td><td>RrTt Pink and tall</td><td>rrTT White and tall</td><td>rrTt White and tall</td></tr><tr><td>rt</td><td>RrTt Pink and tall</td><td>Rrtt Pink and short</td><td>rrTt White and tall</td><td>rrtt White and short</td></tr></table>	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 Pink and tall	Rrtt Pink and short	rrTt White and tall	rrtt White and short	
	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 Pink and tall	Rrtt Pink and short	rrTt White and tall	rrtt White and short																							
	<p>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.</p> <p>Dihybrid cross of the rose plants:</p>																										

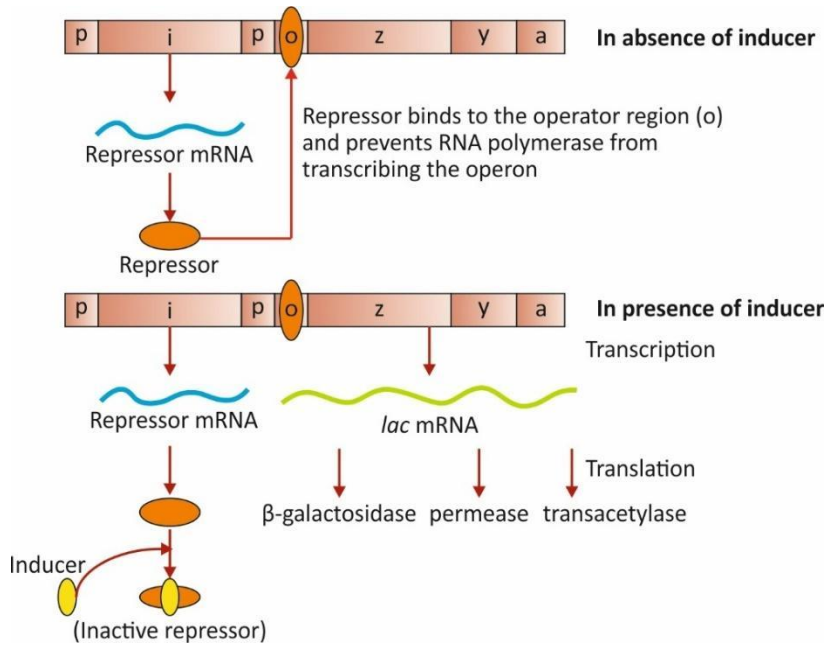
	<div>Parents</div> <div><div>RRTT</div><div>rrtt</div><div></div></div> <div>F1 generation</div> <div>RrTt (Pink and tall)</div> <div>Complete linkage ↓</div> <div>F2 generation</div> <table><tr><td>Gametes</td><td>RT</td><td>Rt</td></tr><tr><td>RT</td><td>RRTT</td><td>RrTt</td></tr><tr><td>rt</td><td>Red and tall</td><td>Pink and tall</td></tr><tr><td></td><td>RrTt</td><td>Rrtt</td></tr><tr><td></td><td>Pink and tall</td><td>Pink and short</td></tr></table> <div>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.</div>	Gametes	RT	Rt	RT	RRTT	RrTt	rt	Red and tall	Pink and tall		RrTt	Rrtt		Pink and tall	Pink and short	
Gametes	RT	Rt															
RT	RRTT	RrTt															
rt	Red and tall	Pink and tall															
	RrTt	Rrtt															
	Pink and tall	Pink and short															
	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 an X-linked recessive disease. Tina and her friend Ketan are suffering from colour blindness. Which of these would be 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 for a woman to be colour-blind, the X chromosome passed on by the father (who has just one X chromosome) must have the colour-blindness trait

<b>Distractor 1</b>	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 the father (who passes the Y chromosome to the son).
<b>Distractor 2</b>	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 the father (who passes the Y chromosome to the son).
<b>Distractor 3</b>	Tina's mother must be colour-blind and her father must be normal, but Ketan's mother is either a carrier or colour-blind.	Student misunderstands that for a female (XX) to be colour-blind, she must inherit X chromosomes bearing the colour-blindness allele from both parents
<b>Chapter name</b>	Molecular Basis of Inheritance	
<b>Essential Idea</b>	In all organisms, DNA stores genetic information and the flow of genetic information occurs from DNA to RNA to protein.	
<b>Item stem</b>	Complete the flow chart of the movement of genetic information in a cell. The unknowns contain molecules and names of processes.	



<b>Correct answer</b>	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
<b>Distractor 1</b>	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
<b>Distractor 2</b>	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
<b>Distractor 3</b>	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	<p>Look at the lac operon in a bacterium.</p> <div></div> <p>Predict how these mutations would affect the function of the operon in the presence and absence of lactose(inducer):</p> <p>A. Mutation of the regulatory gene (i); mutated repressor won't bind to lactose but will bind to the operator.</p> <p>B. Mutation of the operator (o); repressor will not bind to the operator.</p> <p>C. Mutation of the promoter (p); RNA polymerase will not attach to the promoter.</p>		
Marking Rubric			
Part	Description	Marks	

<b>Sample answer</b>	<p>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.</p> <p>B. The lac genes would continue to be transcribed and the enzymes made, whether or not lactose was present.</p> <p>C. RNA polymerase would not be able to transcribe the genes and no proteins would be made, whether or not lactose was present.</p>	
	Predicts what happens to the functioning of the 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	<p>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.</p> <p>In one area, a group of scientists counted both live snails and broken shells.</p> <table border="1"> <thead> <tr> <th></th><th>Rough-shelled</th><th>Smooth-shelled</th><th>Total</th></tr> </thead> <tbody> <tr> <td><b>Living</b></td><td>264</td><td>296</td><td>560</td></tr> <tr> <td><b>Broken</b></td><td>486</td><td>377</td><td>863</td></tr> </tbody> </table> <p>A. Which snail form seems better adapted to this environment? Why?</p> <p>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.</p>				Rough-shelled	Smooth-shelled	Total	<b>Living</b>	264	296	560	<b>Broken</b>	486	377	863
	Rough-shelled	Smooth-shelled	Total												
<b>Living</b>	264	296	560												
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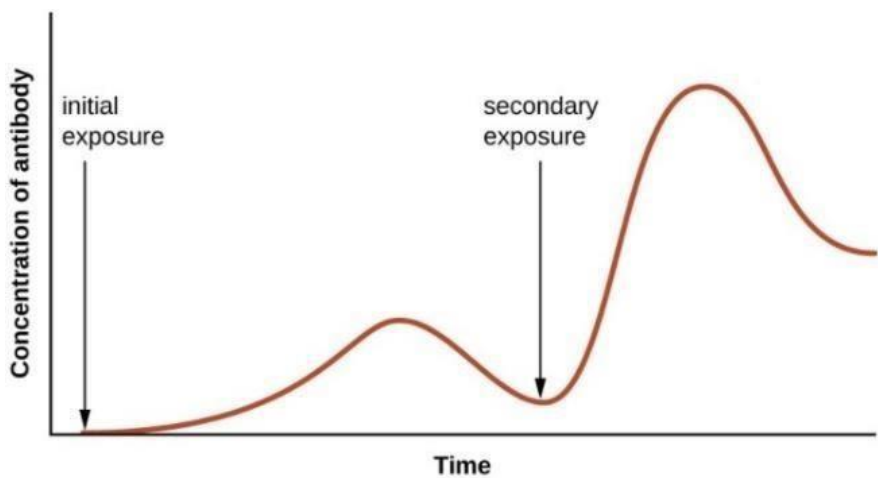
### Marking Rubric

Part	Description	Marks
<b>Sample answer</b>	<p>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.</p> <p>B. The bird predation would reduce the frequency of rough-shelled snails and the frequency of unstriped individuals would increase. It shows directional selection.</p>	
<b>Part A</b>	Mentions smooth-shelled snails to be better adapted	0.5
<b>Part A</b>	Provides appropriate reason for the choice using given data	0.5
<b>Part B</b>	Predicts correctly how the frequency of the population would change and names the type of natural selection	1

Chapter name	Evolution	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	<p>For coat colour of mice, black (Bb) appears dominant to albino (bb).</p> <p>In an experiment, a large population of laboratory mice are randomly mated. It contains 36% albino mice.</p> <p>Since this population has no mutation, gene flow, or natural selection, what is the frequency of heterozygous alleles (Aa) in this population?</p>	
<b>Correct answer</b>	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 ( $2Aa = 2 \times 0.4 \times 0.6 = 0.48$ ).



<b>Distractor 1</b>	0.40	Student misunderstands that the frequency of heterozygous alleles is the same as the frequency of dominant allele
<b>Distractor 2</b>	0.60	Student misunderstands that frequency of heterozygous alleles is same as the frequency of recessive allele
<b>Distractor 3</b>	0.24	Student misunderstands that frequency of heterozygous alleles is same as the frequency of Aa instead of 2Aa

<b>Chapter name</b>	<b>Human Health and Diseases</b>
<b>Essential Idea</b>	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.
<b>Item stem</b>	<p>The graph given below shows the levels of antibodies against a pathogen in a person's body.</p>  <p>A. What do the two peaks mean? Why are they different in size?</p>

	B. It was observed that if a person had previously contracted cowpox, 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 smallpox.  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 terms of immunity.	0.5
Part A	Explains the reason for the difference in the levels of antibodies generated in primary and secondary responses.	0.5
Part B	Provides the reason for active immunity against smallpox when infected with cowpox.	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 the skin, malaria and many others are 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 signs of typhoid.
Distractor 1	ELISA for HIV	Students misunderstands that the symptoms are the signs of HIV.
Distractor 2	Complete blood count (CBC) test	Student misunderstands that the symptoms are signs of malaria.
Distractor 3	RT-PCR test	Student misunderstands that the symptoms are signs 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 an 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 the 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

<b>Part 1</b>	Explains what result shows that fungus B is inhibiting the growth of bacteria A	0.5
<b>Part 2</b>	Infers the logical use of fungus B for human health	1
<b>Part 3</b>	Gives a correct example of a fungus product used as antibiotics	1

Chapter name	Microbes in Human Welfare	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	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, and 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?	
<b>Correct answer</b>	Using cyanobacteria and blue-green algae containing biofertilizer	Student understands the importance of biofertilizers
<b>Distractor 1</b>	Using the method of drip irrigation	Student misunderstands that drip irrigation can replenish soil nutrients.
<b>Distractor 2</b>	Use of Baculoviruses, Trichoderma, Ladybird as biofertilizer.	Student misunderstands biofertilizers with biocontrol agents such as Baculoviruses, Trichoderma, and Ladybird.
<b>Distractor 3</b>	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– CaCl2 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 can be used to make the 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 the ability to take up foreign (extracellular), hydrophilic DNA from its surrounding environment through a hydrophobic cell membrane. b. Sample A – gene gun (plant cells) Sample B – CaCl2 treatment (bacterial cells) Sample C - micro-injection (animal cells)	

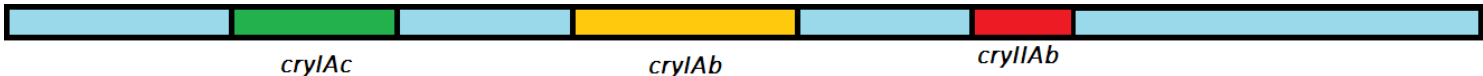
	<p>c. Gene gun - Cells are bombarded with high-velocity micro-particles of gold or tungsten coated with DNA</p> <p>CaCl<sub>2</sub> treatment – Bacterial cells are treated with divalent cation (calcium) and exposed to cold and high temperature alternatively.</p> <p>Micro-injection - recombinant DNA is directly injected into the nucleus of an animal cell</p>	
<b>Part a</b>	Describes the meaning of a competent cell	1
<b>Part b</b>	Identifies the correct method for plant, animal and bacterial cell samples. (0.5 mark for each)	1.5
<b>Part c</b>	Describes the process of three methods correctly (0.5 mark for each)	1.5

Chapter name	Biotechnology - Principles and Processes	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	<p>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.</p> <p>Select the correct arrangement of these processes in the sequence they should be used to create HGH-producing E.coli.</p> <ol style="list-style-type: none"> <li>Isolate plasmids from a culture of E. coli.</li> <li>Bacteria will then replicate plasmids and multiply, producing clones of bacterial cells.</li> <li>Allow E. coli to take up recombinant plasmids.</li> <li>Join the plasmids and the fragments of human DNA with ligase.</li> <li>Identify transformants carrying and expressing the HGH gene using a nucleic acid probe.</li> <li>Cut the plasmids and the human DNA containing the HGH gene with the restriction enzyme to produce molecules with</li> </ol>	

	sticky ends. g) Grow large amounts of the bacteria and extract and purify HGH from the culture.	
<b>Correct answer</b>	(a), (f), (d), (c), (b), (e), (g)	Student understands the step-by-step method of recombinant DNA technology
<b>Distractor 1</b>	(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
<b>Distractor 2</b>	(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
<b>Distractor 3</b>	(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

<b>Chapter name</b>	<b>Biotechnology and its Application</b>
<b>Essential Idea</b>	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.



<p><b>Item stem</b></p>	<p>Some strains of <i>Bacillus thuringiensis</i> produce a protein called Bt toxin coded by cry genes in their growth phase. It can kill certain insects but not bacteria.</p> <p>Why does Bt toxin kill insects but not <i>Bacillus</i>?</p> <p>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.</p> <p>Look at the different cry genes in the DNA of a strain of <i>Bacillus</i>.</p>  <p>Which cry gene should be isolated and incorporated into cotton crop A and maize crop B to control its pest?</p>
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### Marking Rubric

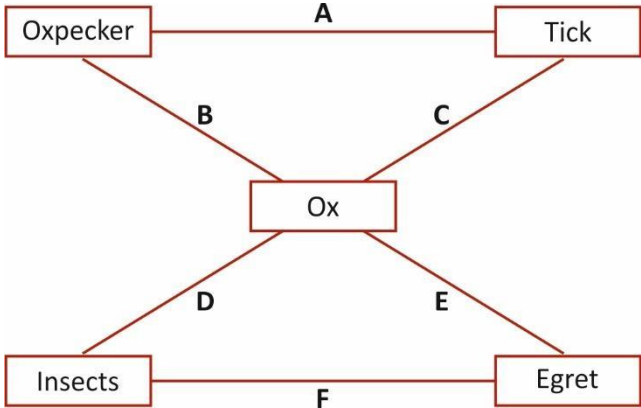
Part	Description	Marks
<p><b>Sample answer</b></p>	<p>A. Bt toxin protein cannot harm <i>Bacillus</i> since when it is present in the bacteria, it exists in the form of crystalline inactive protoxins.</p> <p>In insects, Bt toxin is converted into an active form of toxin due to the alkaline pH of the insect gut which binds to the surface of midgut epithelial cells and creates pores that cause cell swelling and lysis and eventually cause death of the insect.</p> <p>B. The specific Bt toxin genes are isolated from <i>Bacillus thuringiensis</i> and incorporated into several crop plants to produce a transgenic plant that contains Bt toxin and can kill pest insects.</p> <p>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.</p>	

<b>Part A</b>	Explains inactiveness of Bt toxin in Bacteria	0.5
<b>Part A</b>	Explains how Bt toxin harm insects when ingested	1
<b>Part B</b>	Explains how Bt toxin gene in plants can act as pest control	1.5
<b>Part C</b>	Identifies correct cry gene to be incorporated based on plants and pests	1

Chapter name	Biotechnology and its Application	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	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?	
<b>Correct answer</b>	Increased in the cost in biotechnological research.	Student understands the ethical issues concerning RDT and that the cost of the research won't fall into ethical issues.
<b>Distractor 1</b>	Public access to information about the biology of the process to make informed decisions.	Student does not understand that the public point of view is also relevant to ethical issues regarding RDT.
<b>Distractor 2</b>	Anticipate and deal with possible unforeseen and negative consequences.	Student does not understand the ethical issues concerning RDT.
<b>Distractor 3</b>	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	<p>In a genetics study, a specific gene related to the wing shape of fruit fly <i>Drosophila</i> was mutated. Post 1 day of mutagenesis the alive flies (F0 generation) were used for breeding to produce offspring (F1 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.</p> <p>Mutant = Flies that undergo mutation</p> <p>Control population= Flies that do not undergo mutation</p> <p>Consider all mutant <i>drosophila</i> are completely mutated. The following observations were noted.</p> <table border="1"> <thead> <tr> <th rowspan="2"></th><th rowspan="2">Number of flies taken in group</th><th rowspan="2">No. of flies alive 1 day after mutagenesis</th><th colspan="5">No. of offspring in the F1 generation</th><th rowspan="2">No. of offspring that reach adulthood in 5 days</th></tr> <tr> <th>Day 1</th><th>Day 2</th><th>Day 3</th><th>Day 4</th><th>Day 5</th></tr> </thead> <tbody> <tr> <td>Mutant</td><td>5000</td><td>4000</td><td>100</td><td>300</td><td>250</td><td>250</td><td>100</td><td>100</td></tr> <tr> <td>Control</td><td>5000</td><td>4500</td><td>700</td><td>500</td><td>400</td><td>600</td><td>800</td><td>2500</td></tr> </tbody> </table> <p>Answer the following questions using the data given above</p> <p>A. Post 1 day of mutagenesis, what was the death rate in the initial F0 population for both mutant and control groups.</p> <p>B. Calculate the birth rate and death rate for the offspring F1 generation belonging to both mutant and control parents.</p> <p>C. Does the mutation experiment affect the survival of the F0 and F1 generation flies? Give a reason for your argument.</p>									Number of flies taken in group	No. of flies alive 1 day after mutagenesis	No. of offspring in the F1 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
	Number of flies taken in group	No. of flies alive 1 day after mutagenesis	No. of offspring in the F1 generation					No. of offspring that reach adulthood in 5 days																																
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Control	5000	4500	700	500	400	600	800	2500																																
Marking Rubric																																								
Part	Description							Marks																																

<b>Sample answer</b>	<p>Death rate for the mutant group: <math>(5000-4000)/5000 = 0.2</math> individual per fruit fly per day  Death rate for the control group: 0.1 individual per fruit fly per day.</p> <p>Birth rate for Mutant F1 generation: <math>(1000-100)/1000 = 0.9</math> individual per fruit fly per 5 days  Birth rate for control F1 generation: <math>(3000-2500)/3000 = 0.167</math> individual per fruit fly per 5 days</p> <p>Yes. The birth rate for the mutant group is lower than that of the control group showing that mutation affects the survival of the population.</p>	
<b>Part A</b>	Calculates for death rate for the mutant and control group using the correct formula	1
<b>Part B</b>	Calculates for death rate for the mutant and control group using the correct formula	1
<b>Part C</b>	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	<p>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. An Oxpecker (a bird) feeds on the ticks from the skin of the ox, relieving them from the parasites.</p>  <p>Describe the relationships labelled by the alphabet.</p>	
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 benefits 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	<p>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.</p> <p>Gross Primary Productivity (GPP) = 5000 g/m<sup>2</sup>/year Net Primary Productivity (NPP) = 2200 g/m<sup>2</sup>/year</p> <p>A. Using the above data calculate the amount of GPP utilised by plants in respiration.</p> <p>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.</p> <p>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?</p>	
Marking Rubric		
Part	Description	Marks
Sample answer	<p>A. <math>GPP - R = NPP</math></p> <p><math>R = GPP - NPP = 5000 - 2200 = 2800 \text{ g/m}^2/\text{year}</math></p> <p>Respirational loss is 2800 g/m<sup>2</sup>/year</p> <p>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 rainforest.</p> <p>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)</p>	
Part A	Gives the correct formula for the relationship between GPP, NPP and Respirational losses.	0.5

<b>Part A</b>	Calculates respirational losses with proper units.	1
<b>Part B</b>	States that GPP of the desert will be less than that of the rainforest	0.5
<b>Part B</b>	Gives appropriate justification involving biomass production	1
<b>Part C</b>	Calculates energy available for the deer and wolves using 10% rule (1 mark each)	2

Chapter name	Ecosystem	
<b>Essential Idea</b>	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.	
<b>Item stem</b>	<p>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%</p> <p>Soil B: Lignin = 5%; Sugar = 35%; Chitin = 15%; Nitrogen = 45%</p> <p>Which of these is true about their rate of decomposition in both the soil?</p>	
<b>Correct answer</b>	Soil A has a slower rate of decomposition than soil B	Student understands decomposition rate is slower if soil detritus is rich in lignin and chitin but low in nitrogen and water-soluble substances like sugars.
<b>Distractor 1</b>	Soil A has a faster rate of decomposition than soil B	Student misunderstands that the decomposition rate is faster if soil detritus is rich in lignin and chitin but low in nitrogen and water-soluble substances like sugars.
<b>Distractor 2</b>	Both have the same rate of decomposition	Student misunderstands that lignin, chitin, sugar and nitrogen do not tell us about the rate of decomposition.

<b>Distractor 3</b>	Insufficient information	Student misunderstands that lignin, chitin, sugar and nitrogen do not tell us about the rate of decomposition.
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Chapter name	Biodiversity and Conservation	
Essential Idea	Biodiversity exists at all levels of biological organisation--ecological, genetic and species.	
Item stem	Shayam and Rita has a house garden in the 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	<p>Area A and Area B have equal biodiversity (species richness).</p> <p>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.</p> <p>Which of these is true?</p>	
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.

### **13. 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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