



Curriculum of **BIOLOGY**

For Sindh
Grades IX – XII
2024



GOVERNMENT OF SINDH
EDUCATION & LITERACY DEPARTMENT
DIRECTORATE OF CURRICULUM, ASSESSMENT & RESEARCH SINDH JAMSHORO

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PREFACE

This curriculum framework serves as a reference document for various stakeholders, including leadership, teachers, learners, textbook writers, reviewers, and examiners. It outlines the fundamental components of the framework and design principles. The document is applicable to all types of secondary schools and higher institutions in Sindh, specifically catering to students interested in acquiring knowledge about plants, animals, and their environment. It offers specific benchmarks and student learning outcomes for each grade level to assist teachers.”

The current curriculum has been designed to enhance the quality of learning experiences through formal instruction over the four years of studying Biology in educational institutions of Sindh. It includes distinct benchmarks and student learning outcomes. Recognizing that the study of Biology is a continuous developmental process, the benchmarks have been established for each stage of schooling. Additionally, grade-specific student learning outcomes have been provided, allowing teachers and learners to assess their progress toward meeting these benchmarks at the end of each academic year.

While new knowledge and skills will be introduced in each grade, the curriculum also emphasizes integrating this new learning with students’ prior knowledge. Notably, the framework incorporates a spiral progression, where skills are revisited and reinforced for consolidation. In essence, learners are guided toward achieving a ‘stable’ stage—the benchmark—through consistent repetition and reinforcement.

To enhance user-friendliness, this document includes guidelines for instruction and materials development, applicable to both teachers and textbook writers. Additionally, separate guidelines for assessing learning are provided.

Recognizing that curriculum development is an ongoing and dynamic process, these revisions and development will be informed by changing realities and the growing experience of implementation at both secondary and higher secondary levels

We extend a warm welcome to all users of this document, inviting feedback, suggestions and recommendations. Let’s transform it into a dynamic, efficient and ‘living’ resource rather than allowing it to remain dormant on shelves.



INTRODUCTION

Following the 18th constitutional amendment, the Directorate of Curriculum, Assessment and Research (**DCAR**) in Sindh Jamshoro holds the exclusive authority to develop curricula for all subjects. Currently, DCAR Sindh is engaged in revising and formulating curricula across various disciplines. In an effort to maintain consistency with the Federal Curriculum, the Education and Literacy Department of the Government of Sindh has officially adopted the National Curriculum of Pakistan (**NCP**) standards for **five core subjects**: Early Childhood Education, English, General Science, Mathematics, and Computer Science, from ECE to Grade XII. Additionally, standards for Biology, Chemistry, and Physics have been adopted for Grades IX-XII, as per Notification No. SELD/HCW/18/2018, dated August 8, 2022, from Karachi.

The Curriculum of Biology for Sindh 2024 Grades IX-XII is based on Standards of National Curriculum of Pakistan 2022-23 and recognizes the value of students' experiences, their voices and active involvement in the process of learning. Learning experiences from secondary schools to upper-level Institutions should pave the way for construction of knowledge and fostering creativity and should become a source of joy, not stress. Examination system seeks a shift from content-based testing to problem solving and competency-based assessment. These are what the Curriculum of Biology for Sindh targets. In essence, our aspiration is to; "Enable all the students to develop their capacities and become as successful learners, confident individuals, responsible citizens, skilled and effective contributors to society."

The Sindh Curriculum 2024 for Biology is aligned with National Curriculum of Pakistan, worked on benchmarks and SLOs and fulfilled the social, cultural and scientific needs of students and enhance their knowledge in the field Biology.

The study of biology connects us to the world and reminds us of our interconnectedness with all other life forms. It provides opportunities to learn about the processes of all living things. What students learn is directly relevant to our species and environment. Through studying biology, students learn to make more informed, decisions about their own health and significant biological issues such as genetically modified crops, the use of antibiotics, and the eradication of invasive species. Biology helps students to recognize the importance of agriculture and horticulture contributes to its future. Biologists are also at the cutting edge of ecological conservation research. By studying biology, students become much more aware of ecological issues, and better able to debate situations where exploitation of the environment (for example, for farming, mining, or energy production purposes) clashes with conservation objectives, or where we need to develop more sustainable ways of using our natural resources (for example, soil, land, air or water). This Biology Sindh Curriculum 2024 shows major shift from the traditional curriculum to Standard based Curriculum. The aims of this curriculum are to produce students who



would do independent thinking, asking questions, and looking for answers on their own to do better. This curriculum helps students to become biologist as well as scientists. Biology plays an important role in the understanding of complex forms of life involving humans, animals and plants. Biology helps individuals understand the interaction between humanity and the world. It also develops interests in the lives of living organisms in an effort to preserve them.

Notably, the document features a glossary at the end, aiding users who may be unfamiliar with specific terminology, thereby facilitating easier reading and enhancing understanding of various curriculum components.

After completing this Curriculum of Biology Students will be able to:

- Knowledgeable about the key concepts and theories of Biology;
- Able to think scientifically and use Biology content knowledge to make decisions and solve real-life problems.
- Able to construct new knowledge through reading, discussions, and research;
- Familiar with the natural world and respectful of its unity, diversity, fragility, and interconnectedness.
- Able students to make judgments on statements and debates that claim to have a science base.

Curriculum for Biology for Sindh Grades IX-XII, must happen in reality, education will need to:

- Focus on understanding, not syllabus coverage;
- Promote learning that is relevant and thus useful;
- Emphasize scientific literacy for All students;
- Promote interdisciplinary learning to foster connections and collaboration between teachers, students and Institutions leading to improve learning outcomes. Interdisciplinary study allows students to explore a wider range of topics, understand multiple viewpoints, and confidently approach complicated issues. Due to this, students empower to integrate knowledge from various disciplines.
- This document is based on three rather broad categories of activities that connect all scientifically literate people:
 - Knowing and Using science knowledge (learning science)
 - Constructing new science knowledge (doing science)
 - Reflecting on science knowledge (thinking science)



Cross-Cutting Themes

Guidance for the Reader

The idea of Science, Technology, Engineering, Arts and Mathematics (**STEAM**) is an overarching idea for how to break up the study of Biology, into core disciplinary knowledge (that students need to learn in order to pass examination at each grade level) and cross-cutting themes (Interdisciplinary connections and recurring ideas that are best reinforced in every chapter in order to promote students critical thinking and curiosity but is not expected to be assessed in standardized examinations).

Cross-cutting themes should be thoughtfully integrated into every chapter of textbooks that align with these standards. However, this doesn't imply that every subcomponent of each theme must appear in all chapters. Instead, connections should be made where they are appropriate and would enhance the study of the core disciplinary knowledge being taught.

The themes presented below are adapted from the Next Generation Science Standards:

Science: Theoretical understandings about science in general, experimental skills and their mutual overlaps in the methods of scientific inquiry.

Engineering and Technology: Applications of science to create solutions that improve standards of living, along with the design thinking approach of engineering applied to scientific problems and vice versa

Mathematics: The relationship between mathematics and the natural world, as well as its integration with the methodologies of the natural sciences

The Arts: Insights into the nature of science that can be gained from the fine arts and humanities



Theme	Components	Elaboration and Guidance
Science	<p>A) Scientific Knowledge (these themes are applied across the conceptual SLOs)</p> <p>1. Patterns:</p> <ul style="list-style-type: none">(i) Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.(ii) Classifications or explanations used at one scale may fail or need revision when information from smaller or larger scales is introduced; thus, requiring improved investigations and experiments.(iii) Patterns of performance about designed systems can be analyzed and interpreted to reengineer and improve the system.(iv) Mathematical representations are needed to identify some patterns.(v) Empirical evidence is needed to identify patterns. <p>2. Cause and Effect: Mechanism and Prediction</p> <ul style="list-style-type: none">(i) Empirical evidence is required to differentiate between cause and correlation which make claims about specific causes and effects.(ii) Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.(iii) Systems can be designed to achieve desired effects.(iv) Changes in systems may have various causes that may not have equal effects. <p>3. Scale, Proportion, and Quantity</p> <ul style="list-style-type: none">(i) The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.(ii) Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.(iii) Patterns observable at one scale may not be observable or exist at other scales.(iv) The concept of orders of magnitude helps in comprehending the relationship between models at different scales.	<p>Elaborations on (A) Scientific Knowledge:</p> <p>1. Patterns: Observed patterns in nature guide organization to classify it as prompt questions about relationships and causes underlying them.</p> <p>2. Cause and Effect: Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.</p> <p>3. Scale, Proportion and Quantity: In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.</p> <p>4. Systems and System Models: A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.</p> <p>5. Energy and Matter: Tracking energy and matter flows, into, out of, and within systems helps to understand system's behavior.</p> <p>6. Structure and Function: The way an object is shaped or structured determines many of its properties and functions.</p> <p>7. Stability and Change: For both designed and natural systems, conditions that affect stability and factors which control rates of change are critical elements to consider and understand.</p> <p>Elaborations on (B) Scientific Practices:</p> <p>1. Asking Questions and Defining Problems: A practice of science is to ask and define problems, lead to descriptions and explanations of how that natural and designed world(s) works and which can</p>



Theme	Components	Elaboration and Guidance
	<p>(v) Algebraic thinking is employed to analyze scientific data and forecast the impact of a change in one variable on another (e.g., linear growth vs. exponential growth).</p> <p>4. Systems and System Models</p> <p>(i) Systems can be designed to do specific tasks.</p> <p>(ii) When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed to describe models.</p> <p>(iii) Models (e.g., physical, mathematical, computer models) can be used to simulate systems by interactions of different factors i.e. energy, matter and flow of different other factors in their system at different scales.</p> <p>(iv) Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models.</p> <p>5. Energy and Matter: Flows, Cycles, and Conservation</p> <p>(i) The total amount of energy and matter in closed systems is conserved</p> <p>(ii) Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.</p> <p>(iii) Energy cannot be created or destroyed only moves between one place and another place, between objects and/or fields, or between systems.</p> <p>(iv) Energy drives the cycling of matter within and between systems.</p> <p>(v) In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons are conserved.</p> <p>6. Structure and Function</p> <p>(i) Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem.</p> <p>(ii) The functions and properties of natural and designed objects/systems can be inferred from</p>	<p>be empirically tested. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve problems about the designed world. Both scientists and engineers also ask questions to clarify ideas.</p> <p>2. Developing and Using Models: A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations. Modeling tools are used to develop questions, predictions and explanations; analyze and identify flaws in systems; and communicate ideas. Models are used to build and revise scientific explanations and proposed engineered systems. Measurements and observations are used to revise models and designs.</p> <p>3. Planning and Carrying Out Investigations: Scientists and engineers plan to carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the effectiveness, efficiency, and durability of designs under different conditions.</p> <p>4. Analyzing and Interpreting Data: Scientific investigations produce data that must be analyzed in order to derive meaning, because data patterns and trends are not always obvious, scientists use a range of tools including tabulation, graphical interpretation, visualization, and statistical analysis to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technologies make the collection of large</p>



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	<p>their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.</p> <p>7. Stability and change</p> <ul style="list-style-type: none">(i) Much of science deals with constructing explanations i.e. how things change and how they remain stable.(ii) Change and rate of change can be quantified and modeled over very short or very long periods of time. Some changes in system are irreversible.(iii) Feedback (negative or positive) can stabilize or destabilize a system.(iv) Systems can be designed for greater or lesser stability. <p>B) Scientific Practices</p> <p>1. Asking Questions and Defining Problems</p> <ul style="list-style-type: none">(i) Ask questions:<ul style="list-style-type: none">- that arise from careful observation of phenomena, unexpected results, to clarify and/or seek additional information- that arise from examining models or a theory, to clarify and/or seek additional information and relationships.- to determine relationships, including quantitative relationships, between independent and dependent variables.- to clarify and refine a model, an explanation, or an engineering problem.(ii) Evaluate a question to determine if it is testable and relevant.(iii) Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory.(iv) Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	<p>data sets much easier, providing secondary sources for analysis. Engineering investigations include analysis of data collected by the tests of designs. This allows comparison of different solutions and determines how well each meets specific design criteria i.e., which design best solves the problem within given constraints. Like scientists, engineers require a range of tools to identify patterns within data and interpret the results. Advances in science make analysis of proposed solutions more efficient and effective.</p> <p>5. Using Mathematics and Computational Thinking: In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.</p> <p>6. Constructing Explanations and Designing Solutions: The goal of science is the construction of theories that provide explanatory accounts of the world. A theory becomes accepted when it has multiple lines of empirical evidence and greater explanatory power of phenomena than previous theories. The goal of engineering design is to find a systematic solution of problems that is based on scientific knowledge and models of the material world. Each proposed solution results from a process of balancing competing criteria of desired functions, technical feasibility, cost, safety, aesthetics, and compliance with legal requirements. The optimal choice depends on how well the proposed solutions meet criteria and constraints.</p>



Theme	Components	Elaboration and Guidance
	<p>(v) Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.</p> <p>2. Developing and Using Models</p> <p>(i) Evaluate merits and limitations of two different models of the same proposed tool, process, mechanism, or system in order to select or revise a model that best fits the evidence or design criteria.</p> <p>(ii) Design a test of a model to ascertain its reliability.</p> <p>(iii) Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.</p> <p>(iv) Develop and or use multiple types of models to provide mechanistic accounts and/or predict phenomena, and move flexibly between model types based on merits and limitations.</p> <p>(v) Develop a complex model that allows for manipulation and testing of a proposed process or system.</p> <p>(vi) Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.</p> <p>3. Planning and Carrying Out Investigations</p> <p>(i) Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled.</p> <p>(ii) Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of</p>	<p>7. Engaging in Argument from Evidence: In science and engineering, reasoning and argument based on evidence are essential to identifying the best explanation for a natural phenomenon or the best solution to a design problem. Scientists and engineers use. argumentation of listen to, compare, and evaluate competing ideas and methods based on merits. Scientists and engineers engage in argumentation when investigating a phenomenon, testing a design solution, resolving questions about measurements, building data models, and using evidence to evaluate claims.</p> <p>8. Obtaining, Evaluating and Communicating Information: Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity. Communicating information and ideas can be done in multiple ways: using tables, diagrams, graphs, models, and equations as well as orally, in writing, and through extended discussions. Scientists and engineers employ multiple sources to obtain information that is used to evaluate the merit and validity of claims, methods, and designs.</p>



Theme	Components	Elaboration and Guidance
	<p>the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.</p> <p>(iii) Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts.</p> <p>(iv) Select appropriate tools to collect, record, analyze, and evaluate data.</p> <p>(v) Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated.</p> <p>(vi) Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.</p> <p>4. Analyzing and Interpreting Data</p> <p>(i) Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.</p> <p>(ii) Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible.</p> <p>(iii) Consider limitations of data analysis (e.g., measurement error, sample selection) when analyzing and interpreting data.</p> <p>(iv) Compare and contrast various types of data sets (e.g., self-generated, archival) to examine consistency of measurements and observations.</p> <p>(v) Evaluate the impact of new data on a working explanation and/or model of a proposed process or system.</p> <p>(vi) Analyze data to identify design features or characteristics of the components of a proposed process or system to optimize it relative to criteria for success.</p> <p>5. Using Mathematics and Computational Thinking</p>	



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	<ul style="list-style-type: none"> (i) Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system. (ii) Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations. (iii) Apply techniques of algebra and functions to represent and solve scientific and engineering problems. (iv) Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model ‘makes sense’ by comparing the outcomes with what is known about the real world. (v) Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m³, acre-feet, etc.). <p>6. Constructing Explanations and Designing Solutions</p> <ul style="list-style-type: none"> (i) Make a quantitative and/or qualitative claim regarding the relationship between dependent and independent variables. (ii) Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students’ own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (iii) Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (iv) Apply scientific reasoning, theory, and/or models to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (v) Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations. 	



Theme	Components	Elaboration and Guidance
	<p>7. Engaging in Argument from Evidence</p> <ul style="list-style-type: none">(i) Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues.(ii) Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.(iii) Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.(iv) Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.(v) Make and defend a claim based on evidence about the natural world or the effectiveness of a design solution that reflects scientific knowledge, and student-generated evidence.(vi) Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and/or logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). <p>8. Obtaining, Evaluating and Communicating Information</p> <ul style="list-style-type: none">(i) Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.(ii) Compare, integrate and evaluate sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a scientific question or solve a problem.(iii) Gather, read, and evaluate scientific and/or technical information from multiple	



Theme	Components	Elaboration and Guidance
	<p>authoritative sources, assessing the evidence and usefulness of each source.</p> <p>(iv) Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.</p> <p>(v) Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).</p>	
Technology & Engineering	<p>1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.</p> <p>(i) Analyze complex real-world problems by specifying criteria and constraints for successful solutions.</p> <p>(ii) Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.</p> <p>(iii) Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.</p> <p>(iv) All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment</p> <p>(v) New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.</p> <p>2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.</p>	<p>The Engineering Design cycle can be considered to consist of the below three iterative steps in a global problem solving context:</p> <p>Define: Attend to a broad range of considerations in criteria and constraints for problems of social and global significance.</p> <p>Develop solutions: Break a major problem into smaller problems that can be solved separately.</p> <p>Optimize: Prioritize criteria, consider trade-offs, and evaluate social and environmental impacts while testing and refining a complex solution.</p>



Theme	Components	Elaboration and Guidance
	<p>(i) Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.</p> <p>(ii) Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed.</p> <p>3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.</p> <p>(i) Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and trade off considerations.</p> <p>(ii) When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.</p> <p>4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.</p> <p>(i) Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and or the interactions between systems.</p> <p>(ii) Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.</p>	



Theme	Components	Elaboration and Guidance
	<p>(iii) Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions including energy, matter, and information flows within and between systems at different scales.</p> <p>5. Interdependence of Science, Engineering, and Technology</p> <p>(i) Science and engineering complement each other in the cycle known as research and development (R&D).</p> <p>(ii) Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.</p> <p>6. Influence of Engineering, Technology, and Science on Society and the Natural World</p> <p>(i) Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.</p> <p>(ii) Engineers continuously modify these systems to increase benefits while decreasing costs and risks.</p> <p>(iii) New technologies can have deep impacts on society and the environment, including some that were not anticipated.</p> <p>(iv) Analysis of costs and benefits is a critical aspect of decisions about technology.</p>	
The Arts & Mathematics	<p>A) Mathematical Knowledge in Science (these are embedded into the conceptual SLOs, as well as is in the prerequisite mathematical knowledge requirements)</p> <p>B) Nature of Science</p> <p>1. Scientific Investigations Use a Variety of Methods</p> <p>(i) Science investigations use diverse methods and do not always use the same set of procedures to obtain data.</p> <p>(ii) New technologies advance scientific knowledge.</p> <p>(iii) Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness,</p>	



Theme	Components	Elaboration and Guidance
	<p>objectivity, skepticism, replicability of results, and honest and ethical reporting of findings</p> <p>(iv) The discourse practices of science are organized around disciplinary domains that share examples for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use.</p> <p>(v) Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge.</p> <p>2. Science knowledge is based on empirical evidence.</p> <p>(i) Science disciplines share common rules of evidence used to evaluate explanations about natural systems.</p> <p>(ii) Science includes the process of coordinating patterns of evidence with current theory.</p> <p>(iii) Science arguments are strengthened by multiple lines of evidence supporting a single explanation.</p> <p>3. Scientific Knowledge is Open to Revision in Light of New Evidence</p> <p>(i) Scientific explanations can be probabilistic.</p> <p>(ii) Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.</p> <p>(iii) Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.</p> <p>4. Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena</p> <p>(i) Theories and laws provide explanations in science, but theories do not with time become laws or facts.</p> <p>(ii) A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory</p>	



Theme	Components	Elaboration and Guidance
	<p>does not accommodate, the theory is generally modified in light of this new evidence.</p> <p>(iii) Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.</p> <p>(iv) Laws are statements or descriptions of the relationships among observable phenomena.</p> <p>(v) Scientists often use hypotheses to develop and test theories and explanations.</p> <p>5. Science is a Way of Knowing</p> <p>(i) Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise, and extend this knowledge.</p> <p>(ii) Science is a unique way of knowing and there are other ways of knowing</p> <p>(iii) Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.</p> <p>(iv) Science knowledge has a history that includes the refinement of, and changes to, theories, ideas, and beliefs over time.</p> <p>6. Scientific Knowledge Assumes an Order and Consistency in Natural Systems</p> <p>(i) Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.</p> <p>(ii) Science assumes the universe is a vast single system in which basic laws are consistent.</p> <p>7. Science is a Human Endeavor</p> <p>(i) Scientific knowledge is a result of human endeavor, imagination, and creativity.</p> <p>(ii) Individuals and teams from many nations and cultures have contributed to science and to advances in engineering.</p> <p>(iii) Scientists' backgrounds, theoretical commitments, and fields of endeavor influence the nature of their findings.</p> <p>(iv) Technological advances have influenced the progress of science and science has influenced advances in technology.</p> <p>(v) Science and engineering are influenced by society and society is influenced by science and engineering.</p>	



Theme	Components	Elaboration and Guidance
	<p>8. Science Addresses Questions About the Natural and Material World</p> <p>(i) Not all questions can be answered by science.</p> <p>(ii) Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.</p> <p>(iii) Science knowledge indicates what can happen in natural systems not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge</p> <p>(iv) Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.</p>	



PROGRESSION GRID

Theoretical Concepts Progression Grid Guidance for the Reader

Assumption of Prior Knowledge: It is assumed that students will already have knowledge (and be able to apply it as needed in their current class) of what they learned in their previous grades, so SLOs from previous grades are not repeated in the higher grades. In practice, teachers may want to refresh concepts with their students as appropriate.

Organization of the SLOs in the Progression Grid: Inside a grade, teachers are free to teach the content in any order of preference. Textbook publishers are also free to organize the contents of their books in any manner that they consider most effective, as long as all the SLOs in the Progression Grid and Cross-Cutting themes are covered. The SLOs inside a grade do not need to be taught in the order presented in a grade in this Progression Grid. The Nature of Science domain would, for example, be best taught by being integrated into the teaching of all the chapters of the curriculum.

Nature of Science Domain Guidance for the Reader: Nature of Science learning objectives have been added to the Progression Grid. The purpose of studying science at the high school level is not only to prepare students for further study in the sciences. Many students will in fact not go on to study further science or STEM fields. The science that they learn in school may well remain their understanding of the subject for the rest of their lives. Hence these curricula must consider what citizens in a democratic society ought to know about the nature of science. “Nature of Science” (NOS) means teaching about science’s underlying assumptions, and its methodologies. This involves some integrated study of the history of science, and some of the broad concepts from the philosophy of science. It is important to study NOS because it helps students become critical thinkers about the scientific information, they consume from the world around them. Teaching NOS in the study of Biology, Chemistry, Physics is a cutting-edge international trend.

- **In the Nature** of Science domain SLOs, unless explicitly stated, where the SLO begins with the phrase ‘explain with examples’ it is enough that student’s study 2-3 examples and can use them in their answers for examination questions. There is no need to extensively or comprehensively study the history of science or its applications in other fields. The purpose here is that students are able to develop an appreciation of these aspects of the field of chemistry with some rigor (hence these SLOs are expected to be assessed), but not to become so extensive that it takes a lot of time out from building competence in rest of the domains on chemistry skills and knowledge.
- **Assessment** of Nature of Science in standardized board exams will be kept to objective knowledge; students will not be expected to write argumentative essays or express subjective perspectives. Rather assessment in the standardized exams will occur through multiple choice questions and/or through short answer questions that require two-three sentence responses. Sample questions are provided in the Curriculum Guidelines. In their regular classroom study, teachers are encouraged to teach these topics through learner-centered activities that promote curiosity, inquiry, creativity, critical discussion and collaboration.

Optional SLOs: SLOs that are italicized are optional, as they may be advanced or too much to cover with the rest of the content in the grade.



DOMAIN A: NATURE OF SCIENCE IN BIOLOGY

This field studies science's underlying assumptions, and its methodologies. This involves some integrated study of the history, philosophy and sociology of science.

Note: In the Nature of Science in biology domain, the SLO begins with the phrase "explain with examples," it is sufficient for students to study 2-3 examples and use them in their examination answers. There is no need for an extensive or comprehensive study of the history of science or its applications in other fields. The goal for students is to develop an appreciation of these aspects of different scientific fields with some rigor (hence these SLOs will be assessed), but not so extensively that it detracts from building competence in other areas of biological science skills and knowledge.

Assessment of the Nature of Science in standardized board examinations will focus on objective knowledge. Students will not be required to write argumentative essays or express subjective perspectives. Instead, assessment will be conducted through multiple-choice questions and/or short answer questions requiring two-to-three sentence responses. Sample questions are provided in the Curriculum Guidelines.

In regular classroom study, teachers are encouraged to teach these topics through learner-centered activities that promote curiosity, inquiry, creativity, critical discussion, and collaboration.

Standard: Students should be able to:

Explain and evaluate with examples that science operates on the basis of discrete facts and historical context that affects its current practices and paradigms

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Critically analyze claims made about the relationship of biology with society		N/A	
<p>[SLO:B-09-A-01] Concept of biology</p> <p>[SLO:B-09-A-02] Point out Quranic instructions to reveal the study of Life</p> <p>[SL0:B-09-A-03] Understand the major fields of biology as Botany, zoology and Microbiology</p> <p>[SL0:B-09-A-04] Define with examples that biology has many sub fields. Morphology Cell biology Histology Anatomy Physiology Molecular biology</p>			



Grade – IX	Grade – X	Grade – XI	Grade – XII
<p>Genetics Taxonomy Paleontology Environmental biology Marine biology Fresh water biology Developmental biology Parasitology Pathology Immunology Pharmacology</p> <p>[SLO:B-09-A-05] Relate that biology connects with other natural sciences and distinguish in terms of the broad subject matter as well as interdisciplinary researchers working together to share knowledge between the below fields:- -Biophysics -Biochemistry -Computational Biology -Biogeography -Biostatistics -Biotechnology -Bio-economics</p> <p>[SLO:B-09-A-06] Identify the careers in Biology and explain with examples how biology is a subset of the natural sciences.</p> <p>[SLO:B-09-A-07] Understand the steps of the scientific method that is recognition of biological problem Observation Hypothesis Deduction Experiments Results</p>			



Grade – IX	Grade – X	Grade – XI	Grade – XII
[SLO:B-09-A-08] Evaluate the terms “hypothesis”, theory and law in the context of research in the natural science with the help of example.			



DOMAIN B: MOLECULAR BIOLOGY

Standard: *Students should be able to:*

- Describe the structure and function of the four main biomolecules: carbohydrates, lipids, proteins, and nucleic acids.
- Explain the role of DNA as the genetic material and its role in heredity.
- Describe the structure of DNA, including the double helix and the four nitrogenous bases.
- Explain the process of DNA replication and its importance in cell division.
- Describe the process of transcription and translation, including the role of RNA and ribosomes.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Critically analyze claims made about the relationship of biology with society		Benchmark 1: Describe in detail the structure, chemistry and functions of the four major biomolecules, their types and reactions inside cells and tissues	
<p>[SLO:B-9-B-01] Understand the concept of biochemistry/ Molecular Biology by introducing levels of organization.</p> <p>[SLO:B-09-B-02] Outline the various types of common biomolecules (Protein, Carbohydrates, Lipids and Nucleic acid) including their locations inside the cell and main roles.</p> <p>[SLO:B-09-B-03] Describe the structure, function and sources of protein with structure of amino acids.</p> <p>[SLO:B-09-B-04] Understand the concept of carbohydrates and outline the structure, function and sources of carbohydrates.</p> <p>[SLO:B-09-B-05] Identify carbohydrates as mono saccharides, disaccharides and polysaccharides.</p>		<p>SLO:B-11-B-01] Define biochemistry /molecular biology by introducing levels of organization.</p> <p>[SLO:B-11-B-02] Describe Briefly the different types of bonds found in biological molecules (Hydrogen bond, covalent bond, Ionic, hydrophobic and hydrophilic interactions)</p> <p>[SLO:B-11-B-03] Distinguish Carbohydrates, Proteins, Lipids and Nucleic acids as the four fundamentals kinds of biological molecules</p> <p>[SLO:B-11-B-04] Describe and draw sketches of the condensation (dehydration) synthesis and hydrolysis reactions for the making and breaking of macromolecule polymers.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
<p>[SLO:B-09-B-06] Explain the structure, function and sources of lipids.</p> <p>[SLO:B-09-B-07] Understand the structure of DNA as a double helix macromolecule made of nucleotides with base pairing in between the two helices through complementary base pairing.</p> <p>[SLO:B-09-B-08] State the function of DNA as carrier of hereditary information.</p> <p>[SLO:B-09-B-09] Understand the structure of RNA as single stranded macromolecule made of nucleotides with nitrogenous base overhangs.</p> <p>[SLO:B-09-B-10] Demonstrate how RNA function as tool for converting hereditary information into functional proteins.</p> <p>[SLO:B-09-B-11] Outline how information in the DNA is transformed on RNA and then into Proteins for expression.</p>		<p>[SLO:B-11-B-05] State the properties of water (high polarity, hydrogen bonding, high specific heat, high heat of vaporization, cohesion, adhesion hydrophobic exclusion, ionization and lower density of ice) allow it to be the medium of life.</p> <p>[SLO:B-11-B-06] Define carbohydrates and classify them.</p> <p>[SLO:B-11-B-07] Compare and contrast the properties and roles of mono saccharides and write their formulae.</p> <p>[SLO:B-11-B-08] Compare the isomers and stereo isomers of glucose.</p> <p>[SLO:B-11-B-09] Distinguish the properties and roles of disaccharides</p> <p>[SLO:B-11-B-10] Describe glycosidic bonds in disaccharides.</p> <p>[SLO:B-11-B-11] Describe the structure properties and roles of polysaccharides starch, glycogen, cellulose and chitin. Role of glycosidic bond in polysaccharides</p> <p>[SLO:B-11-B-12] Define protein, amino acid, recognized essential</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>amino acid and structural formula of amino acid. Also identify essential and non-essential amino acids.</p> <p>[SLO:B-11-B-13] Outline the synthesis and breakage of peptide linkages.</p> <p>[SLO:B-11-B-14] Justify the significance of the sequence of amino acids through the example of sickle cell hemoglobin</p> <p>[SLO:B-11-B-15] Classify proteins as globular and fibrous proteins.</p> <p>[SLO:B-11-B-16] List the roles of structural proteins and functional proteins with three examples</p> <p>[SLO:B-11-B-17] Define lipids</p> <p>[SLO:B-11-B-18] Describe the properties and roles of acylglycerols, phospholipids, terpenes and waxes.</p> <p>[SLO:B-11-B-19] Illustrate the molecular structure (making and breaking) of an acylglycerol, a phospholipid and a terpene</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-B-20] Evaluate steroids and prostaglandins as important groups of lipids</p> <p>[SLO:B-11-B-21] Describe nucleic acids and molecular structure of nucleotides.</p> <p>[SLO:B-11-B-22] Distinguish among the nitrogenous bases found in the nucleotides of nucleic acids.</p> <p>[SLO:B-11-B-23] Outline the examples of a mononucleotide (ATP) and a dinucleotide (NAD).</p> <p>[SLO:B-11-B-24] Illustrate the formation of phosphodiester bond</p> <p>[SLO:B-11-B-25] Explain the double helical structure of DNA as proposed by Watson and Crick.</p> <p>[SLO:B-11-B-26] Explain the general structure of RNA.</p> <p>[SLO:B-11-B-27] Distinguish in terms of functions and roles, the three types of RNA</p> <p>[SLO:B-11-B-28] Discuss the Central Dogma.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-B-29] Define conjugated molecules and describe the roles of common conjugated molecules i.e. glycolipids, glycoproteins, lipoproteins and nucleoproteins</p>	



DOMAIN C: CELL AND ITS ORGANELLES

Standard: Students should be able to:

- Describe the structure and function of cells, including prokaryotic and eukaryotic cells.
- Identify and describe the main sub-cellular organelles, including the nucleus, mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes.
- Explain the role of the cell membrane and describe its structure.
- Explain the process of cellular respiration and its role in producing energy.
- Describe the process of cellular division, including mitosis and meiosis.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students Should be able to describe the structure of animal and plant cells and the structure and roles of different organelles inside the cells.		Benchmark 1: Students will be able to describe the function and draw the structures of cell and its organelles. How they interact to maintain cellular homeostasis and communicate with each other.	
<p>[SLO:B-09-C-01] Describe cell as the basic unit of life</p> <p>[SLO:B-09-C-02] Sketch animal and plant cells, point out different organelles (nucleus with the concept of Chromosome structure, mitochondria, cell membranes, etc) and outline their roles. Compare animal and plant cells.</p> <p>[SLO:B-09-C-03] Outline structural advantages of plant and animal cells with reference to Cell wall, Plastids, Centrioles, and Lysosomes etc.</p> <p>[SLO:B-09-C-04] Identify different types of cells (Mesophyll cell, epidermal cell, neurons, muscle, red blood cell, liver cell) and sketch their structures.</p>		<p>[SLO:B-11-C-01] Describe that cell is the basic unit of all living organisms with respect to properties of life. (Irritability, Metabolism Nutrition, Homeostasis, Growth, Reproduction)</p> <p>[SLO:B-11-C-02] Compare and contrast the working of a light microscope and electron microscope with focus on magnification, resolution and contrast.</p> <p>[SLO:B-11-C-03] Differentiate between prokaryotic and eukaryotic cells with diagrams.</p> <p>[SLO:B-11-C-04] Identify the Microscopic structure of animal and plant cells.</p> <p>[SLO: B-11-C-05] Describe the locations, chemical composition and significance of the primary, secondary cell wall and of middle lamella.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
<p>[SLO: B-09-C-05] Understand the concept of division of labour and how it applies: - Within Cell organelles (Mitochondria and chloroplast etc.) - Multi cellular organisms (Muscle fibre and Neuron etc.)</p> <p>[SLO:B-09-C-06] Concept of Stem cells as unspecialized cell.</p>		<p>[SLO: B-11-C-06] Describe the structure and functions of organelles. Cell membrane, Endoplasmic reticulum (SER and RER), Ribosomes, Golgi apparatus, Lysosomes, Peroxisomes, Glyoxysomes, Vacuoles, Mitochondria, Plastids, Centrioles, Cytoskeleton and Nucleus.</p>	
Benchmark 2: Students should be able to describe the different stages of cell division and the roles of organelles in this process		Benchmark 2: Students will be able to understand terms such as stem cells, the structure of cell membrane and its role in transport of material.	
<p>[SLO:B-09-C-07] Concept of Cell cycle</p> <p>[SLO:B-09-C-08] Describe mitosis, meiosis and stages of mitosis, meiosis (by use of sketch and diagrams)</p> <p>[SLO:B-09-C-09] Compare the processes of mitosis and meiosis</p> <p>[SLO:B-09-C-10] Outline the significance of mitosis and meiosis.</p>		<p>[SLO:B-11-C-07] Explain the structure of the cell membrane and the techniques that can be used to study it.</p> <p>[SLO:B-11-C-08] Explain the methods of membrane transport mechanisms with diagrams: [Diffusion, Facilitated diffusion, Osmosis, Active transport (endocytosis and exocytosis)].</p> <p>[SLO:B-11-C-09] Define cell signaling.</p> <p>[SLO:B-11-C-10] Discuss the pathway of a signal from outside the cell to the inside. (Protein signal and steroid signal)</p> <p>[SLO:B-11-C-11] Define Stem cells and advantages of using stem cells</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-C-12] Categorize different types of stem cells</p> <p>[SLO:B-11-C-13] Evaluate the advantages and disadvantages of using induced Pluripotent Stem Cells.</p> <p>[SLO:B-11-C-14] Draw the stages of Mitosis and meiosis.</p>	



DOMAIN D: TISSUES, ORGANS AND SYSTEMS

Standard: Students should be able to:

- Describe the structure and function of tissues, including epithelial, connective, muscle, and nervous tissue.
- Explain the role of organs in maintaining homeostasis.
- Describe the structure and function of the major organ systems, including the circulatory, digestive, respiratory, nervous, endocrine, muscular, and skeletal systems.
- Explain how the different organ systems interact to maintain homeostasis in the body.
- Describe how diseases can affect the functioning of organ systems.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to: Describe the basic types of tissues epithelial, connective, nervous tissues in animals. Meristematic and permanent tissues in plants, their constituent cells and explain their structure and functions		N/A	
[SLO:B-09-D-01] Distinguish between tissues, organs and systems with examples from animals and plants.			
[SLO:B-09-D-02] The concept of emergent properties as gain in functionalities and how it applies to the following: <ul style="list-style-type: none"> - going from organelles to cells - going from cells to tissues - going from tissues to organs - going from organs to systems - going from systems to living organisms 			
[SLO:B-09-D-03] Enlist the different types of tissue come together to form the stomach (organ) in the human body.			



Grade – IX	Grade – X	Grade – XI	Grade – XII
[SLO:B-09-D-04] Discuss the different types of tissue come together to form the leaf.			
Benchmark 2: Students should be able to explain the structure and function of major organ systems in animals, including the digestive, respiratory, cardiovascular, nervous, endocrine, and reproductive systems and their disorders	N/A		
[SLO:B-09-D-05] Understand the organ systems come together to form the human body. [SLO:B-09-D-06] Tabulate disorders (Food poisoning, Tuberculosis, Heart attack, diabetes, Parkinson’s disease and infertility) with related organs and their symptoms.			
Benchmark 3: Student should be able to understand concept of homeostasis and describe the role of various organs in homeostasis.	N/A		
[SLO:B-09-D-07] Concept of homeostasis and describe its advantages. [SLO:B-09-D-08] Understand the various organs and systems of the human body to maintain homeostasis. [SLO:B-09-D-09] Understand the various organs and systems of plants to maintain homeostasis.			



DOMAIN E: EVOLUTION, BIODIVERSITY AND CLASSIFICATION

Standard: Students should be able to:

- Define evolution and natural selection.
- Explain the mechanisms of genetic variation and inheritance.
- Describe how populations change over time and how speciation occurs.
- Explain the evidence for common ancestry and the history of life on Earth.
- Describe the major taxonomic categories and their characteristics, including the classification of organisms into species, genus, family, order, class, phylum, kingdom and domain.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to explain the concept of evolution and theory of evolution by natural selection and provide evidence for its occurrence.		Benchmark 1: Students will be able to distinguish evolution from creationism and explain the factors that influence evolution and inheritance.	
<p>[SLO:B-09-E-01] Understand concepts of evolution of living organisms and the theory of evolution by natural selection with examples</p> <p>[SLO:B-09-E-02] Concept of Species</p> <p>[SLO:B-09-E-03] Concept of speciation</p> <p>[SLO:B-09-E-04] State the sources of variations which can lead to speciation and evolution.</p> <p>[SLO:B-09-E-05] Interpret the significance of Darwin's observations made during his voyage on HMS Beagle.</p> <p>[SLO:B-09-E-06] To understand the evidences of evolution with regards to the following: - Paleontology (fossil record) - Comparative anatomy (homologous</p>			<p>[SLO:B-12-E-01] Explain the theory of organic evolution in the light of Lamarckism and Darwinism with their drawbacks.</p> <p>[SLO:B-12-E-02] Concept of Neo-Darwinism.</p> <p>[SLO:B-12-E-03] Explain that evolution happens due to variation in organisms and the selection pressures that organisms face.</p> <p>[SLO:B-12-E-04] Analyze the evidence of evolution that comes from molecular biology.</p> <p>[SLO:B-12-E-05] Differentiate between convergent and divergent evolution on the basis of inheritance of the homologous and analogous structures.</p> <p>[SLO:B-12-E-06] Describe the Endo symbiotic theory about the mechanism of</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
structures, vestigial structures) - Selective breeding and biogeography			evolution of eukaryotes from prokaryotes
Benchmark 2: Students should be able to describe the process of classification and explain how taxonomy helps us understand the diversity of life on Earth.		Benchmark 2: Students should be able to describe the biodiversity among plants and animals.	
<p>[SLO:B-09-E-07] Concept of biodiversity and classification.</p> <p>[SLO:B-09-E-08] Understand the advantages of classification.</p> <p>[SLO:B-09-E-09] Discuss the history of classification schemes.</p> <p>[SLO:B-09-E-10] List the three distinct domains into which living organisms are broadly classified.</p> <p>[SLO:B-09-E-11] List the taxonomic ranks of classification.</p> <p>[SLO:B-09-E-12] Understand the concept of binomial nomenclature system.</p> <p>[SLO:B-09-E-13] Understand the complications of classifying viruses</p>		<p>[SLO:B-11-E-01] Describe non-vascular plants (Bryophytes)</p> <p>[SLO:B-11-E-02] Explain the life cycle of polytrichome</p> <p>[SLO:B-11-E-03] Describe the general features of vascular plants</p> <p>[SLO:B-11-E-04] Identify the division between vascular plants [Psilopsida, Lycopsida, Sphenopsida Pteriopsida, Spermopsida (gymnosperms, angiosperms)]</p> <p>[SLO:B-11-E-05] Explain the life cycle of ferns as example of Pteriopsida.</p> <p>[SLO:B-11-E-06] Describe the general characteristic of gymnosperms and classify them into classes.</p> <p>[SLO:B-11-E-07] Describe the life cycle of Pinus</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-E-08] Describe the general characteristics of angiosperms and classify them into classes</p> <p>[SLO:B-11-E-09] Explain the life cycle of angiosperms</p> <p>[SLO:B-11-E-10] Describe general characteristics and economic importance of the following angiospermic families Brassicaceae Solanaceae Poaceae</p> <p>[SLO:B-11-E-11] Basis of classification of animals.</p> <p>[SLO:B-11-E-12] Describe the general characteristics, importance and example of Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Mollusca, Arthropoda and Echinodermata.</p> <p>[SLO:B-11-E-13] Describe the general characteristics of chordates distinguish between invertebrate chordates and vertebrate chordates.</p> <p>[SLO:B-11-E-14] Describe the general characteristics of cyclostomes, pisces, amphibian, reptiles, aves and mammals.</p>	



DOMAIN F: ACELLULAR LIFE

Standard: *Students should be able to:*

- *Describe the characteristics and diversity of a cellular life, including viruses and viroids.*
- *Explain the replication and infection cycles of viruses.*
- *Compare and contrast the structure and function of virus particles.*
- *Analyze the impacts of viruses on human health and the environment.*
- *Evaluate the current methods for controlling and preventing viral infections.*

Grade – IX	Grade – X	Grade – XI	Grade – XII
N/A		Benchmark 1: Students should be able to analyze the role of acellular life forms in maintaining the balance of ecosystems, causing diseases, and in biotechnology applications.	
		[SLO:B-11-F-01] Justify the status of viruses among living and nonliving things. [SLO:B-11-F-02] Trace the history of viruses since their discovery. [SLO:B-11-F-03] Classify viruses on the basis of their hosts, morphology and genomic constituent. [SLO:B-11-F-04] Describe the structure of a model bacteriophage, and HIV. [SLO:B-11-F-05] Justify that a virus must have a host cell to parasitize in order to complete its life cycle. [SLO:B-11-F-06] Explain a virus survives inside a host cell, protected from the immune system. [SLO:B-11-F-07]	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>Determine the method a virus employs to survive/ pass over unfavorable conditions when it does not have a host to complete the life cycle.</p> <p>[SLO:B-11-F-08] Describe the Lytic and Lysogenic life cycles of a virus.</p>	
N/A		<p>Benchmark 2: Students should be able to analyze the role of acellular life forms in maintaining the balance of ecosystems, causing diseases and the treatment of these diseases.</p>	
		<p>[SLO:B-11-F-09] Outline the usage of bacteriophage in genetic engineering.</p> <p>[SLO:B-11-F-10] Explain the lifecycle of HIV.</p> <p>[SLO:B-11-F-11] Justify the name of the virus i.e. “Human Immunodeficiency Virus” by establishing T-helper cells as the basis of immune system.</p> <p>[SLO:B-11-F-12] Deduce the specificity of HIV on its host cells.</p> <p>[SLO:B-11-F-13] List the symptoms of AIDS.</p> <p>[SLO:B-11-F-14] Explain opportunistic diseases that may attack an AIDS victim.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-F-15] Describe the Treatments available for AIDS.</p> <p>[SLO:B-11-F-16] List some common control measures against the transmission of HIV.</p> <p>[SLO:B-11-F-17] Describe the causative agent, symptoms, treatment and prevention of the following viral diseases: hepatitis C, herpes, polio and leaf curl virus disease of cotton.</p> <p>[SLO:B-11-F-18] List the sources of transmission for each of the above-mentioned diseases.</p> <p>[SLO:B-11-F-19] Describe the structure of prions and viroids.</p> <p>[SLO:B-11-F-20] List the diseases caused by prions and viroids.</p> <p>[SLO:B-11-F-21] Interpret how viral infections cause global economic loss.</p> <p>[SLO:B-11-F-22] Describe the limitations of the vaccine for the common cold / flu virus</p>	



DOMAIN G: PROKARYOTES, PROTISTS AND FUNGI

Standard: *Students should be able to:*

- *Explain the differences in structure and function between prokaryotic and eukaryotic cells.*
- *Classify and describe the diversity of organisms within the domains of Bacteria and Archaea.*
- *Describe the unique characteristics and functions of protists, including those that are unicellular, colonial, or multi cellular.*
- *Explain the importance of fungi in the ecosystem, including their role in decomposition, nutrient cycling, and symbiotic relationships with other organisms.*
- *Compare and contrast the different modes of nutrition and lifestyle of prokaryotes, protists, and fungi.*

Grade – IX	Grade – X	Grade – XI	Grade – XII
N/A		Benchmark 1: Students will be able to distinguish and compare the structures and functions of different prokaryotes, protists and fungi.	
		<p>[SLO:B-11-G-01] Outline the Taxonomic position of prokaryotes in terms of domains archaea and bacteria and in terms of kingdom monera.</p> <p>[SLO:B-11-G-02] Explain the phylogenetic position of prokaryotes.</p> <p>[SLO:B-11-G-03] Justify the occurrence of bacteria in the widest range of habitats.</p> <p>[SLO:B-11-G-04] Draw a labeled diagram of a generalized bacterial cell.</p> <p>[SLO:B-11-G-05] Justify cyanobacteria are considered as the most prominent of the photosynthetic bacteria.</p> <p>[SLO:B-11-G-06] Describe detailed structure and chemical composition of bacterial cell wall and extra protective layers.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-G-07] Compare cell wall differences in Gram-positive and Gram-negative bacteria.</p> <p>[SLO:B-11-G-08] Illustrate with diagrams the great diversity of shapes and sizes found in bacteria.</p>	
N/A		Benchmark 2: Evaluate functions of Bacteria and their life cycles.	
		<p>[SLO:B-11-G-09] Justify the endospore formation in bacteria as a mechanism of survival to withstand unfavorable conditions.</p> <p>[SLO:B-11-G-10] Explain motility in bacteria.</p> <p>[SLO:B-11-G-11] Describe with diagram structure of bacterial flagellum.</p> <p>[SLO:B-11-G-12] Describe genomic organization of bacteria with respect to circular DNA and plasmids.</p> <p>[SLO:B-11-G-13] Classify bacteria on the basis of methods of obtaining energy and carbon.</p> <p>[SLO:B-11-G-14] Differentiate between the mechanism of photosynthesis in Cyanobacteria and other photosynthetic bacteria.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-G-15] List the phases in the growth of bacteria.</p> <p>[SLO:B-11-G-16] Describe different methods of reproduction in bacteria.</p>	
N/A		<p>Benchmark 3: Explain the ecological significance of these organisms, including their role in nutrient cycling, decomposition, and mutualistic relationships.</p>	
		<p>[SLO:B-11-G-17] Describe bacteria as recyclers of nature. Outline the ecological and economic importance of bacteria.</p> <p>[SLO:B-11-G-18] Explain the use of bacteria in research and technology.</p> <p>[SLO:B-11-G-19] Describe common bacterial diseases in man e.g. cholera, typhoid, tuberculosis, and pneumonia; emphasizing their symptoms, causative bacteria, treatments, and preventative measures.</p> <p>[SLO:B-11-G-20] Describe common bacterial diseases in plants e.g. spots, blights, soft rots, wilts, and galls; emphasizing their symptoms, causative bacteria, and preventative measures.</p> <p>[SLO:B-11-G-21] Define the term normal flora.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-G-22] Describe the benefits of the bacterial flora of humans.</p> <p>[SLO:B-11-G-23] Enlist the chemical and physical methods used to control harmful bacteria.</p> <p>[SLO:B-11-G-24] Explain protists as a diverse group of eukaryotes that has polyphyletic origin and defined only by exclusion from other groups.</p> <p>[SLO:B-11-G-25] Explain the salient features with examples of protozoa, algae, myxomycota and oomycota as the major groups of protists.</p> <p>[SLO:B-11-G-26] Justify how protists are important for humans.</p> <p>[SLO:B-11-G-27] Classify fungi into zygomycota, ascomycota, deuteromycota and basidiomycota and give the diagnostic features of each group.</p> <p>[SLO:B-11-G-28] Explain yeast as unicellular fungi that are used for baking and brewing and are also becoming very important for genetic research.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-G-29] Name a few fungi from which antibiotics are obtained.</p> <p>[SLO:B-11-G-30] Explain the mutualism established in mycorrhizae and lichen associations.</p> <p>[SLO:B-11-G-31] Give examples of edible fungi.</p> <p>[SLO:B-11-G-32] Describe the ecological impact of fungi causing Decomposition and recycling of materials.</p> <p>[SLO:B-11-G-33] Discuss the pathogenic role of fungi.</p>	



DOMAIN H: FORM AND FUNCTIONS OF PLANTS

Standard: Students should be able to:

- Describe the basic structure and anatomy of plant cells and organs, including stems, roots, leaves, and flowers.
- Explain the process of photosynthesis, including the role of chlorophyll and other pigments.
- Discuss the significance of seeds and the different methods of seed dispersal.
- Describe the basic processes of plant growth and development, including germination, shoot and root development, and the role of hormones.
- Outline the adaptations that allow plants to survive in different environments, including ways to conserve water, regulate temperature, and defend against herbivores.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to describe the unique characteristics and adaptations of different types of plants, nutrient intake and movement of water and sugar, and reproduction in plants.		Benchmark 1: Students should be able to describe the unique processes including respiration, photosynthesis, nutrient intake and movement of water and sugar.	
<p>[SLO:B-09-H-01] Understand the concept of mineral nutrition in plants.</p> <p>[SLO:B-09-H-02] Categorize minerals nutrients of plants into macronutrients and micronutrients.</p> <p>[SLO:B-09-H-03] State that nitrogen is important in protein synthesis and magnesium for chlorophyll formation.</p> <p>[SLO:B-09-H-04] Explain the internal structure of root and root hair.</p> <p>[SLO:B-09-H-05] Conceptualize transport and its needs.</p> <p>SLO:B-09-H-06] Explain osmotic adjustments in plants.</p>		<p>[SLO:B-11-H-01] List the macro and micronutrients of plants highlighting the role of each nutrient.</p> <p>[SLO:B-11-H-02] State the examples of carnivorous plant.</p> <p>[SLO:B-11-H-03] Explain the role of stomata and palisade tissue in the exchange of gases in plants.</p> <p>[SLO:B-11-H-04] Relate transpiration with gaseous exchange in plants.</p> <p>[SLO:B-11-H-05] Describe the xylem elements in vessels, tracheids, fibers and phloem elements i.e. sieve tube, companion cells and relate their structures with functions.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
<p>[SLO:B-09-H-07] Describe how roots take up water and mineral salts by passive and active absorption.</p> <p>[SLO:B-09-H-08] Describe transpiration and relate this process with cell surface and stomatal opening and closing.</p> <p>[SLO:B-09-H-09] Describe temperature, wind and humidity as the factors affecting the rate of transpiration.</p> <p>[SLO:B-09-H-10] Describe mechanism of transport of water and salts in plants.</p> <p>[SLO:B-09-H-11] Explain the mechanism of food translocation by the theory of pressure flow mechanism.</p> <p>[SLO:B-09-H-12] Describe the process of gaseous exchange in plants.</p> <p>[SLO:B-09-H-13] Define reproduction and its types, asexual reproduction i.e. spore formation and vegetative propagation.</p> <p>[SLO:B-09-H-14] Distinguish between natural vegetative propagation (through stem, sucker and leaves) and artificial propagation (stem cuttings and grafting).</p>		<p>[SLO:B-11-H-06] Discuss the movement of water between plant cells, and between the cells and their environment in terms of water potential.</p> <p>[SLO:B-11-H-07] Describe the movement of water lateral roots in terms of symplast, apoplast and vacuolar pathways.</p> <p>[SLO:B-11-H-08] Explain the vertical movement of water in xylem through TACT mechanism.</p> <p>[SLO:B-11-H-09] Describe the mechanisms involved in the opening and closing of stomata.</p> <p>[SLO:B-11-H-10] Explain the movement of sugars within plants.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
[SLO: B-09-H-15] Rationalize how Apomixis is a type of asexual reproduction.			
N/A		Benchmark 2: Explain osmotic adjustment in plants and be acquainted with growth and movement in plants in response to environmental factors.	
		[SLO:B-11-H-11] Define osmotic adjustment. [SLO:B-11-H-12] State movement of water into or out of the cell in isotonic, hypotonic, and hypertonic conditions. [SLO:B-11-H-13] Explain the osmotic adjustments in hydrophytes, halophytes, xerophytes and mesophytes. [SLO:B-11-H-14] List the adaptations in plants to cope with low and high temperatures [SLO:B-11-H-15] Describe the turgor pressure and its significance in providing support to herbaceous plants. [SLO:B-11-H-16] Describe the structure of supporting tissues in plants. [SLO:B-11-H-17] Define growth and explain primary and secondary growth in plants. [SLO:B-11-H-18] Justify the formation of annual rings	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-H-19] Explain the influence of apical meristem on the growth of lateral shoots.</p> <p>[SLO:B-11-H-20] Outline the role of important plant growth regulators.</p> <p>[SLO:B-11-H-21] Explain the types of movement in plants in response to light, force of gravity, touch and chemicals.</p> <p>[SLO:B-11-H-22] Define photoperiodism.</p> <p>[SLO:B-11-H-23] Classify with examples plants on the basis of photoperiodism and Describe the mechanism of photoperiodism with reference to the mode of action of phytochrome.</p> <p>[SLO:B-11-H-24] Explain the role of low temperature treatment on flower production especially to biennials and perennials.</p>	



DOMAIN I: METABOLISM

Standard: *Students should be able to:*

- Define metabolism and describe how it is related to cellular respiration and photosynthesis.
- Explain the role of enzymes in metabolic reactions and describe the process of enzyme-catalyzed reactions.
- Define enzymes and explain their role in metabolic reactions.
- Describe the factors that affect enzyme activity, including temperature, pH, and substrate concentration.
- Explain the importance of enzymes in maintaining homeostasis and how disturbances can lead to disease

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to describe the concepts of metabolism, anabolism and catabolism, and explain how enzymes help in metabolism.		Benchmark 1: Students will be able to explain the role of enzymes in biological systems, including the facilitation of chemical reactions and regulation of metabolic pathways.	
[SLO:B-09-I-01] Understand metabolism and its types by providing illustrative examples.		[SLO:B-11-I-01] Describe enzyme structure. Identify the role and component parts of the active site of an enzyme.	
[SLO:B-09-I-02] Define Enzymes and describe their characteristics.		[SLO:B-11-I-02] Differentiate among the three types of cofactors i.e. in-organic ions, prosthetic group and coenzymes, with examples.	
[SLO:B-09-I-03] Explain how enzymes help in metabolism.		[SLO:B-11-I-03] Explain the mechanism of enzyme action with the help of lock and key and Induced Fit Model, compare induce fit model with Lock and Key model.	
[SLO:B-09-I-04] Explain the mechanism of enzyme action.		[SLO:B-11-I-04] Explain enzyme catalysis with example of specific reactions	
[SLO:B-09-I-05] Assess the factors which could influence enzyme activity.			
[SLO:B-09-I-06] Describe competitive and non-competitive inhibition.			



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-I-05] Define energy of activation and discuss through graph how an enzyme speeds up a reaction by lowering the energy of activation.</p>	
N/A		<p>Benchmark2: Students will be able to describe the factors that affect enzyme activity, including temperature, pH, substrate concentration, and inhibitors, and explain how used to control enzyme act these factors can be activity.</p>	
		<p>[SLO:B-11-I-06] Explain the effect of temperature on the rate of enzyme action with example of human and thermophilic bacteria</p> <p>[SLO:B-11-I-07] Investigate the effect of pH on enzyme activity Compare the optimum pH of different enzymes like trypsin, pepsin and papain.</p> <p>[SLO:B-11-I-08] Demonstrate that the concentration of enzyme affects the rate of enzyme action.</p> <p>[SLO: B-11-I-09] Describe enzymatic inhibition, its types and its significance with examples.</p> <p>[SLO:B-11-I-10] Name the molecules which act as inhibitors.</p> <p>[SLO:B-11-I-11] Categorize inhibitors into competitive and non-competitive inhibitors.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-I-12] Explain feedback inhibition.</p> <p>[SLO:B-11-I-13] Classify enzymes on the basis of the catalytic reactions (oxido-reductases, transferases, hydrolases, isomerases, and ligases).</p> <p>[SLO:B-11-I-14] Classify enzymes on the basis of their substrate (lipases, diastase, amylase, protease, etc.).</p>	
Benchmark 2: Students should be able to explain the processes of cellular respiration and photosynthesis and the energy conversions.		Benchmark3: Explain in detail how photosynthesis and respiration occurs and understand the processes involved.	
<p>[SLO:B-09-I-07] Define bio-energetic and its role in understanding the conversions of energy in an organism.</p> <p>[SLO:B-09-I-08] Discuss the role of ATP as energy currency.</p> <p>[SLO:B-09-I-09] Describe photosynthesis in plants.</p> <p>[SLO:B-09-I-10] Define cellular respiration and differentiate between aerobic and anaerobic respiration.</p>		<p>[SLO:B-11-I-15] Define photosynthesis and explain the role of light, carbon dioxide and water in photosynthesis</p> <p>[SLO:B-11-I-16] Identify the two general kinds of photosynthetic pigments (carotenoids and chlorophylls)</p> <p>[SLO:B-11-I-17] Describe the roles of photosynthetic pigments in the absorption and conversion of light energy</p> <p>[SLO:B-11-I-18] Differentiate between the absorption spectra of chlorophyll ‘a’ and ‘b’</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-I-19] Describe the arrangement of photosynthetic pigments in photosystem-I and II.</p> <p>[SLO:B-11-I-20] Describe the events of non-cyclic photophosphorylation and cyclic Photophosphorylation.</p> <p>[SLO:B-11-I-21] Explain the Calvin cycle (the regeneration of RuBP should be understood in outline only)</p> <p>[SLO:B-11-I-22] Define respiration and explain the process of anaerobic respiration in terms of glycolysis and conversion of pyruvate into lactic acid or ethanol.</p> <p>[SLO:B-11-I-23] Outline the link between conversions of pyruvate into acetyl-CoA.</p> <p>[SLO:B-11-I-24] Outline the steps of Krebs cycle.</p> <p>[SLO:B-11-I-25] Trace the passage of electrons through the electron transport chain.</p> <p>[SLO:B-11-I-26] Describe chemiosmosis and relate it with electron transport chain.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-I-27] Explain the substrate level phosphorylation during which exergonic reactions are coupled with the synthesis of ATP.</p> <p>[SLO:B-11-I-28] Justify the importance of G3P in photosynthesis</p> <p>[SLO:B-11-I-29] Outline the formation of acetyl CoA from fats</p> <p>[SLO:B-11-I-30] Compare and contrast oxidation of fats and glucose.</p> <p>[SLO:B-11-I-31] Define photo respiration</p> <p>[SLO:B-11-I-32] Outline the events occurring through photorespiration.</p> <p>[SLO:B-11-I-33] Rationalize how the disadvantageous process of photo respiration evolved.</p> <p>[SLO:B-11-I-34] Explain the effect of temperature on the oxidative activity of RuBP carboxylase.</p> <p>[SLO:B-11-I-35] Outline the process of C4 and CAM photosynthesis as an adaptation evolved in some plants to deal with the problem of photorespiration.</p>	



DOMAIN J: HUMAN PHYSIOLOGY

Standard: *Students should be able to:*

- Describe the structure and function of the various systems of the human body, including the skeletal, muscular, respiratory, circulatory, digestive, urinary, and nervous systems.
- Explain the role of hormones in regulating body functions and describe the endocrine system.
- Describe the processes of cellular respiration and energy production and their relationship to human health.
- Explain how the human body maintains homeostasis and the role of feedback mechanisms.
- Describe how the different systems of the body interact to maintain health and respond to disease and injury

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Student should be able to identify structure and functions of human digestive, circulatory, respiratory and urinary systems and their common disorders.		Benchmark 1: Identify and explain the functions of the major organs of the digestive system in the human body.	
	<p>[SLO:B-10-J-01] Concept of holozoic nutrition and its steps i.e. ingestion, digestion, absorption, assimilation and egestion.</p> <p>[SLO:B-10-J-02] Identify the structures and functions of the gastrointestinal tract (GIT) and associated glands.</p> <p>[SLO:B-10-J-03] Concept of swallowing and peristalsis.</p> <p>[SLO:B-10-J-04] Sort out the action of enzymes and other secretions, secreted in specific regions of gastrointestinal tract and associated glands with respect to their substrates and products.</p> <p>[SLO:B-10-J-05] Understand why liver is secretory, metabolic, storage and detoxification center of the body.</p>	<p>[SLO:B-11-J-01] Describe digestion, discuss mechanical and chemical digestion in the oral cavity.</p> <p>[SLO:B-11-J-02] Explain the process of swallowing. Explain peristalsis.</p> <p>[SLO:B-11-J-03] Illustrate with diagram, the structure of the stomach and relate each component with the mechanical and chemical digestion in the stomach.</p> <p>[SLO:B-11-J-04] Identify the role of the nervous system and gastrin hormone on the secretion of gastric juice.</p> <p>[SLO:B-11-J-05] Describe the major actions carried out on food in the three regions of the small intestine.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>[SLO:B-10-J-06] Understand the structure of a villus, including the roles of capillaries and lacteals.</p> <p>[SLO:B-10-J-07] Identify the signs and symptoms, causes as well as risk factors, treatments and preventions of the disorders of gastrointestinal tract (GIT) i.e. diarrhea, constipation, and peptic ulcer.</p> <p>[SLO:B-10-J-08] Understand the pathways of pulmonary and systemic circulation.</p> <p>[SLO:B-10-J-09] Identify and describe the structures and general functions of each organ of the cardiovascular system (CVS).</p> <p>[SLO:B-10-J-10] Recognize and describe the components of blood.</p> <p>[SLO:B-10-J-11] Identify cell types found in blood and their roles.</p> <p>[SLO:B-10-J-12] Understand that blood is also work as transporting medium.</p> <p>[SLO:B-10-J-13] Explain the structure (external and internal) of the human heart with a diagram.</p>	<p>[SLO:B-11-J-06] Trace the absorption of digested products from the small intestine, lumen to the blood capillaries and lacteals of the villi.</p> <p>[SLO:B-11-J-07] Describe the component parts of large intestine with their respective roles.</p> <p>[SLO:B-11-J-08] Correlate the involuntary reflex for egestion in infants and the voluntary control in adults.</p> <p>[SLO:B-11-J-09] Explain the storage and metabolic role of the liver.</p> <p>[SLO:B-11-J-10] Describe composition of bile and relate its constituents with respective roles.</p> <p>[SLO:B-11-J-11] Outline the structure of pancreas and explain its function as an exocrine gland.</p> <p>[SLO:B-11-J-12] Relate the secretion of bile and pancreatic juice with the secretin and cholecystokinin hormones.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>[SLO:B-10-J-14] Identify common sign and symptoms of heart diseases. i.e. Coronary Heart Disease, Myocardial Infarction, Angina pectoris.</p> <p>[SLO:B-10-J-15] Enlist the harmful effects of smoking related to cardiovascular diseases (CVD)</p> <p>[SLO:B-10-J-16] Identify the air passageway and role of lungs.</p> <p>[SLO:B-10-J-17] Understand the mechanism of breathing in terms of movement of ribs and diaphragm.</p> <p>[SLO:B-10-J-18] Differentiate between the composition of inspired and expired air.</p> <p>[SLO:B-10-J-19] Identify sign and symptoms of disorders i.e. Bronchitis, Asthma, pneumonia, emphysema and lung cancer.</p> <p>[SLO:B-10-J-20] Recognize structure and general functions of each organ of the urinary system.</p> <p>[SLO:B-10-J-21] Understand the external and internal structure and functions of kidney</p>		



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>[SLO:B-10-J-22] Understand structure and function of nephron as basic unit of kidney.</p> <p>[SLO:B-10-J-23] Identify the role of kidney in the formation and composition of urine.</p> <p>[SLO:B-10-J-24] Identify that how kidney works as osmoregulatory organ.</p> <p>[SLO:B-10-J-25] Outline the causes of kidney failure and treatments.</p>		
N/A		Benchmark 2: Identify and explain the functions of the major organs of the circulatory system in the human body.	
		<p>[SLO:B-11-J-13] Define circulatory system and its types, explain the components of human circulatory system</p> <p>[SLO:B-11-J-14] State the location of heart and describe the role of pericardium, explain the structure of the walls of heart and rationalize the thickness of the walls of each chamber.</p> <p>[SLO:B-11-J-15] Trace the flow of blood through the heart as regulated by the valves.</p> <p>[SLO:B-11-J-16] State the phases of Heartbeat.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-J-17] Explain the role of SA node, AV node and Purkinje fibers in controlling the heartbeat.</p> <p>[SLO:B-11-J-18] List the principles and uses of Electrocardiogram.</p> <p>[SLO:B-11-J-19] Describe the detailed structure of arteries, veins and capillaries.</p> <p>[SLO:B-11-J-20] Describe the role of arterioles in vasoconstriction and vasodilation.</p> <p>[SLO:B-11-J-21] Describe the role of pre capillary sphincters in regulating the flow of blood through capillaries.</p> <p>[SLO:B-11-J-22] Trace the path of the blood through the pulmonary and systemic circulation (coronary, hepatic portal and renal circulation).</p> <p>[SLO:B-11-J-23] Compare the rate of blood flow through arteries, arterioles, capillaries, venules and veins.</p> <p>[SLO:B-11-J-24] Define blood pressure and explain its periods of systolic and diastolic pressure.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-J-25] State the role of baroreceptors and volume receptors in regulating the blood pressure.</p> <p>[SLO:B-11-J-26] Define the term thrombus and differentiate between thrombus and embolus.</p> <p>[SLO:B-11-J-27] Identify the factors Causing atherosclerosis and arteriosclerosis.</p> <p>[SLO:B-11-J-28] Categorize Angina pectoris, heart attack, and heart failure as the stages of cardiovascular disease development.</p> <p>[SLO:B-11-J-29] State the congenital heart problem related to the malfunctioning of cardiac valves.</p> <p>[SLO:B-11-J-30] Describe the principles of angiography.</p> <p>[SLO:B-11-J-31] Outline the main principles of coronary bypass, angioplasty and open-heart surgery.</p> <p>[SLO:B-11-J-32] Define hypertension and describe the factors that regulate blood pressure as hypertension and hypotension.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-J-33] List the changes in lifestyles that can protect man from hypertension and cardiac problems.</p> <p>[SLO:B-11-J-34] Describe the formation, composition and function of intercellular fluid.</p> <p>[SLO:B-11-J-35] Compare the composition of intercellular fluid with that of lymph.</p> <p>[SLO:B-11-J-36] Explain the structure and role of lymph capillaries, lymph vessels and lymph ducts.</p> <p>[SLO:B-11-J-37] Describe the functions of lymph nodes and state the role of spleen as containing lymphoid tissue</p>	
N/A		Benchmark 3: Identify and explain the functions of the major organs of the respiratory system in the human body.	
		<p>[SLO:B-11-J-38] Define the respiratory surface and list its properties</p> <p>[SLO:B-11-J-39] Describe the main structural features and functions of the components of human respiratory system.</p> <p>[SLO:B-11-J-40] Explain the ventilation mechanism in humans.</p>	



Grade – IX	Grade – X	Grade – XI	Grade – XII
		<p>[SLO:B-11-J-41] Discuss the transport of oxygen and carbon dioxide through blood and outline the role of respiratory pigments in it</p> <p>[SLO:B-11-J-42] State the causes, symptoms and treatment of upper Respiratory Tract Infections (sinusitis, otitis media) and lower Respiratory Tract Infections (pneumonia, Pulmonary tuberculosis).</p> <p>[SLO:B-11-J-43] Describe the disorders of lungs(emphysema and COPD)</p> <p>[SLO:B-11-J-44] List the effects of smoking on respiratory system</p>	
N/A		<p>Benchmark 4: Identify the concept of homeostasis and explain three main types of homeostasis that is osmoregulation, excretion and thermoregulation in human body.</p>	
			<p>[SLO:B-12-J-01] Describe homeostasis and three elements i.e. receptors, control center and effectors which operate homeostatic mechanisms.</p> <p>[SLO:B-12-J-02] Relate the homeostatic mechanisms with the negative and positive feedback systems.</p> <p>[SLO:B-12-J-03] Define osmoregulation.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-J-04] Differentiate between osmoconformers and osmoregulators.</p> <p>[SLO:B-12-J-05] Explain the problems faced by osmoregulators.</p> <p>[SLO:B-12-J-06] Explain the different methods of osmoregulation found in freshwater, marine water and terrestrial animals.</p> <p>[SLO:B-12-J-07] Describe urinary system and need of excretion.</p> <p>[SLO:B-12-J-08] Enlist various nitrogenous compounds excreted during the process of excretion. Explain the nature of excretory products in relation to habitat.</p> <p>[SLO:B-12-J-09] Enlist different organs of the urinary system.</p> <p>[SLO:B-12-J-10] Describe the structure of kidney</p> <p>[SLO:B-12-J-11] Relate the structure of the kidney with its function.</p> <p>[SLO:B-12-J-12] Explain the detailed structure of a nephron.</p> <p>[SLO:B-12-J-13] Explain the processes of glomerular filtration,</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>selective re-absorption and tubular secretion and counter current exchange as the events in kidney functioning.</p> <p>[SLO:B-12-J-14] Explain regulatory mechanism involved in concentration of urine</p> <p>[SLO:B-12-J-15] Justify the functioning of kidneys as both excretion and osmoregulation.</p> <p>[SLO:B-12-J-16] Compare the function of two major capillary beds in kidneys i.e. glomerular capillaries and peritubular capillaries.</p> <p>[SLO:B-12-J-17] List urinary tract infections and the bacteria responsible.</p> <p>[SLO:B-12-J-18] Explain the cause and treatments of kidney stones.</p> <p>[SLO:B-12-J-19] Outline the causes of kidney failure.</p> <p>[SLO:B-12-J-20] Explain in detail the mechanism and problems related to dialysis.</p> <p>[SLO:B-12-J-21] Describe the principles and the problems associated with kidney transplant.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-J-22] Define thermoregulation and explain its need.</p> <p>[SLO:B-12-J-23] Classify animals on the basis of the source of body heat i.e. ectotherms and endotherms.</p> <p>[SLO:B-12-J-24] Describe the regulatory strategies in man for thermoregulation</p>
N/A		Benchmark 5: Identify and explain the functions of the major organs of the skeletal system in the human body.	
			<p>[SLO:B-12-J-25] Describe the structure of bone and compare it with that of cartilage.</p> <p>[SLO:B-12-J-26] Explain the functions of osteoblasts, osteoclasts and osteocytes.</p> <p>[SLO:B-12-J-27] Identify the main divisions of the human skeleton and list the bones of the axial and appendicular skeleton of man.</p> <p>[SLO:B-12-J-28] Describe three types of joints i.e. fibrous joints, cartilaginous joints and synovial joints and give example of each.</p> <p>[SLO:B-12-J-29] Describe the disorders of human skeleton (disc-slip, spondylosis, sciatica, arthritis and</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>osteoporosis) and their causes.</p> <p>[SLO:B-12-J-30] State different types of fractures (simple, compound and complicated) and describe the repair process of simple fractures.</p> <p>[SLO:B-12-J-31] Describe the injuries in joints (dislocation and sprain) and their first aid treatment.</p> <p>[SLO:B-12-J-32] Compare smooth muscles, cardiac muscles and skeletal muscles.</p> <p>[SLO:B-12-J-33] Annotate the ultrastructure of the skeletal muscle.</p> <p>[SLO:B-12-J-34] Explain the sliding filaments theory of muscle contraction.</p> <p>[SLO:B-12-J-35] Describe the action of antagonistic muscles in the movement of knee joint.</p> <p>[SLO:B-12-J-36] Explain muscle fatigue, cramps and tetany.</p> <p>[SLO:B-12-J-37] Differentiate between tetanus and muscle tetany.</p>



DOMAIN K: COORDINATION AND CONTROL

Standard: Students should be able to:

- Describe the structure and function of the nervous system, including the central and peripheral nervous systems.
- Explain the role of neurons in transmitting and processing information.
- Describe the process of neurotransmission and how it affects the functioning of the nervous system.
- Explain how the nervous system regulates and coordinates body functions, including the role of reflex arcs.
- Describe the structure and function of the human endocrine system, including the role of hormones in regulating body functions.
- Explain the process of hormone secretion, including the role of the hypothalamus and pituitary gland.
- Describe the effects of hormones on various target tissues, including the growth and development of cells and tissues.
- Explain the role of hormones in regulating metabolism and energy balance, including the regulation of glucose and insulin levels

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to describe the organization of the nervous system, also explain the role of brain, spinal cord, and nerves in transmitting signals, chemical coordination responses		Benchmark 1: Students should be able to explain the functions of the nervous system, including the structure, types and function of neurons, nerve impulses, reflex action, synapses and neurotransmitters types and their roles.	
	<p>[SLO:B-10-K-01] Concept of neuron, outline the types of neurons with diagrams.</p> <p>[SLO:B-10-K-02] Concept of stimulus and response with examples.</p> <p>[SLO:B-10-K-03] Understand the mechanism of nerve impulse as electrochemical signal that travel across neuron</p> <p>[SLO:B-10-K-04] Sketch synapses</p> <p>[SLO:B-10-K-05] Concept of neurotransmitters</p> <p>[SLO:B-10-K-06] Sketch out the involvement of the nervous system when a</p>		<p>[SLO:B-12-K-01] Recognize receptors as transducers sensitive to various stimuli.</p> <p>[SLO:B-12-K-02] Trace the path of a message transmitted to the CNS (central nervous system) for processing.</p> <p>[SLO:B-12-K-03] Identify muscles and glands as the effectors.</p> <p>[SLO:B-12-K-04] Describe the detailed structure of neuron and explain types of neuron as sensory neuron, associative and motor neuron</p> <p>[SLO:B-12-K-05] Differentiate between myelinated and unmyelinated neurons.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>person accidentally touches something painfully hot and withdraws hand as a reflex.</p> <p>[SLO:B-10-K-07] Understand the nervous system and its role.</p> <p>[SLO:B-10-K-08] Concept of central nervous system and peripheral nervous system.</p> <p>[SLO:B-10-K-09] Define drugs and their effect on nervous system.</p> <p>[SLO:B-10-K-10] Concept of gland and differentiate between endocrine and exocrine glands. Emphasis the endocrine system.</p> <p>[SLO:B-10-K-11] List out major endocrine glands and their hormones with functions.</p>		<p>[SLO:B-12-K-06] Explain reflex action with the help of reflex arc (monosynaptic and polysynaptic).</p> <p>[SLO:B-12-K-07] Define nerve impulse. Describe the generation and transmission of nerve impulse.</p> <p>[SLO:B-12-K-08] Describe the factors responsible for the resting membrane potential of neuron.</p> <p>[SLO:B-12-K-09] Evaluate from a graph the phenomena of polarization, depolarization and hyper polarization of neurolemma.</p> <p>[SLO:B-12-K-10] Compare the velocities of nerve impulse in the axon membrane and in the synaptic cleft.</p> <p>[SLO:B-12-K-11] Describe the role of local circuits in saltatory conduction of nerve impulse.</p> <p>[SLO:B-12-K-12] Outline the structure of synapse. Describe the synaptic transmission of nerve impulse.</p> <p>[SLO:B-12-K-13] Classify neurotransmitters as inhibitory and excitatory and list some common examples.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-K-14] Identify the main components of the nervous system.</p> <p>[SLO:B-12-K-15] Describe the architecture of human brain, explain its major divisions and subdivisions of brain along with their vital functions.</p> <p>[SLO:B-12-K-16] Explain peripheral nervous system, Sketch out cranial and spinal nerves in human.</p> <p>[SLO:B-12-K-17] Explain the structure, types and functions of autonomic nervous system.</p>
N/A		<p>Benchmark 2: Students should be able to describe the role of chemical messenger (pheromones and hormones) and the endocrine system in maintaining homeostasis in the human body.</p>	
			<p>[SLO:B-12-K-18] Define chemical messengers. describe pheromones and hormones as chemical messengers.</p> <p>[SLO:B-12-K-19] Describe the chemical nature of hormones and correlate it with important human hormones.</p> <p>[SLO:B-12-K-20] Locate the major endocrine glands in human body name the hormones they release and their functions; (pituitary, pineal, thyroid, parathyroid, thymus,</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>pancreas, adrenal, gonads.)</p> <p>[SLO:B-12-K-21] Enlist hormones of other endocrine tissues.</p> <p>[SLO:B-12-K-22] Relate the problems associated with the imbalance of these hormones.</p> <p>[SLO:B-12-K-23] Explain the Neurosecretory role of hypothalamus.</p> <p>[SLO:B-12-K-24] Outline the concept of Feedback mechanism of hormones and describe positive feedback with reference to Oxytocin and negative feedback with reference to Insulin and Glucagon</p>
N/A		Benchmark 3: Students should be able to explain how different sensory receptors work; effect of drugs on these receptors and the nervous system.	
			<p>[SLO:B-12-K-25] Explain the structure and function for smell, taste, vision, hearing, touch and pain receptors.</p> <p>[SLO:B-12-K-26] Define narcotic drugs as agents that interact with normal nervous activities.</p> <p>[SLO:B-12-K-27] Compare the use and abuse of drugs with respect to nicotine, caffeine, opium, cannabis, heroine, alcohol and inhalants like</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>nail polish remover and glue.</p> <p>[SLO:B-12-K-28] Explain the terms; drug addiction and drug tolerance with reference to caffeine and nicotine and their adverse effects on the nervous system.</p> <p>[SLO:B-12-K-29] Describe the way how analgesic can reduce or numb pain. Discuss how these can be addictive.</p> <p>[SLO:B-12-K-30] Classify nervous disorders their symptoms into vascular (stroke), infectious (encephalitis and meningitis), structural (tumor), functional (headache, epilepsy) and degenerative (Alzheimer and Parkinson's).</p> <p>[SLO:B-12-K-31] Explain the principles of the important diagnostic tests for nervous disorders i.e. EEG, CT scan and MRI</p>



DOMAIN L: REPRODUCTION AND INHERITANCE

Standard: *Students should be able to:*

- Describe the processes of reproduction in organisms, including asexual and sexual reproduction.
- Explain the role of meiosis in producing genetically diverse offspring.
- Describe the structure and function of gametes and the role of fertilization in sexual reproduction.
- Explain the patterns of inheritance, including dominant and recessive traits, and how they are influenced by genes and chromosomes.
- Describe how genetic variation and mutations can lead to evolutionary change.
- Describe the central dogma of molecular biology, which outlines the flow of genetic information from DNA to RNA to protein.
- Explain the basic structure and function of genes, including the role of codons and introns.
- Distinguish between different types of inheritance patterns, including dominant and recessive traits, and sex-linked traits.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to explain the differences between asexual and sexual reproduction, and describe the steps involved in the process of fertilization, development, and birth.		Benchmark 1: Students should be able to explain the human reproductive system; their hormones, female reproductive cycles, disorders and STDs.	
	<p>[SLO:B-10-L-01] Concept of Reproduction, types of reproduction i.e. asexual and sexual reproduction.</p> <p>[SLO:B-10-L-02] Understand the process of gametogenesis and fertilization.</p> <p>[SLO:B-10-L-03] Understand the role of hormones in both male and female sexual development.</p> <p>[SLO:B-10-L-04] Concept of gene, allele genotype, phenotype, homozygous, heterozygous, dominant, and recessive.</p> <p>SLO:B-10-L-05] Understand the concept of Mendelian inheritance laws with the help of</p>		<p>[SLO:B-12- L-01] Describe the organs of the male reproductive system and identify their functions</p> <p>[SLO:B-12-L-02] Outline the hormones which influence male reproductive system.</p> <p>[SLO:B-12-L-03] Explain common disorder related to male reproductive system.</p> <p>[SLO: B-12-L-04] Explain the organs of female reproductive system and describe their functions</p> <p>[SLO: B-12-L-05] Describe the menstrual cycle and its hormonal control.</p> <p>[SLO:B-12-L-06]</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>monohybrid and dihybrid cross.</p> <p>[SLO:B-10-L-06] Correlate the Mendalian factors with chromosomes.</p> <p>[SLO:B-10-L-07] Concept of Autosome and sex chromosomes, describe sex determination in humans.</p>		<p>Explain common disorders related to female reproductive system</p> <p>[SLO:B-12-L-07] Describe common STDs (Gonorrhea, syphilis, herpes and HIV infection)</p>
N/A		<p>Benchmark 2: Students will be able to explain the laws of inheritance, including the principles of dominant and recessive genes, segregation, independent assortment, understand and demonstrate how traits are passed from parents to offspring.</p>	
			<p>[SLO:B-12-L-08] Define inheritance, describe gene as unit of inheritance.</p> <p>[SLO:B-12-L-09] Explain the Law of Segregation and Independent Assortment, using suitable example of pea plant.</p> <p>[SLO:B-12-L-10] Relate the Law of Independent Assortment to random orientation of chromosomes during meiosis.</p> <p>[SLO:B-12-L-11] Express limitations of Independent Assortment and its usefulness.</p> <p>[SLO:B-12-L-12] Describe the exceptions to the Mendel's Laws of inheritance.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-L-13] Explain incomplete dominance and exemplify it through the inheritance of flower colour in 4 O' clock plant.</p> <p>[SLO:B-12-L-14] Describe coat colour in cattle as an example of co-dominance and differentiate between incomplete dominance and co-dominance.</p> <p>[SLO:B-12-L-15] Define multiple alleles with the example of ABO blood groups.</p> <p>[SLO:B-12-L-16] Investigate the reasons for O-ve individual as the Universal donor and AB +ve as the Universal recipient.</p> <p>[SLO:B-12-L-17] Enlist various human blood group systems.</p> <p>[SLO:B-12-L-18] Relate the positive and negative blood types with the presence and absence of Rh factor.</p> <p>[SLO:B-12-L-19] Justify why Rh incompatibility could be a danger to the developing foetus and mother.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-L-20] Suggest measures to counter the problem of Erythroblastosis fetalis before it occurs.</p> <p>[SLO:B-12-L-21] Define gene interaction and relate the terms polygenic inheritance and epistasis.</p> <p>[SLO:B-12-L-22] Describe polygenic inheritance using suitable examples from plants (grain colour in wheat) and animals (skin colour in man).</p> <p>[SLO:B-12-L-23] List at least five polygenic traits discovered in human.</p> <p>[SLO:B-12-L-24] Describe coat color in Labrador retrievers and pigment phenotype in foxgloves; and Bombay phenotype as an example of recessive epistasis justify modified Mendelian ratios.</p> <p>[SLO:B-12-L-25] Compare the terms gene linkage and crossing over.</p> <p>[SLO:B-12-L-26] Explain that gene linkage counters Independent Assortment and crossing-over modifies the progeny.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-L-27] Suggest that linkage can be observed / evaluated only if the number of progeny is quite large.</p> <p>[SLO:B-12-L-28] Explain the mechanisms of sex determination in animals.</p> <p>[SLO:B-12-L-29] Identify male and female individuals from the karyotype of man.</p> <p>[SLO:B-12-L-30] Solve the genetics problems related to XX-XY sex determination.</p> <p>[SLO:B-12-L-31] Describe the concept of sex-linked inheritance.</p> <p>[SLO:B-12-L-32] Explain the inheritance of sex-linked traits (eye colour) in <i>Drosophila</i>.</p> <p>[SLO:B-12-L-33] Define sex-linked inheritance in human as X-linked and Y-linked. Explain X-linked disorders in human (colour blindness and haemophilia).</p> <p>[SLO:B-12-L-34] Describe the Y-linked inheritance in human and explain holandric genes.</p> <p>[SLO:B-12-L-35] Explain the techniques employed for embryonic screening e.g., Amniocentesis and</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			Chorionic Villus Sampling.
N/A		Benchmark 3: Students should be to understand mechanism of DNA replication and its discovery.	
			<p>[SLO:B-12-L-36] Narrate the experimental work of Griffith; Avery, McCarty, Macleod and Hershey-Chase, proved DNA as the hereditary material.</p> <p>[SLO:B-12-L-37] Define DNA replication and explain the three models proposed about the mechanism of DNA replication.</p> <p>[SLO:B-12-L-38] Narrate the work of Meselson and Stahl to justify the semi conservative replication as the method of replication.</p> <p>[SLO:B-12-L-39] Describe the events of the process of DNA replication.</p> <p>[SLO:B-12-L-40] Describe DNA stability and variability as two characters of the replicating DNA molecule.</p>
N/A		Benchmark 4: Students should be able to understand the process of transcription and translation as part of the protein synthesis process.	
			[SLO:B-12-L-41] Describe the characteristics of genetic code (Universal, triplet, non-overlapping, co-linearity, unambiguous,



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>degenerate, and has no punctuation).</p> <p>[SLO:B-12-L-42] Differentiate between the terms genetic code and codon.</p> <p>[SLO:B-12-L-43] Define central dogma, describe the mechanism of protein synthesis.</p> <p>[SLO:B-12-L-44] Explain the mechanism of transcription.</p> <p>[SLO:B-12-L-45] Explain why the length of transcribed mRNA molecule (in Eukaryotes) shortens as it enters the cytoplasm for translation.</p> <p>[SLO:B-12-L-46] Differentiate between protein synthesis in prokaryotes and eukaryotes.</p> <p>[SLO:B-12-L-47] Suggest possible ways in which the synthesized protein can be used within or outside a cell that synthesized it.</p> <p>[SLO:B-12-L-48] State the importance of the regulation of gene expression.</p> <p>[SLO:B-12-L-49] Explain mechanism of positive and negative gene expression through activator and repressor protein, respectively.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-L-50] Define mutation and identify its causes.</p> <p>[SLO:B-12-L-51] Differentiate between natural and induced mutations.</p> <p>[SLO:B-12-L-52] Justify most mutations are harmful.</p> <p>[SLO:B-12-L-53] Rationalize that mutations might be a contributing factor towards evolution.</p> <p>[SLO:B-12-L-54] Describe the symptoms and causes of the chromosomal mutations. (Down's syndrome, Klinefelter's syndrome and Turner's syndrome)</p> <p>[SLO:B-12-L-55] Describe the symptoms and causes of some of the gene mutations.</p>



DOMAIN M: DISEASES AND IMMUNITY

Standard: *Students should be able to:*

- Describe the causes of diseases, including infectious and non-infectious diseases.
- Explain the role of pathogens, including viruses, bacteria, fungi, and parasites, in causing disease.
- Describe the body's immune response to pathogens, including the role of white blood cells, antibodies, and the complement system.
- Explain how vaccines work and the importance of herd immunity.
- Describe how genetic factors can affect susceptibility to disease and describe examples of inherited diseases.
- Explain the mechanisms of immune tolerance and autoimmunity and their impact on human health.
- Describe the role of vaccines in preventing disease and the mechanism of action of various vaccine types, including live attenuated, inactivated, and subunit vaccines.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students Should be able to explain the mechanisms of the immune system, including the role of white blood cells, antibodies, and vaccines, and describe how they protect the body against invading pathogens and promote recovery from infection.		Benchmark 1: Students should be able to explain the functioning and interplay of the various components of the immune system of human body in identifying and combating pathogens.	
	<p>[SLO:B-10-M-01] Concept of illness, infection, disease and pathogen.</p> <p>[SLO:B-10-M-02] List different types of pathogens, e.g. Viruses, Bacteria, Protozoa and Fungi; list their common diseases such as polio, typhoid, malaria and ringworm.</p> <p>[SLO:B-10-M-03] Concept of immunity and list the role of the immune system.</p> <p>[SLO:B-10-M-04] Concept of innate and adaptive immunity with examples; three lines of defenses; components of human immune system i.e., Lymphatic system, lymph nodes and lymph;</p>		<p>[SLO:B-12-M-01] List the structural features of human skin that make it an impenetrable barrier against invasion by microbes.</p> <p>[SLO:B-12-M-02] Explain how sebaceous (oil secreting) and sweat glands within the epidermis inhibit the growth and also kill microorganisms.</p> <p>[SLO:B-12-M-03] Recognize the role of the acid of the digestive tract as killing bacteria present in food.</p> <p>[SLO:B-12-M-04] Explain the role of the ciliated epithelium of the nasal cavity, the mucous of the bronchi and</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>Types of immune cells in our blood and their roles.</p> <p>[SLO:B-10-M-05] State the function of adaptive immunity</p> <p>[SLO:B-10-M-06] Concept of vaccine which helps to boost immunity with examples of polio and typhoid.</p>		<p>bronchioles in trapping airborne microorganisms.</p> <p>[SLO:B-12-M-05] Describe the role of monocytes, macrophages, dendritic cells and neutrophils.</p> <p>[SLO:B-12-M-06] Explain how Natural Killer (NK) cells kill infected and cancerous cells.</p> <p>[SLO:B-12-M-07] State the way proteins of the complement system kill bacteria and that interferon inhibits viruses from infecting cells.</p> <p>[SLO:B-12-M-08] State the events of the inflammatory response as a generalized, non-specific defense.</p> <p>[SLO:B-12-M-09] Outline the release of pyrogens and their effect on the hypothalamus to boost the body's temperature.</p> <p>[SLO:B-12-M-10] List the ways that fever affects microbes.</p> <p>[SLO:B-12-M-11] Define the specific immune system as providing specific defense and acting as the most powerful means of resisting infection.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>[SLO:B-12-M-12] Identify T-cells, and B-cells as components of the immune system.</p> <p>[SLO:B-12-M-13] State inborn and acquired immunity as the two basic types of immunity.</p> <p>[SLO:B-12-M-14] Differentiate between active and passive immunity as the two types of acquired immunity.</p> <p>[SLO:B-12-M-15] Describe the role of T-cells in cell-mediated immunity.</p> <p>[SLO:B-12-M-16] Describe the role of B-cells in antibody-mediated immunity.</p> <p>[SLO:B-12-M-17] Discuss the role of T-cells and B-cells in transplant rejections.</p>
Benchmark 2: Student should be able to understand how numerous illnesses like Diabetes, Cancer, COVID-19, Alzheimer's, and other prevalent diseases harm the body and the measures that are taken to treat them.		Benchmark 2: Student should be able to describe the types of vaccines, their mechanisms of action and the types of acquired immunity.	
	<p>[SLO:B-10-M-07] Describe the discovery of Penicillin.</p> <p>[SLO:B-10-M-08] Concept of Antibiotics</p> <p>[SLO:B-10-M-09] Understand diabetes and its sub-types explain the effects on the human body.</p> <p>[SLO:B-10-M-10]</p>		<p>[SLO:B-12-M-18] Identify the process of vaccination as a means to develop active acquired immunity.</p> <p>[SLO:B-12-M-19] Describe the types of antibodies and their role. Draw the structure of IgG antibody.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>Understand cancer and its effects on the human body.</p> <p>[SLO:B-10-M-11] Understand Covid19 and list the harmful effects on the human body.</p> <p>[SLO:B-10-M-12] Understand that HIV compromises the Immune system and over times leads to development Acquired Immune Deficiency Syndrome (AIDS).</p> <p>[SLO:B-10-M-13] Describe infectious and non-infectious diseases and their types with examples.</p> <p>[SLO:B-10-M-14] Define zoonotic diseases and give their types.</p> <p>[SLO:B-10-M-15] Describe vector borne diseases with Examples.</p> <p>[SLO:B-10-M-16] Enlist allergies with some common types.</p> <p>[SLO:B-10-M-17] Understand plant diseases commonly present in Pakistan, in terms of their effect on plant health and yield and their treatment. (Rust, smut, red rot of sugarcane)</p>		<p>[SLO:B-12-M-20] Explain the role of memory cells in long term immunity.</p> <p>[SLO:B-12-M-21] Define allergies and correlate the symptoms of allergies with the release of histamines.</p> <p>[SLO:B-12-M-22] Describe the autoimmune diseases with examples.</p>



DOMAIN N: BIOTECHNOLOGY

Standard: *Students should be able to:*

- Describe the process of gene cloning and how it is used in biotechnology.
- Describe the application of biotechnology in various fields, including medicine, agriculture, and industry.
- Explain the principles of genetic engineering and recombinant DNA technology, including gene cloning, PCR, and sequencing.
- Describe the use of biotechnology in producing therapeutic proteins, including vaccines, monoclonal antibodies, and growth hormones.
- Explain the principles of synthetic biology, including metabolic engineering, gene circuit design, and biosensors.

Grade – IX	Grade – X	Grade – XI	Grade – XII
Benchmark 1: Students should be able to explain the basic principles of biotechnology and applications in agriculture, medicine, gene editing, marine biology, environment and industry.		Benchmark 1: Student should be able to describe the genetic engineering, recombinant DNA technology and addressing global issues, including organ transplant, healthcare and environment.	
	<p>[SLO:B-10-N-01] Concept of biotechnology.</p> <p>[SLO:B-10-N-02] Understand with examples that food biotechnology is advanced field of agriculture especially in Pakistan.</p> <p>[SLO:B-10-N-03] Understand with examples that medical biotechnology has advanced healthcare methods in diabetes and cancer.</p> <p>[SLO:B-10-N-04] State the potential advantages that genetic editing provides in the context of medicine and agriculture, give some examples.</p>		<p>[SLO:B-12-N-01] Introduce genetic-engineering.</p> <p>[SLO:B-12-N-02] Describe plasmid as vector prokaryotes and explain how recombinant plasmids can be formed</p> <p>[SLO:B-12-N-03] Outline the Function of Restriction Enzymes</p> <p>[SLO:B-12-N-04] Define Genetically modified organism (GMO).</p> <p>[SLO:B-12-N-05] Explain the formation of human insulin protein in bacteria.</p> <p>[SLO:B-12-N-06] Describe how vertical food farms (soil free) work.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
	<p>[SLO:B-10-N-05] Analyze the benefits of marine biotechnology, with the help of examples.</p> <p>[SLO:B-10-N-06] Describe the bioremediation can help us in taking better care of our environment with an example.</p> <p>[SLO:B-10-N-07] The concept and applications of industrial biotechnology with examples.</p>		<p>[SLO:B-12-N-07] Compare and contrast the advantages of vertical food farms with general agricultural practices prevalent in Pakistan.</p> <p>[SLO:B-12-N-08] Explain polymerase chain reaction (PCR)</p> <p>[SLO:B-12-N-09] Describe DNA sequencing and DNA profiling.</p>
N/A		Benchmark 2: Understanding the history of biological warfare and bio-defenses, the development of modern-day biological weapons and other applications in biosynthetic.	
			<p>[SLO:B-12-N-10] Explain the role of biological warfare with examples.</p> <p>[SLO:B-12-N-11] Explain how pathogens are used as weapons and types of modern-day biological weapons, including biotoxins, bioregulators, and bio-vectors</p> <p>[SLO:B-12-N-12] Describe how Bio-defenses could work to protect from biological warfare with examples (vaccine development, diseases surveillance and countermeasure research).</p> <p>[SLO:B-12-N-13] Examine the hype behind the comics “genomics,</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			<p>transcriptomics, proteomics metabolomics”, to what extent is it valid or overblown?</p> <p>[SLO:B-12-N-14] Explain synthetic biology with examples.</p> <p>[SLO:B-12-N-15] Describe the ethical and societal implications of biological weapons and biodefense, including issues related to biosecurity, international regulations, and dual-use research.</p>



DOMAIN O: PHARMACOLOGICAL DRUGS

Standard: *Students should be able to:*

- Describe the mechanism of action of various drug classes, including pain relievers, antidepressants, and antibiotics.
- Explain the factors that determine drug efficacy and toxicity, including dose, route of administration, and pharmacokinetics.
- Describe the side effects and potential drug interactions of various drugs.
- Explain the principles of drug design and development, including target selection, lead optimization, and clinical trials.
- Describe the role of pharmacology in the treatment of diseases, including the use of drugs to prevent, diagnose, and treat a range of medical conditions.

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N/A		Benchmark 1: Student should be able to explain the role of pharmacological drugs in treating diseases and understand their mechanisms of action, side effects, and drug interactions.	
			<p>[SLO:B-12-O-01] Explain the drug discovery and development process.</p> <p>[SLO:B-12-O-02] Define 4 classes of Antibiotics (penicillin, Tetracyclins, Fluriquinolones and Sulfonamides) and describe their mode of action</p> <p>[SLO:B-12-O-03] Define antivirals and Antiretroviral</p> <p>[SLO:B-12-O-04] Describe advantages of monoclonal antibodies and compared to other drug classes.</p>



DOMAIN P: ENVIRONMENTAL BIOLOGY

Standard: *Students should be able to:*

- Describe the role of living organisms in their environment, including the relationships between and among biotic and abiotic factors.
- Describe the structure and function of ecosystems, including biomes, communities, populations, and individuals.
- Analyze the effects of human activities on the environment and the impact on biodiversity.
- Evaluate the methods used to monitor and manage environmental resources, such as habitat restoration and conservation.
- Describe the processes that drive the cycling of matter and energy in ecosystems, including photosynthesis, cellular respiration, and decomposition.

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N/A		Benchmark 1: Students should be able to describe and explain the basic principles of ecology, trophic levels, and energy transfer between them.	
			<p>[SLO:B-12-P-01] Define environment, population, community, habitat, ecosystem and biosphere.</p> <p>[SLO:B-12-P-02] Describe the various modes of nutrition in an ecosystem.</p> <p>[SLO:B-12-P-03] Identify plants as producers that convert light energy in to chemical energy and production of biomass.</p> <p>[SLO:B-12-P-04] Define different trophic levels.</p> <p>[SLO:B-12-P-05] Describe the loss of energy between trophic levels.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
N/A		Benchmark 2: Students will be able to analyze and interpret ecological data, including species interactions, food chains and food web, energy flow, and nutrient cycling. Additionally, students will be able to evaluate and discuss the impacts of human activities (e.g., pollution, habitat destruction, introduction of non-native species) on ecosystems and biodiversity.	
			<p>[SLO:B-12-P-06] Define biogeochemical cycles and locate the primary reservoirs of the chemicals in these cycles.</p> <p>[SLO:B-12-P-07] Describe the water cycle in detail.</p> <p>[SLO:B-12-P-08] Define the terms aquifers and water table.</p> <p>[SLO:B-12-P-09] Discuss the nitrogen cycle in detail.</p> <p>[SLO:B-12-P-10] Describe productivity in terms of gross primary productivity (GPP) and net primary productivity (NPP).</p> <p>[SLO:B-12-P-11] Interpret the pyramids of number, biomass, and energy.</p> <p>[SLO:B-12-P-12] Define ecological succession as the process by which ecosystems transform from simple to complex.</p> <p>[SLO:B-12-P-13] Describe primary and secondary succession.</p>



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			<p>[SLO:B-12-P-14] Differentiate between xerarch and hydrarch succession. Explain the xerarch succession on a bare rock starting from the small patches of lichens to the vegetation of flowering plants.</p> <p>[SLO:B-12-P-15] Describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/viable size.</p> <p>[SLO:B-12-P-16] Explain the effect of growth of the human population on the ecosystem.</p> <p>[SLO:B-12-P-17] Describe the major ecosystems of Pakistan</p>



DOMAIN Q: CLIMATE CHANGE

Standard: Students should be able to:

- Describe the role of greenhouse gases in the Earth's atmosphere and their impact on climate change.
- Explain the evidence for and against the existence of climate change, including data from temperature records, ice cores, and other sources.
- Describe the potential impacts of climate change on various ecosystems and species, including changes in distribution, migration patterns and extinction risk.
- Explain the role of human activities, such as deforestation and fossil fuel burning, in contributing to climate change.
- Describe the mitigation and adaptation strategies used to reduce the impacts of climate change on biodiversity and ecosystems.

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N/A		Benchmark 1: Explain the causes and impacts of global climate change on different regions, ecosystems and species and how to control the issue.	
			<p>[SLO:B-12-Q-01] Describe how climatic change impacts flora and fauna.</p> <p>[SLO:B-12-Q-02] Describe how climate change can impact ocean biology in terms of its temperature and pH as harmful effects.</p> <p>[SLO:B-12-Q-03] Enlist species that have gone endangered and extinct due to climatic change in Pakistan.</p> <p>[SLO:B-12-Q-04] Define greenhouse gases. Explain the greenhouse effect, providing examples of gases that demonstrate this behaviour.</p> <p>[SLO:B-12-Q-05] Describe the harmful effects of greenhouse gases on the environment.</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			[SLO:B-12-Q-06] Explain how coral reefs are used as a barometer for the health of an aquatic ecosystem concerning ocean acidification



DOMAIN R: STRUCTURAL BIOLOGY AND COMPUTATIONAL BIOLOGY

Standard: Students should be able to:

- Describe the study of the three-dimensional structures of biological molecules, including proteins, DNA and RNA.
- Explain the techniques used in structural biology, including X-ray crystallography, nuclear magnetic resonance spectroscopy and cryo-electron microscopy.
- Describe the role of structural biology in understanding biological function and disease.
- Define computational biology and explain its role in biology.
- Describe the application of computational methods in various areas of biology, including genetics, genomics, systems biology and evolution

Grade – IX	Grade – X	Grade – XI	Grade – XII
N/A		Benchmark 1: Students should be able to explain the molecular basis of biological structure and function and different techniques used to estimate these structures.	
			<p>[SLO:B-12-R-01] Define structural biology.</p> <p>[SLO:B-12-R-02] Explain that structure determination of biomolecules are important</p> <p>[SLO:B-12-R-03] Describe how X-ray crystallography works.</p> <p>[SLO:B-12-R-04] Outline the on line databases where biomolecule structures are available.</p>
N/A		Benchmark 2: Students should be able to develop an understanding of computational applications, and its applications in understanding structural biology, evolution, genomics, proteomics, and biological structures in addition to its role in agriculture and industry.	
			<p>[SLO:B-12-R-05] Describe computational Biology.</p> <p>[SLO:B-12-R-06] Understand biological structures using computational methods in agricultural</p>



Grade – IX	Grade – X	Grade – XI	Grade – XII
			biotechnology, including crop improvement and pest management. [SLO:B-12-R-07] Define Sequence and structural Homology.



DOMAIN S: BIOSTATISTICS AND DATA HANDLING

Standard: *Students should be able to:*

- *Define biostatistics and explain its role in biology.*
- *Explain the process of collecting, organizing, and analyzing data in biology.*
- *Describe various statistical methods used in biology, including descriptive statistics, inferential statistics, and hypothesis testing.*
- *Explain the importance of proper data management, including data accuracy and data security.*
- *Describe how data can be represented graphically, including bar graphs, histograms, and scatterplots.*

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Benchmark 01: Student should be able to Collect, analyze, and interpret data using appropriate statistical methods.		Benchmark 1: students should be able to Collect, analyze, and interpret data using appropriate statistical methods, including graphical representation and analysis.	
	<p>[SLO:B-10 – S-01] Understand biostatistics and its uses</p> <p>[SLO:B-10 – S-02] Determine mean, median, and mode of given data set.</p> <p>[SLO:B-10 – S-03] Describe the techniques of data collection and analysis to interpret the results</p> <p>[SLO:B-10 – S-04] Sketch a bar chart for a given set of biological data.</p>		<p>[SLO:B-12 – S-01] Define biostatistics and its use.</p> <p>[SLO:B-12-S-02] Define mean, median, mode, standard deviation, range, percentile.</p> <p>[SLO:B-12-S-03] Calculate mean, median, mode, standard deviation, range, percentile from a given set of data.</p> <p>[SLO:B-12-S-04] Sketch a bar diagram for the given set of data.</p> <p>[SLO:B-12-S-05] Sketch error bars based on range or standard deviation for a given set of data on a bar diagram.</p> <p>[SLO:B-12-S-06] Evaluate the appropriate type of figure or diagram for a given set of data from experiment (bar diagram, pie diagram, x-y axis data graph etc.).</p>



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			<p>[SLO:B-12-S-07] Design an appropriate experiment with a control group and dependent, independent and control variables.</p> <p>[SLO:B-12-S-08] Make the appropriate chart with proper title, labeled axis, legend, axis units.</p>



DOMAIN X: EXPERIMENTATION SKILLS

It covers the skills that are necessary for understanding, how to design and conduct biology experiments. These skills are not meant to be applied only in the science lab but as skills of critical analysis for understanding data as well.

Standard: Students should be able to:

Design and demonstrate the knowledge of common biological concepts by using experimental terminology. Experiment should be conducted by using safety measures during usage of apparatus and materials

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Benchmark 1: Understand the terminology and methodology with various experimental techniques.	N/A	
<p>[SLO:X-09-01] Students should be able to carry out simple experiments of:</p> <ul style="list-style-type: none"> • Diffusion • Osmosis • Food tests • Rates of enzyme-catalyzed reactions • pH and the use of hydrogen-carbonate indicator, litmus and universal indicator • Photosynthesis (rate and limiting factors) • Effect of mineral ions on plant growth • Transpiration • Heart rate and breathing rate • Respiration • Tropic response • Nervous responses • Observation and dissection of seeds and flowers • Germination • Continuous and discontinuous variation • Sampling techniques <p>[SLO:X-09-02] Should be able to use of a microscope to examine biological specimens</p> <p>[SLO:X-09-03] • Calculate the magnification of biological specimens.</p>		
Benchmark 2: Students should be able to understand and replicate the required techniques for the given experiments.		
<p>[SLO: B-09-10-X-04] Students should be able to use techniques, apparatus and materials safely.</p> <ul style="list-style-type: none"> • Identify apparatus from diagrams or descriptions • Draw and label diagrams of apparatus and biological specimens 		



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<ul style="list-style-type: none"> • Use of common techniques, apparatus and materials • Describe tests to determine the pH of solutions and substances using a universal indicator. • Describe and explain techniques • Describe and explain hazards and identify safety precautions <p>To ensure the accuracy of observations and data</p>		
Standard: Students should be able to demonstrate the knowledge for selection of apparatus and use of techniques and materials safely.		
Benchmark 1: Students should be able to follow provided safety instructions and take general precautions in a lab setting		
[SLO:B-09-10-X-05] Students should be able to understand for safety measurements and precautions <ul style="list-style-type: none"> • Understand the need to wear personal protective equipment (PPE) • Tie and cover up long hair 		
Standard: Students should be able to understand the essence of scientific experimentation and carry out the necessary steps of understanding the terminology, taking general lab precautions, understanding the lab equipment, recording data and providing suggestions on improving the experimental techniques.		
Benchmark 1: Understand the scientific ideas that general science lab terms convey.	Benchmark 1: Plan the experiment and clearly convey the reasons for the experimental technique to follow.	
[SLO:B-09-10-X-06] Students are able to Understand and express scientific ideas using the below terms: <ul style="list-style-type: none"> - True value: the value that would be obtained in an ideal measurement - Measurement error: the difference between a measured value and the true value of a quantity - Accuracy: a measurement result is described as accurate if it is close to the true value - Precision: how close the measured values of a quantity are to each other - Repeatability: a measurement is repeatable if the same or similar result is obtained when the measurement is repeated under the same conditions, using the same method, within the same experiment - Reproducibility: a measurement is reproducible if the same or similar result is obtained when the measurement is made under either different conditions or by a different method or in a different experiment 	[SLO:B-11-X-01] Decisions relating to measurements and observations [SLO:B-11-X-02] Within an investigation, students should be able to: <ul style="list-style-type: none"> • Identify the independent variable and dependent variable. • Decide a suitable range of values to use for the independent variable at which measurements of the dependent variable are recorded • Decide the number of different values of the independent variable (a 	Defining the problem [SLO: B-12-X-01] <ul style="list-style-type: none"> • Using the context provided, students should be able to: • state a relevant prediction, either in words or in the form of a sketch graph showing the expected result, and link this to an underlying hypothesis • Identify the independent and dependent variables • Identify which key variables must be standardized in order to test a hypothesis. (Variables expected to have a minimal effect, such as variation



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<p>- Validity of experimental design: an experiment is valid if the experiment tests what it says it will test. The experiment must be a fair test where only the independent variable and dependent variable may change, and controlled variables are kept constant</p> <p>- Range: the maximum and minimum value of the independent or dependent variables</p> <p>- Anomaly: an anomaly is a value in a set of results that appears to be outside the general pattern of the results, i.e. an extreme value that is either very high or very low in comparison to others</p> <p>- Independent variables: independent variables are the variables that are changed in a scientific experiment by the scientist. Changing an independent variable may cause a change in the dependent variable</p> <p>- Dependent variables: dependent variables are the variables that are observed or measured in a scientific experiment. Dependent variables may change based on changes made to the independent variables</p>	<p>minimum of five) and the intervals between them.</p> <ul style="list-style-type: none"> • Decide how to change the value of the independent variable. • Decide how the dependent variable should be measured. • Decide the number of replicates at each value. • Decide on appropriate controls for the experiment or investigation. • Decide which variables need to be standardized and how to standardize them. (Variable expected to have a minimal effect, such as variation between test-tubes of the same type, do not need to be standardized.) <p>When using the light microscope and photomicroscope and photomicrographs, students should be able to:</p> <ul style="list-style-type: none"> • Set up a light microscope to view and observe specimens. • Follow instructions to find and draw particular tissues in plant and animal specimens and label the drawings appropriately. • Follow instructions to find and draw particular cells and structures within the cells. • Make a temporary slide of stained cells or tissues. • Calculate actual sizes of tissues or cells from measurements of photomicrographs, using 	<p>between test-tubes of the same type, do not need to be standardized)</p> <p>Methods</p> <p>[SLO: B-12-X-02]</p> <ul style="list-style-type: none"> • Using the context provided, students should be able to: • Describe how to vary the independent variable • Describe how to measure the values of the independent and dependent variables accurately and to an appropriate precision • Describe how to standardize each of the other key variables • Describe, where appropriate, suitable volumes and concentrations of reagents. Concentrations may be specified in % (w/v), or mol dm⁻³ • Describe how different concentrations would be prepared by serial dilution or proportional dilution. • Describe appropriate control experiments • Describe, in a logical sequence, the steps involved in the procedure, including how to use the apparatus to collect results. • Describe how the quality of results can be assessed by considering: <ul style="list-style-type: none"> -The occurrence of anomalous results -The spread of results including the use of



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	<p>magnifications, scale bars or representations of eyepiece graticule and stage micrometers.</p> <ul style="list-style-type: none"> • Estimate the number of cells or cell organelles in a given area using a sampling method, such as grids or fields of view. 	<p>standard deviation, standard error and/or 95% confidence intervals (95% CI).</p> <ul style="list-style-type: none"> • Describe how to assess the validity of the results by considering both the accuracy of the measurements and the repeatability of the results • Prepare a simple risk assessment of their plans, taking into account the severity of any hazards and the probability that a problem could occur Describe the precautions that would need to be taken to minimize risks where possible.
Benchmark 2: Plan experiments and investigations.	Benchmark 2: Collect data and record observations in the form of readings, estimates and accurate drawings.	
<p>[SLO:B-09-10-X-07] Students are able to</p> <ul style="list-style-type: none"> • Identify the independent variable and dependent variable • Describe how and explain why variables should be controlled • Suggest an appropriate number and range of values for the independent variable. • suggest the most appropriate apparatus or technique and justify the choice made • Describe experimental procedures • Identify risks and suggest appropriate safety precautions • Describe how to record the results of an experiment • Describe how to process the results of an experiment to form a conclusion or to evaluate a prediction • Make reasoned predictions of expected results 	<p>[SLO:B-11-X-03]</p> <ul style="list-style-type: none"> • Within an investigation, students should be able to: • Follow instructions to collect results • Consider the hazards of the procedure, including the use of any solutions and reagents, and assess the risk as low, medium or high • Take readings to obtain accurate data (quantitative results) or observations (qualitative results). • When using the light microscope and photomicrographs, Students should be able to: • Draw plan diagrams to show the distribution of 	



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	<p>tissues in a specimen, with no cells drawn and the correct proportions of layers of tissues</p> <ul style="list-style-type: none"> • Draw the observable features of cells in a specimen showing: <ul style="list-style-type: none"> - the correct shapes - the thicknesses of cell walls where applicable (drawn with two lines or drawn with three lines where two cells touch) - the relative sizes and proportions - observable cell contents only • Measure tissue layers or cells from photomicrographs • using a ruler or given scale, including representations of eyepiece graticule. • Make accurate observations from specimens including counting numbers of cells or cell organelles <p>Record similarities and differences between two specimens using only their observable features.</p>	
Benchmark 3: Make and record observations, measurements and estimates.	Benchmark 3: Evaluate and interpret the recorded data and display the calculations and reasoning.	
<ul style="list-style-type: none"> • Take readings from apparatus (analogue and digital) or from diagrams of apparatus • Take readings with appropriate precision, reading to the nearest half-scale division where required • Correct for zero errors where required. • Make observations, measurements or estimates that are in agreement with expected results or values. • Take sufficient observations or measurements • Repeat observations or measurements where appropriate. • Record qualitative observations from tests. 	<p>Presentation of data and observations</p> <p>[SLO: B-11-X-04]</p> <ul style="list-style-type: none"> • Recording data and Observations within an investigation, students should be able to: • Record raw results (unprocessed) and calculated results (processed) in an 	<p>Dealing with data</p> <p>[SLO: B-12-X-03]</p> <p>From provided data, students should be able to:</p> <ul style="list-style-type: none"> • Use tables and graphs to show the key points in quantitative data • Sketch or draw suitable graphs, displaying the independent variable on



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Record observations and measurements systematically, for example in a suitable table, to an appropriate degree of precision and using appropriate units	<p>appropriate table with:</p> <ul style="list-style-type: none"> - descriptive headings, including any required units (no units in body of table) -heading for the independent variable to the left of (or above, if the table is in rows) the dependent variable <ul style="list-style-type: none"> • Record quantitative data to the number of decimal places that is appropriate for the measuring instrument used • Record qualitative observations using clear descriptions - record calculated values (processed results) in an appropriate table. When using the light microscope and photomicrographs, Students should be able to: • Record the fine details of the specimen, including drawing the detailed shapes of layers or outlines of specimens in plan diagrams and drawing the shape and position of observable cell organelles in cells. <p>[SLO:B-11-X-05]</p> <ul style="list-style-type: none"> • Display of calculation and Reasoning <p>[SLO:B-11-X-06]</p> <ul style="list-style-type: none"> • Within an investigation and when using the light microscope and photomicrographs, students should be able to: 	<p>the x-axis and the dependent variable on the y-axis including, where required, confidence limit error bars</p> <ul style="list-style-type: none"> • Decide which calculations are necessary in order to draw conclusions • Carry out appropriate calculations to simplify or explain data, including gmeans, percentages and rates of change • Carry out calculations in order to compare data, including percentage gain or loss • Use values of standard deviation or standard error, or graphs with standard error bars, to determine whether differences in mean values are likely to be statistically significant • Choose and carry out statistical tests (limited to those described in the Mathematical requirements section of the syllabus) appropriate to the type of data collected and justify use of these tests • State a null hypothesis for a statistical test • Recognize the different types of variable and the different types of data presented, as shown in the table below. <p>[SLO:B-12-X-04]</p> <ul style="list-style-type: none"> • Type of variable Type of data Qualitative



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	<ul style="list-style-type: none"> • Display calculations clearly, showing all the steps and reasoning • Use the correct number of significant figures for calculated quantities. This should be the same as, or one more than, the smallest number of significant figures in the data used in the calculation. • Layout of data and observations <p>[SLO:B-11-X-07]</p> <ul style="list-style-type: none"> • Within an investigation, Students should be able to: • Display data as a graph (continuous data), bar chart (discontinuous or categorical) or histogram (frequency data) • Draw a graph, bar chart or histogram clearly and accurately with: <ul style="list-style-type: none"> - the independent variable on the x-axis and the dependent variable on the y-axis - axes labeled to match the relevant table headings, including units where appropriate - a scale where both axes should use most or all of the grid available and allow the graph to be read easily to within half a square - all graph points plotted accurately using a sharp pencil, as a 	<p>categorical nominal, i.e. values or observations belonging to it can be sorted according to category, e.g. colour of flowers ordered ordinal, where values can be placed in an order or rank and the interval between them may not be equal, e.g. the order in which test-tubes containing starch and iodine become colourless after adding amylase Quantitative continuous, which can have any value within a specific range, e.g. body mass, leaf length</p>



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	<p>small cross or a small dot in a circle, with the intersection of the cross or center of the dot exactly on the required point</p> <ul style="list-style-type: none">-the plotted points of a graph connected with a clear, sharp and unbroken line, either as a line of best fit, a smooth curve or with ruled straight lines joining the points- no extrapolation of graph lines unless this can be assumed from the data- all bars on a bar chart or histogram plotted accurately, with clear, unbroken lines that are drawn with a sharp pencil and ruler. <p>[SLO:B-11-X-08]</p> <ul style="list-style-type: none">• When using the light microscope and photomicrographs, students should be able to:• Make drawings, using a sharp pencil to give finely drawn lines that are clear and unbroken• Make drawings that use most of the available space and show all the features observed in the specimen, with no shading• Organize comparative observations, showing differences and similarities between specimens.	



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Benchmark 4: Interpret and evaluate experimental observations and data	Benchmark 4: Analyze the results of the experiment and provide conclusions.	
<ul style="list-style-type: none"> • Process data, including for use in further calculations or for graph plotting, using a calculator as appropriate • Present data graphically, including the use of best-fit lines where appropriate • Analyse and interpret observations and data, including data presented graphically • Use interpolation and extrapolation graphically to determine a gradient or intercept • Form conclusions justified by reference to observations and data and with appropriate explanation • Evaluate the quality of observations and data, identifying any anomalous results and taking appropriate action <p>Comment on and explain whether results are equal within the limits of experimental accuracy (assumed to be $\pm 10\%$ at this level of study)</p>	Analysis, conclusions evaluation <p>[SLO: B-11-X-09] Interpreting data and observations</p> <p>[SLO: B-11-X-10] Within an investigation, students should be able to:</p> <ul style="list-style-type: none"> • Calculate an answer with the correct number of significant figures using quantitative results or data provided • Use a graph to find unknown values • Estimate the concentrations of unknown solutions from qualitative results • Identify the contents of unknown solutions using biological molecule tests • Identify anomalous results and suggest how to deal with anomalies • Describe patterns and trends using the data provided in tables and graphs • Evaluate the confidence with which conclusions might be made. When using the light microscope and photomicrographs, Students should be able to: • Calculate an answer with the correct number of significant figures using quantitative results or data provided compare observable 	Conclusions <p>[SLO:B-12-X-05] Students should be able to: Summarize the main conclusions from the results</p> <ul style="list-style-type: none"> • Identify key points of the raw data and processed data, including graphs and statistical test results • Discuss the extent to which a given hypothesis is supported by experimental data and the strengths and weaknesses of the evidence • Give detailed scientific explanations of the conclusions Make further predictions and hypotheses based on the conclusions. <p>Evaluation</p> <p>[SLO:B-12-X-06] Students should be able to:</p> <ul style="list-style-type: none"> • Identify anomalous values in a table or graph of data and suggest how to deal with anomalies • Suggest possible explanations for anomalous readings • Assess whether the results have been replicated sufficiently • Assess whether the range of values of the independent variable and the



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	<p>features of specimens of biological material including similarities and differences between specimens on microscope slide and specimens in photomicrographs.</p> <p>Drawing conclusions [SLO:B-11-X-11] From results, observations or information provided, students should be able to:</p> <ul style="list-style-type: none"> • Summarize the main conclusions • State and explain whether a hypothesis is supported - make predictions from the patterns and trends in data • Suggest explanations for observations, results, patterns, trends and conclusions. 	<p>intervals between the values were appropriate</p> <ul style="list-style-type: none"> • Assess whether the method of measuring is appropriate for the dependent variable • Assess the extent to which selected variables have been effectively Controlled+ make informed judgments about: <ul style="list-style-type: none"> — the validity of the investigation - the extent to which the data can be used to test the hypothesis, how much confidence can be put in the conclusions <p>Suggest how an investigation could be improved to increase confidence in the results.</p>
Benchmark 5: Evaluate methods and suggest possible improvements	Benchmark 5: Identify sources of error and suggesting improvements	
<ul style="list-style-type: none"> • evaluate experimental arrangements, methods and techniques, including the control of variables • Identify sources of error, including measurement error, random error and systematic error • Identify possible causes of uncertainty in data or in a conclusion <p>Suggest possible improvements to the apparatus, experimental arrangements, methods or techniques</p>	<p>[SLO:B-11-X-12] Within an investigation and when using the light microscope and photomicrographs, students should be able to:</p> <ul style="list-style-type: none"> • Identify systematic or random errors in an investigation, understanding that systematic errors may not affect the trend in results whereas a random error may affect the trend. • Identify the main sources of error in a particular Investigation. 	



Grade – IX – X	Grade – XI	Grade – XII
	<ul style="list-style-type: none">• Suggest improvements to a procedure that will increase the accuracy of the observations or measurements, including:<ul style="list-style-type: none">- Using a more effective method to standardize relevant variables- using a more accurate method of measuring the dependent variable- using smaller intervals for the values of the independent variable- collecting replicate measurements so that a mean can be calculated• Suggest how to extend the investigation to answer a new question, for example by investigating a different independent variable or applying the method to a new context. Describe clearly, in words or diagrams, improvements to the procedure or modifications to extend the investigation.	



CONTENTS

IX

Chapter 01

NATURE OF SCIENCE IN BIOLOGY

Students will learn about:

The examples of science that operates in a historical context that affects its current practices and its relation with other fields of science

In this chapter

(13 Periods)

- Introduction of Biology (02)
- Quranic view on development of life on this planet. (01)
- Major fields of Biology (03)
- Biology as an Interdisciplinary science (02)
- Careers in Biological sciences (02)
- Biological Methods (03)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1.1-Introduction of biology

- Concept of Biology

1.2-Quranic view on development of life on this planet

- Point out Quranic instructions to reveal the study of Life

1.3-Major fields of biology

- Understand the major fields of biology as Botany, zoology and Microbiology
- Define with examples that biology has many sub fields.
Morphology, Cell biology, Histology, Anatomy, Physiology, Molecular biology, Genetics, Taxonomy, Paleontology, Environmental biology, Marine biology, Fresh water biology, Developmental biology, Parasitology, Pathology, Immunology and Pharmacology

1.4-Biology as an interdisciplinary science

- Relate that biology connects with other natural sciences and distinguish in terms of the broad subject matter as well as interdisciplinary researchers working together to share knowledge between the below fields:-
Biophysics, Biochemistry, Computational Biology, Biogeography, Biostatistics, Biotechnology and Bio-economics



1.5-Careers in biological science

- Identify the careers in Biology and explain with examples how biology is a subset of the natural sciences.

1.6-Biological methods

- Understand the steps of the scientific method that is recognition of biological problem, Observation, Hypothesis, Deduction, Experiments, Results.
- Evaluate the terms “hypothesis”, theory and law in the context of research in the natural science with the help of example.



Chapter 02

MOLECULAR BIOLOGY

Students will learn about:

The molecular basis of life, basic molecules require for life activities and formation of cell.

In this chapter

(16 Periods)

- | | |
|--|------|
| • Introduction to molecular Biology. | (04) |
| • Protein | (02) |
| • Carbohydrates | (03) |
| • Lipids | (03) |
| • Nucleic acid | (02) |
| • Role of DNA and RNA in protein synthesis | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

2.1-Introduction to molecular biology

- Understand the concept of biochemistry/ Molecular Biology by introducing levels of organization.
- Outline the various types of common biomolecules (Protein, Carbohydrates, Lipids and Nucleic acid) including their locations inside the cell and main roles.

2.2-Protein

- Describe the structure, function and sources of protein with structure of amino acids.

2.3-Carbohydrates

- Understand the concept of carbohydrates and outline the structure, function and sources of carbohydrates.
- Identify carbohydrates as monosaccharides, disaccharides and polysaccharides.

2.4-Lipids

- Explain the structure, function and sources of lipids.

2.5-Nucleic acid

- Understand the structure of DNA as a double helix macromolecule made of nucleotides with base pairing in between the two helices through complementary base pairing.
- State the function of DNA as carrier of hereditary information.
- Understand the structure of RNA as single stranded macromolecule made of nucleotides with nitrogenous base overhangs.

2.6-Role of DNA and RNA in protein synthesis

- Demonstrate how RNA functions as a tool for converting hereditary information into functional proteins.
- Outline how information in the DNA is transformed on RNA and then into Proteins for expression.



Chapter 03

ENZYMES

Students will learn about:

The concept of metabolism, the role of enzymes in metabolic reactions and the process of enzyme-catalyzed reactions

The factors that affect enzyme activity and inhibition of enzyme activity

In this chapter

(10 Periods)

- | | |
|---|------|
| • Introduction to metabolism | (01) |
| • Enzymes and their characteristics | (02) |
| • Role of enzymes in metabolic activities | (01) |
| • Factors affecting enzyme activity | (03) |
| • Feedback inhibition | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

3.1-Introduction to metabolism

- Understand metabolism and its types by providing illustrative examples.

3.2-Enzymes and their characteristics

- Define enzymes and describe their characteristics.

3.3-Role of enzymes in metabolic activities

- Explain how enzymes help in metabolism.
- Explain the mechanism of enzyme action.

3.4-Factors affecting enzyme activity

- Assess the factors which could influence enzyme activity

3.5-Feedback inhibition

- Describe competitive and non-competitive inhibition.



Chapter 04

CELL

Students will learn about:

The cell as basic unit of life

The structure and function of cells, including plant and animal cells

Concept of cell organelles and their role

Identification of different types of cells.

In this chapter

(14 Periods)

- | | |
|--|------|
| • Cell | (01) |
| • Structure of Animal and Plant cells. | (01) |
| • Cytoplasmic Organelles of plant and animal cells | (05) |
| • Cell Specialization | (03) |
| • Division of Labour | (02) |
| • Concept of Stem cell | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

4.1-Cell

- Describe cell as the basic unit of life.

4.2-Structure of animal and plant cells

- Sketch animal and plant cells, point out different organelles (nucleus with the concept of Chromosome structure, mitochondria, cell membranes, etc) and outline their roles. Compare animal and plant cells.
- Outline structural advantages of plant and animal cells with reference to Cell wall, Plastids, Centrioles, and Lysosomes etc.

4.3-Cell specialization

- Identify different types of cells (Mesophyll cell, epidermal cell, neurons, muscle, red blood cell, liver cell) and sketch their structures.

4.4-Division of labour

- Understand the concept of division of labour and how it applies:
 - Within Cell organelles (Mitochondria and chloroplast etc.)
 - Multi cellular organisms (Muscle fibre and Neuron etc.)

4.5-Concept of stem cell

- Concept of Stem cells as unspecialized cell



Chapter 05

Cell Cycle

Students will learn about:

The concept of cell cycle

The process of cellular division, including mitosis and meiosis

In this chapter

(07 Periods)

- Introduction to cell cycle (02)
- Mitosis and Meiosis (05)

MAJOR CONCEPTS AND LEARNING OUTCOMES

5.1-Introduction to Cell Cycle

- Concept of Cell cycle

5.2-Mitosis and Meiosis

- Describe mitosis, meiosis and stages of mitosis, meiosis (by use of sketch and diagrams)
- Compare the processes of mitosis and meiosis.
- Outline the significance of mitosis and meiosis.



Chapter 06

TISSUES, ORGANS AND SYSTEMS

Students will learn about:

The structure and function of plant and animal tissues

The role of organs in maintaining homeostasis

The structure and function of the major organ systems, including the circulatory, digestive, respiratory, nervous, endocrine muscular and skeletal systems

The Different organ systems interact to maintain homeostasis in the body

In this chapter

(11 Periods)

- Introduction to tissues, Organs and Systems (02)
- Functional levels of organization (01)
- Tissues level of organization (02)
- Organ level of organization (02)
- Homeostasis (04)

MAJOR CONCEPTS AND LEARNING OUTCOMES

6.1-Introduction to tissues, Organs and Systems

- Distinguish between tissues, organs and systems with examples from animals and plants.

6.2-Functional levels of organization

- The concept of emergent properties as gain in functionalities and how it applies to the following:
 - going from organelles to cells
 - going from cells to tissues
 - going from tissues to organs
 - going from organs to systems
 - going from systems to living organisms

6.3- Organ level of organization

- Enlist the different types of tissue come together to form the stomach (organ) in the human body.
- Discuss the different types of tissue come together to form the leaf.
- Understand the organ systems come together to form the human body.
- Tabulate disorders (Food poisoning, Tuberculosis, Heart attack, diabetes, Parkinson's disease and infertility) with related organs and their symptoms.

6.4-Homeostasis

- Concept of homeostasis and describe its advantages.
- Understand the various organs and systems of the human body to maintain homeostasis.
- Understand the various organs and systems of plants to maintain homeostasis

**Chapter 07****BIOENERGETICS***Students will learn about:*

Define metabolism and describe how it is related to cellular respiration and photosynthesis.

In this chapter**(07 Periods)**

- Introduction to Bioenergetics (01)
- Photosynthesis (03)
- Cellular respiration (03)

MAJOR CONCEPTS AND LEARNING OUTCOMES**7.1-Introduction to Bioenergetics**

- Define bio-energetics and its role in understanding the conversions of energy in an organism.
- Discuss the role of ATP as energy currency.

7.2-Photosynthesis

- Describe photosynthesis in plants.

7.3-Cellular Respiration

- Define cellular respiration and differentiate between aerobic and anaerobic respiration



Chapter 08

BIODIVERSITY

Students will learn about:

The major taxonomic categories and their characteristics, including the classification of organisms into species, genus, family, order, class, phylum and kingdom.

In this chapter

(10 Periods)

- | | |
|---|------|
| • Biodiversity and Classification | (04) |
| • History of Classification | (03) |
| • Taxonomic ranks and binomial classification | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

8.1-Biodiversity and Classification

- Concept of biodiversity and classification.
- Understand the advantages of classification.

8.2-History of Classification

- Discuss the history of classification schemes

8.3-Taxonomic ranks and Binomial classification

- List the three distinct domains into which living organisms are broadly classified.
- List the taxonomic ranks of classification.
- Understand the concept of binomial nomenclature system.
- Understand the complications of classifying viruses.



Chapter 09

FORM AND FUNCTIONS OF PLANTS

Students will learn about:

The basic structure and anatomy of plant cells and organs including stem, roots, leaves and flowers.

The adaptations that allow plants to survive in different environments, including ways to conserve water, regulate temperature and defend against herbivores.

In this chapter

(13Periods)

- | | |
|-------------------------------|------|
| • Mineral Nutrition in plants | (02) |
| • Uptake of water by roots | (01) |
| • Osmotic adjustment in plant | (03) |
| • Transport in plants | (02) |
| • Gaseous exchange in plants | (01) |
| • Reproduction in plants | (04) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

9.1-Mineral Nutrition in Plants

- Understand the concept of mineral nutrition in plants.
- Categorize minerals nutrients of plants into macronutrients and micronutrients.
- State that nitrogen is important in protein synthesis and magnesium for chlorophyll formation.

9.2-Uptake Of Water by Roots

- Explain the internal structure of root and root hair.
- Conceptualize transport and its needs.

9.3-Osmotic Adjustment in Plant

- Explain osmotic adjustments in plants.

9.4-Transport in Plants

- Describe how roots take up water and mineral salts by passive and active absorption.
- Describe transpiration and relate this process with cell surface and stomatal opening and closing.
- Describe temperature, wind and humidity as the factors affecting the rate of transpiration.
- Describe mechanism of transport of water and salts in plants
- Explain the mechanism of food translocation by the theory of Pressure Flow Mechanism.

9.5-Gaseous Exchange in Plants

- Describe the process of gaseous exchange in plants.



9.6-Reproduction in plants

- Define reproduction and its types, asexual reproduction i.e. spore formation and vegetative propagation.
- Distinguish between natural vegetative propagation (through stem, sucker and leaves) and artificial propagation (stem cuttings and grafting).
- Rationalize how apomixis is a type of asexual reproduction.



Chapter 10

EVOLUTION

Students will learn about:

The evolution and natural selection.

The population change over time and how speciation occurs.

In this chapter

(11 Periods)

- | | |
|----------------------------------|------|
| • Concept of Evolution | (02) |
| • Concept of speciation | (03) |
| • Darwinism | (02) |
| • Evidences of organic evolution | (04) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

10.1-Concept Of Evolution

- Understand concepts of evolution of living organisms and the theory of evolution by natural selection with examples

10.2-Concept of Speciation

- Concept of Species
- Concept of speciation
- State the sources of variations which can lead to speciation and evolution

10.3-Darwinism

- Interpret the significance of Darwin's observations made during his voyage on HMS Beagle

10.4-Evidences of Organic Evolution

- To understand the evidences of evolution with regards to the following:
 - Paleontology (fossil record)
 - Comparative anatomy (homologous structures, vestigial structures)
 - Selective breeding and biogeography



X

Chapter 11

HOLOZOIC NUTRITION

Students will learn about:

The concept of Nutrition

The structure and function of human digestive system

In this chapter

(08 Periods)

- Holozoic Nutrition (02)
- Functions of GIT and role of accessory glands (04)
- Disorders of GIT (02)

MAJOR CONCEPTS AND LEARNING OUTCOMES

11.1-Holozoic Nutrition

- Concept of holozoic nutrition and its steps i.e. ingestion, digestion, absorption, assimilation and egestion.

11.2-Functions Of GIT and Role of Accessory Glands

- Identify the structures and functions of the gastrointestinal tract (GIT) and associated glands.
- Concept of swallowing and peristalsis.
- Sort out the action of enzymes and other secretions, secreted in specific regions of gastrointestinal tract and associated glands with respect to their substrates and products.
- Understand why liver is secretory, metabolic, storage and detoxification center of the body.
- Understand the structure of a villus, including the roles of capillaries and lacteals.

11.3-Disorders of GIT

- Identify the signs and symptoms, causes as well as risk factors, treatments and preventions of the disorders of gastrointestinal tract (GIT) i.e. diarrhea, constipation, and peptic ulcer.



Chapter 12

GASEOUS EXCHANGE

Students will learn about:

The concept of gaseous exchange.

The structure and function of the Respiratory System of Human and Respiratory disorders.

In this chapter

(10 Periods)

- | | |
|------------------------------|------|
| • Respiratory Passage of Man | (03) |
| • Mechanism of Breathing | (04) |
| • Respiratory Disorders | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

12.1-Respiratory Passage of Man

- Identify the air passageway and role of lungs.

12.2-Mechanism of Breathing

- Understand the mechanism of breathing in terms of movement of ribs and diaphragm.
- Differentiate between the composition of inspired and expired air.

12.3-Respiratory Disorders

- Identify sign and symptoms of disorders i.e. Bronchitis, Asthma, pneumonia, emphysema and lung cancer



Chapter 13

CIRCULATION

Students will learn about:

The structure and function of the Circulatory System of Human, Cardiovascular disorders and the lymphatic system.

In this chapter

(14 Periods)

- | | |
|-----------------------------|------|
| • Circulation and Its types | (03) |
| • Cardiovascular system | (06) |
| • Blood and its composition | (03) |
| • Cardiovascular disorders | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

13.1-Circulation and Its types

- Understand the pathways of pulmonary and systemic circulation.

13.2-Cardiovascular System

- Identify and describe the structures and general functions of each organ of the cardiovascular system (CVS).
- Explain the structure (external and internal) of the human heart with a diagram.

13.3-Blood and its composition

- Recognize and describe the components of blood.
- Identify cell types found in blood and their roles.
- Understand that blood also work as transporting medium.

13.4-Cardiovascular Disorders

- Identify common sign and symptoms of heart diseases. (i.e. Coronary Heart Disease, Myocardial Infarction, Angina pectoris.
- Enlist the harmful effects of smoking related to cardiovascular diseases (CVD)



Chapter 14

EXCRETORY SYSTEM

Students will learn about:

The concept of excretion

The structure and function of the excretory system of man

In this chapter

(10 Periods)

- | | |
|-------------------------|------|
| • Urinary System of Man | (04) |
| • Kidney Failure | (06) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

14.1-Human Urinary System

- Recognize structure and general functions of each organ of the urinary system.
- Understand the external and internal structure and functions of kidney
- Understand structure and function of nephron as basic unit of kidney.
- Identify the role of kidney in the formation and composition of urine.
- Identify that how kidney works as osmoregulatory organ.

14.2-Kidney Failure

- Outline the causes of kidney failure and treatments.



Chapter 15

COORDINATION AND CONTROL

Students will learn about:

The structure and function of the nervous system, including the central and peripheral nervous systems

The role of neurons in transmitting and processing information

The process of neurotransmission and how it affects the functioning of the nervous system

The nervous system regulates and coordinates body functions, including the role of reflex arcs

In this chapter

(15 Periods)

- Neurons (02)
- Nerve Impulse (02)
- Reflex action (03)
- Nervous system (02)
- Glands and types of glands (02)
- Major Endocrine Glands (04)

MAJOR CONCEPTS AND LEARNING OUTCOMES

Nervous System of Man

15.1- Neurons

- Concept of neuron, outline the types of neurons with diagrams
- Concept of stimulus and response with examples.

15.2- Nerve Impulse

- Understand the mechanism of nerve impulse as electrochemical signal that travel across neuron
- Sketch synapses
- Concept of neurotransmitters

15.3- Reflex Action

- Sketch out the involvement of the nervous system when a person accidentally touches something painfully hot and withdraws hand as a reflex.

15.4- Nervous System

- Understand the nervous system and its role.
- Concept of central nervous system and peripheral nervous system.
- Define drugs and their effect on nervous system.

15.5- Glands and types of glands

- Concept of gland and differentiate between endocrine and exocrine glands. Emphasis the endocrine system.

15.6- Major Endocrine Glands

- List out major endocrine glands and their hormones with functions



Chapter 16

REPRODUCTION

Students will learn about:

The processes of reproduction in organisms, including asexual and sexual reproduction

The role of meiosis in producing genetically diverse offspring

The structure and function of gametes and the role of fertilization in sexual reproduction

In this chapter

(10 Periods)

- Reproduction and types of reproduction (06)
- Reproductive system and hormones (04)

MAJOR CONCEPTS AND LEARNING OUTCOMES

16.1- Reproduction and types of reproduction

- Concept of Reproduction, types of reproduction i.e. asexual and sexual reproduction.
- Understand the process of gametogenesis and fertilization

16.2-Reproductive system and hormones

- Understand the role of hormones in both male and female sexual development.



Chapter 17

INHERITANCE

Students will learn about:

The patterns of inheritance, including dominant and recessive traits, and how they are influenced by genes and chromosomes.

How genetic variation and mutations can lead to evolutionary change.

The basic structure and function of genes, including the role of codons and introns.

Distinguish between different types of inheritance patterns, including dominant and recessive traits, and sex-linked traits.

In this chapter

(10 Periods)

- Introduction to genetics and gene (03)
- Mendelian Inheritance (04)
- Sex determination (03)

MAJOR CONCEPTS AND LEARNING OUTCOMES

17.1-Introduction to Genetics and Gene

- Concept of Gene, allele, genotype, phenotype, homozygous, heterozygous, dominant, and recessive.

17.2-Mendelian Inheritance

- Understand the concept of Mendelian inheritance laws with the help of monohybrid and dihybrid cross.
- Correlate the Mendelian factors with chromosomes.

17.3-Sex determination

- Concept of autosome and sex chromosomes, describe sex determination in humans.



Chapter 18

DISEASES AND IMMUNITY

Students will learn about:

Describe the causes of diseases, including infectious and non-infectious diseases.

Explain the role of pathogens, including viruses, bacteria, fungi and parasites in causing disease.

Describe the body's immune response to pathogens, including the role of white blood cells, antibodies and the complement system.

In this chapter

(16 Periods)

- | | |
|--|------|
| • Concept of disease, pathogen and illness | (02) |
| • Immune system | (05) |
| • Vaccine and Antibiotics | (04) |
| • Diseases | (05) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

18.1-Concept of Disease, Pathogen and Illness

- Concept of illness, infection, disease and pathogen.
- List different types of pathogens, e.g. Viruses, Bacteria, Protozoa and Fungi; list their common diseases such as polio, typhoid, malaria and ringworm.

18.2-Immune System

Concept of immunity and list the role of the immune system.

Concept of innate and adaptive immunity with examples; three lines of defenses; components of human immune system i.e., Lymphatic system, lymph nodes and lymph; Types of immune cells in our blood and their roles.

State the function of adaptive immunity

18.3-Vaccine and Antibiotics

- Concept of vaccine which helps to boost immunity with examples of polio and typhoid.
- Describe the discovery of Penicillin.
- Concept of Antibiotics

18.4-Diseases

- Understand diabetes and its sub-types explain the effects on the human body.
- Understand cancer and its effects on the human body.
- Understand Covid19 and list the harmful effects on the human body.
- Understand that HIV compromises the Immune system and over times leads to development Acquired Immune Deficiency Syndrome (AIDS).
- Describe infectious and non-infectious diseases and their types with examples.
- Define zoonotic diseases and give their types.
- Describe vector borne diseases with Examples.
- Enlist allergies with some common types.
- Understand plant diseases commonly present in Pakistan, in terms of their effect on plant health and yield and their treatment. (Rust, smut, red rot of sugarcane)



Chapter 19

BIOTECHNOLOGY

Students will learn about:

The application of biotechnology in various fields, including medicine, agriculture, and industry.

The principles of genetic engineering and recombinant DNA technology, including gene cloning, PCR, and sequencing.

The process of gene cloning and how it is used in biotechnology.

The use of biotechnology in producing therapeutic proteins, including vaccines, monoclonal antibodies, and growth hormones.

The principles of synthetic biology, including metabolic engineering, gene circuit design, and biosensors.

In this chapter

(10 Periods)

- | | |
|--|------|
| • Introduction to Biotechnology | (02) |
| • Biotechnology in Food and Healthcare | (03) |
| • Marine Biotechnology | (03) |
| • Application of Biotechnology | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

19.1-Introduction to Biotechnology

- Concept of biotechnology.
-

19.2-Biotechnology in Food and Healthcare

- Understand with examples that food biotechnology is advanced field of agriculture especially in Pakistan.
- Understand with examples that medical biotechnology has advanced healthcare methods in diabetes and cancer.
- State the potential advantages that genetic editing provides in the context of medicine and agriculture, give some examples

19.3- Marine Biotechnology

- Analyze the benefits of marine biotechnology, with the help of examples.

19.4-Application of Biotechnology

- Describe the bioremediation can help us in taking better care of our environment with an example.
- The concept and applications of industrial biotechnology with examples.



Chapter 20

BIostatISTICS AND DATA HANDLING

Students will learn about:

The biostatistics and explain its role in biology.

The process of collecting, organizing, and analyzing data in biology.

The various statistical methods used in biology, including descriptive statistics, inferential statistics, and hypothesis testing.

The importance of proper data management, including data accuracy and data security.

The data can be represented graphically, including bar graphs, histograms, and scatter plots.

In this chapter

(10 Periods)

- | | |
|------------------------------|------|
| • Biostatistics and its uses | (03) |
| • Central Tendency | (05) |
| • Data Collection | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

20.1-Introduction to Biostatistics

- Understand biostatistics and its uses

20.2-Central Tendency

- Determine mean, median, and mode of given data set.

20.3-Data Collection

- Describe the techniques of data collection and analysis to interpret the results.
- Sketch a bar chart for a given set of biological data



XI

Chapter 01

BIOLOGICAL MOLECULES

Students will learn about:

The structure and function of the four main biomolecules:

Carbohydrates, Lipids, Proteins, and Nucleic acids.

The role of DNA as the genetic material and its role in heredity.

The structure of DNA, including the double helix and the four nitrogenous bases.

The process of DNA replication and its importance in cell division.

The process of transcription and translation, including the role of RNA and ribosomes.

In this chapter

(25 Periods)

- | | |
|--|------|
| • Biochemistry and Level of Organization. | (02) |
| • Main types of biological molecules | (03) |
| • Role of condensation and hydrolysis in biological molecules. | (01) |
| • Importance of water in living system | (02) |
| • Carbohydrates. | (03) |
| • Proteins. | (04) |
| • Lipids. | (04) |
| • Nucleic acids. | (04) |
| • Conjugated molecules. | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

1.1-Biochemistry and Level of Organization

- Define biochemistry /molecular biology by introducing levels of organization.
- Describe Briefly the different types of bonds found in biological molecules (Hydrogen bond, covalent bond, Ionic, hydrophobic and hydrophilic interactions)

1.2-Main Types of Biological Molecules

- Distinguish Carbohydrates, Proteins, Lipids and Nucleic acids as the four fundamental kinds of biological molecules

1.3-Role of condensation and hydrolysis in biological molecules

- Describe and draw sketches of the condensation (dehydration) synthesis and hydrolysis reactions for the making and breaking of macromolecule polymers.

**1.4-Importance of water in living system**

- State the properties of water (high polarity, hydrogen bonding, high specific heat, high heat of vaporization, cohesion, adhesion, hydrophobic exclusion, ionization and lower density of ice) allows it to be the medium of life.

1.5-Carbohydrates

- Define carbohydrates and classify them.
- Compare and contrast the properties and roles of monosaccharides and write their formulae.
- Compare the isomers and stereoisomers of glucose.
- Distinguish the properties and roles of disaccharides.
- Describe glycosidic bonds in disaccharides.
- Describe the structure properties and roles of polysaccharides, starch, glycogen, cellulose and chitin. Role of glycosidic bond in polysaccharides.

1.6-Proteins

- Define protein, amino acid, recognized essential amino acid and structural formula of amino acid. Also identify essential and non-essential amino acids.
- Outline the synthesis and breakage of peptide linkages.
- Justify the significance of the sequence of amino acids through the example of sickle cell hemoglobin.
- Classify proteins as globular and fibrous proteins.
- List the roles of structural proteins and functional proteins with 3 examples.

1.7-Lipids

- Define lipids
- Describe the properties and roles of acylglycerols, phospholipids, terpenes and waxes.
- Illustrate the molecular structure (making and breaking) of an acylglycerol, a phospholipid and a terpene
- Evaluate steroids and prostaglandins as important groups of lipids.

1.8-Nucleic Acids

- Describe nucleic acids and molecular structure of nucleotides.
- Outline the examples of a mononucleotide (ATP) and a dinucleotide (NAD).
- Illustrate the formation of phosphodiester bond
- Explain the double helical structure of DNA as proposed by Watson and Crick.
- Explain the general structure of RNA.
- Distinguish in terms of functions and roles, the three types of RNA
- Discuss the Central Dogma.

1.9-Conjugated molecules

- Define conjugated molecules and describe the roles of common conjugated molecules i.e. glycolipids, glycoproteins, lipoproteins and nucleoproteins.



Chapter 02

ENZYMES

Students will learn about:

Define enzymes and explain their role in metabolic reactions.

The role of enzymes in metabolic reactions and the process of enzyme-catalyzed reactions.

The factors that affect enzyme activity, including temperature, pH, and substrate concentration.

In this chapter

(10 Periods)

- | | |
|---|------|
| • Enzyme and Structure of enzyme. | (02) |
| • Concept of Activation energy | (01) |
| • Components of enzymes and their role. | (01) |
| • Mode of enzyme action | (02) |
| • Factors affecting enzyme activity | (03) |
| • Feedback inhibition | (01) |
| • Classification of enzymes. | (01) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

2.1-Enzyme and Structure of enzyme.

- Describe enzyme structure. Identify the role and component parts of the active site of an enzyme.

2.2-Concept of Activation energy

- Define energy of activation and discuss through graph how an enzyme speeds up a reaction by lowering the energy of activation.

2.3-Components of enzymes and their role

- Differentiate among the three types of cofactors i.e. in-organic ions, prosthetic group and coenzymes, with examples.

2.4-Mode of enzyme action

- Explain the mechanism of enzyme action with the help of lock and key and Induced Fit Model, compare induce fit model with Lock and Key model.
- Explain enzyme catalysis with example of specific reactions

2.5-Factors affecting enzyme activity

- Explain the effect of temperature on the rate of enzyme action with example of human and thermophilic bacteria.
- Investigate the effect of pH on enzyme activity Compare the optimum pH of different enzymes like trypsin, pepsin, papain.
- Demonstrate that the concentration of enzyme affects the rate of enzyme action.

2.6-Feedback inhibition



- Describe enzymatic inhibition, its types and its significance with examples.
- Name the molecules which act as inhibitors.
- Categorize inhibitors into competitive and non-competitive inhibitors.
- Explain feedback inhibition.

2.7-Classification of enzymes

- Classify enzymes on the basis of the catalytic reactions (oxido-reductases, transferases, hydrolases, isomerases, and ligases).
- Classify enzymes on the basis of their substrate (lipases, diastase, amylase, protease, etc.)



Chapter 03

CELL AND ITS ORGANELLES

Students will learn about:

The structure and function of cells, including prokaryotic and eukaryotic cells.

The main subcellular organelles, including the nucleus, mitochondria, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, and peroxisomes.

The role of the cell membrane and describe its structure.

Concept of cell signaling and its pathway.

Concept of stem cell and its types with advantages and disadvantages.

In this chapter

(18 Periods)

- | | |
|---|------|
| • Cell is basic unit of living organism with respect to major properties. | (01) |
| • Microscopy | (02) |
| • Prokaryotic and eukaryotic cells. | (01) |
| • Ultra Structure of Animal and Plant Cells | (01) |
| • Cell wall. | (01) |
| • Organelles of eukaryotic cell | (07) |
| • Structure of cell membrane | (02) |
| • Cell signaling and its pathway | (02) |
| • Concept of stem cell | (01) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

3.1-Cell is Basic Unit of Living Organism with respect to major properties.

- Describe that cell is the basic unit of all living organisms with respect to properties of life. (Irritability, Metabolism Nutrition, Homeostasis, Growth and Reproduction)

3.2-Microscopy

- Compare and contrast the working of a light microscope and electron microscope with focus on magnification, resolution and contrast.

3.3-Prokaryotic and Eukaryotic cells

- Differentiate between prokaryotic and eukaryotic cells with diagrams.

3.4-Ultra structure of Animal and plant cells

- Identify the Microscopic structure of animal and plant cells.

3.5-Cell Wall.

- Describe the locations, chemical composition and significance of the primary, secondary cell wall and of middle lamella.

3.6-Structure of Cell Membrane

- Explain the structure of the cell membrane and the techniques that can be used to study it.



- Explain the methods of membrane transport mechanisms with diagrams: [simple diffusion, Facilitated diffusion, Osmosis, Active transport (endocytosis and exocytosis)].

3.7-Organelles of Eukaryotic cell

- Describe the structure and functions of organelles. Endoplasmic reticulum (SER and RER), Ribosomes, Golgi apparatus, Lysosomes, Peroxisomes, Glyoxysomes, Vacuoles, Mitochondria, Plastids, Centrioles, Cytoskeleton and Nucleus.

3.8-Cell Signaling and its Pathway

- Define cell signaling.
- Discuss the pathway of a signal from outside the cell to the inside. (Protein signal and steroid signal)

3.9-Concept of Stem Cell

- Define Stem cells and advantages of using stem cells.
- Categorize different types of stem cells
- Evaluate the advantages and disadvantages of using induced Pluripotent Stem Cells.
- Draw the stages of Mitosis and Meiosis.



Chapter 04

BIOENERGETICS

Students will learn about:

The fundamental metabolism processes i.e. Photosynthesis and Respiration, How energy convert and stored in living system by these processes. This chapter also develops basic concepts of photorespiration.

In this chapter

(13 Periods)

- | | |
|---------------------------------|------|
| • Introduction of Bioenergetics | (01) |
| • Photosynthesis. | (06) |
| • Cellular Respiration | (04) |
| • Photorespiration | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

4.1-Introduction of Bioenergetics

4.2-Photosynthesis.

- Define photosynthesis and explain the role of light, carbon dioxide and water in photosynthesis
- Identify the two general kinds of photosynthetic pigments (carotenoids and chlorophylls)
- Describe the roles of photosynthetic pigments in the absorption and conversion of light energy
- Differentiate between the absorption spectra of chlorophyll 'a' and 'b'
- Describe the arrangement of photosynthetic pigments in photo system-I and II.
- Describe the events of non-cyclic photo phosphorylation and cyclic photo phosphorylation.
- Explain the Calvin cycle (the regeneration of RuBP should be understood in outline only.)

4.3- Cellular Respiration

- Define respiration and explain the process of anaerobic respiration in terms of glycolysis and conversion of pyruvate into lactic acid or ethanol.
- Outline the link between conversion of pyruvate into acetyl-CoA.
- Outline the steps of Krebs cycle.
- Trace the passage of electrons through the electron transport chain.
- Describe Chemiosmosis and Relate it with electron transport chain.
- Explain the substrate level phosphorylation during which exergonic reactions are coupled with the synthesis of ATP.
- Justify the importance of G3P in photosynthesis
- Outline the formation of acetyl CoA from fats
- Compare and contrast oxidation of fats and glucose.

4.4-Photorespiration

- Define photorespiration
- Outline the events occurring through photorespiration.
- Rationalize how the disadvantageous process of photorespiration evolved.
- Explain the effect of temperature on the oxidative activity of RuBP carboxylase.
- Outline the process of C₄ and CAM photosynthesis as an adaptation evolved in some plants to deal with the problem of photorespiration.



Chapter 05

ACELLULAR LIFE

Students will learn about:

The characteristics and diversity of acellular life, including viruses and viroids.

The replication and infection cycles of viruses.

Compare and contrast the structure and function of virus particles.

The impacts of viruses on human health and the environment.

Methods for controlling and preventing viral infections.

In this chapter

(12 Periods)

- Viruses- Discovery and Structure (02)
- Parasitic Nature of Viruses (02)
- Life cycle of Bacteriophage (02)
- Life cycle of Human Immunodeficiency Virus. (02)
- Viral Diseases (03)
- Prions and Viroids (01)

MAJOR CONCEPTS AND LEARNING OUTCOMES

5.1-Viruses- Discovery and Structure

- Justify the status of viruses among living and nonliving things.
- Trace the history of viruses since their discovery.
- Describe the structure of a model bacteriophage, and HIV and.

5.2-Parasitic Nature of Viruses

- Classify viruses on the bases of their hosts and structure.
- Justify that a virus must have a host cell to parasitize in order to complete its life cycle.
- Explain a virus survives inside a host cell, protected from the immune system.
- Determine the method a virus employs to survive/ pass over unfavorable conditions when it does not have a host to complete the life cycle.

5.3-Life Cycle of Bacteriophage

- Describe the Lytic and Lysogenic life cycles of a virus.
- Outline the usage of bacteriophage in genetic engineering.

5.4- Human Immunodeficiency Virus.

- Explain the life cycle of HIV.
- Justify the name of the virus i.e., “Human Immunodeficiency Virus” by establishing T-helper cells as the basis of immune system.
- Reason out the specificity of HIV on its host cells.
- List the symptoms of AIDS.
- Explain opportunistic diseases that may attack an AIDS victim.
- Describe the Treatments available for AIDS.
- List some common control measures against the transmission of HIV.



5.5-Viral Diseases

- Describe the causative agent, symptoms, treatment and prevention of the following viral diseases: hepatitis C, herpes, polio and leaf curl virus disease of cotton.
- List the sources of transmission for each of the above-mentioned diseases.
- Interpret how viral infections cause global economic loss.
- Describe the limitations of the vaccine for the common cold / flu virus

5.6-Prions and Viroids

- Describe the structure of prions and viroids.
- List the diseases caused by prions and viroids.



Chapter 06

PROKARYOTES

Students will learn about:

The world of cellular organisms that lack membrane bound nucleus.

The differences in structure and function between prokaryotic and eukaryotic cells.

The diversity of organisms within the domains of Bacteria and Archaea.

In this chapter

(12Periods)

- | | |
|---|------|
| • Taxonomy of Prokaryotes | (02) |
| • Bacteria structure, ecology and Diversity | (03) |
| • Modes of Nutrition in Bacteria. | (02) |
| • Growth and Reproduction in Bacteria | (01) |
| • Importance in Bacteria | (02) |
| • The Bacterial Flora of Humans | (01) |
| • Control of Harmful Bacteria | (01) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

6.1-Taxonomy of Prokaryotes

- Outline the Taxonomic position of prokaryotes in terms of domains archaea and bacteria and in terms of kingdom monera.
- Explain the phylogenetic position of prokaryotes.
- Justify the occurrence of bacteria in the widest range of habitats.

6.2-Bacteria Structure, Ecology and Diversity

- Draw a labeled diagram of a generalized bacterial cell.
- Describe detailed structure and chemical composition of bacterial cell wall and extra protective layers.
- Compare cell wall differences in Gram-positive and Gram-negative bacteria.
- Illustrate with diagrams the great diversity of shapes and sizes found in bacteria.
- Explain motility in bacteria.
- Describe with diagram structure of bacterial flagellum.

6.3-Modes of Nutrition in Bacteria.

- Justify cyanobacteria are considered as the most prominent of the photosynthetic bacteria.
- Classify bacteria on the basis of methods of obtaining energy and carbon.
- Differentiate between the mechanism of photosynthesis in cyanobacteria and other photosynthetic bacteria.

6.4-Growth and Reproduction in Bacteria

- Justify the endospore formation in bacteria as a mechanism of survival to withstand unfavorable conditions.



- List the phases in the growth of bacteria.
- Describe different methods of reproduction in bacteria.
- Describe genomic organization of bacteria with respect to circular DNA and plasmids.

6.5-Importance in Bacteria

- Describe bacteria as recyclers of nature. Outline the ecological and economic importance of bacteria.
- Explain the use of bacteria in research and technology.
- Describe common bacterial diseases in man e.g. cholera, typhoid, tuberculosis, and pneumonia; emphasizing their symptoms, causative bacteria, treatments, and preventative measures.
- Describe common bacterial diseases in plants e.g. spots, blights, soft rots, wilts, and galls; emphasizing their symptoms, causative bacteria, and preventative measures.

6.6-The Bacterial Flora of Humans

- Define the term normal flora.
- Describe the benefits of the bacterial flora of humans.

6.7-Control of Harmful Bacteria

- Enlist the chemical and physical methods used to control harmful bacteria.



Chapter 07

PROTISTA AND FUNGI

Students will learn about:

The unique characteristics and functions of protists, including those that are unicellular, colonial, or multi cellular.

The importance of fungi in the ecosystem, including their role in decomposition, nutrient cycling, and symbiotic relationships with other organisms.

The different modes of nutrition and lifestyle of protists, and fungi.

In this chapter

(12 Periods)

- | | |
|------------------------------------|------|
| • Prototists | (02) |
| • Major groups of Protists | (03) |
| • General characteristics of Fungi | (02) |
| • Diversity among Fungi | (03) |
| • Importance of Fungi | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

7.1-Prototists

- Explain protists as a diverse group of eukaryotes that has polyphyletic origin and defined only by exclusion from other groups
- Justify how protists are important for humans.

7.2-Major Groups of Protists

- Explain the salient features with examples of protozoa, algae, myxomycota and oomycota as the major groups of protists

7.3-General characteristics and Diversity of Fungi

- Classify fungi into zygomycota, ascomycota, deutromycota and basidiomycota and give the diagnostic features of each group.

7.4-Importance of Fungi

- Explain yeast as unicellular fungi that are used for baking and brewing and are also becoming very important for genetic research.
- Name a few fungi from which antibiotics are obtained.
- Explain the mutualism established in mycorrhizae and lichen associations.
- Give examples of edible fungi.
- Describe the ecological impact of fungi causing decomposition and recycling of materials.
- Discuss the pathogenic role of fungi.



Chapter 08

DIVERSITY AMONG PLANTS

Students will learn about:

The plant dominant the terrestrial environment and provide services for all living things. Plant for their food and many other products.

The diversity and importance of plants.

In this chapter

(15 Periods)

- Non-vascular plants (03)
- Seedless vascular plants (06)
- Seeded plants (06)

MAJOR CONCEPTS AND LEARNING OUTCOMES

8.1-Non-vascular Plants

- Describe non-vascular plants (Bryophytes)
- Explain the life cycle of polytrichum.

8.2-Seedless Vascular Plants

- Describe the general features of vascular plants
- Identify the division between vascular plants [Psilopsida, Lycopsida, Sphenopsida Pteriopsida, Spermopsida (gymnosperms, angiosperms)]
- Explain the life cycle of ferns as example of Pteriopsida.

8.3-SeededPlants

- Describe the general characteristic of gymnosperms and classify them into classes.
- Describe the life cycle of pinus
- Describe the general characteristics of angiosperms and classify them into classes
- Explain the life cycle of angiosperms
- Describe general characteristics and economic importance of the following angiospermic families Brassicaceae, Solanaceae and Poaceae



Chapter 09

DIVERSITY AMONG ANIMALS

Students will learn about:

The classification of animals and general characteristics of different animals groups.

In this chapter

(20 Periods)

- | | |
|-------------------------------------|------|
| • Criteria of Animal Classification | (04) |
| • Invertebrates | (10) |
| • Chordates | (06) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

9.1-Criteria of Animal Classification

- Basis of classification of animals

9.2-Invertebrates

- Describe the general characteristics, importance and example of Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Mollusca, Arthropoda and Echinodermata.

9.3-Chordates

- Describe the general characteristics of chordates distinguish between invertebrate chordates and vertebrate chordates
- Describe the general characteristics of cyclostomes, Pisces, amphibian, reptiles, aves and mammals.



Chapter 10

FORM AND FUNCTIONS OF PLANTS

Students will learn about:

The basic structure and anatomy of plant cells and organs, including stems, roots, leaves, and flowers.

The significance of seeds and the different methods of seed dispersal.

The basic processes of plant growth and development, including germination, shoot and root development, and the role of hormones.

The adaptations that allow plants to survive in different environments, including ways to conserve water, regulate temperature, and defend against herbivores.

In this chapter

(20 Periods)

- | | |
|------------------------------------|------|
| • Nutrition in plants. | (01) |
| • Gaseous Exchange in Plants | (02) |
| • Transport in Plant | (06) |
| • Homeostasis in Plants | (03) |
| • Support in Plants | (02) |
| • Growth and Development in Plants | (03) |
| • Growth Responses in Plants | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

10.1-Nutrition In plants.

- List the macro and micronutrients of plants highlighting the role of each nutrient.
- State the examples of carnivorous plant.

10.2-Gaseous Exchange in Plants

- Explain the role of stomata and palisade tissue in the exchange of gasses in plants.
- Relate transpiration with gaseous exchange in plants.

10.3-Transport In Plant

- Describe the xylem elements in vessels, tracheids, fibers and phloem elements i.e. sieve tube, companion cells and relate their structures with functions.
- Discuss the movement of water between plant cells, and between the cells and their environment in terms of water potential.
- Describe the movement of water lateral roots in terms of symplast, apoplast and vacuolar pathways.
- Explain the vertical movement of water in xylem through TACT mechanism.
- Describe the Mechanisms involved in the opening and closing of stomata.
- Explain the movement of sugars within plants.

10.4-Homeostasis in Plants

- Define osmotic adjustment.



- State movement of water into or out of the cell in isotonic, hypotonic, and hypertonic conditions.
- Explain the osmotic adjustments in hydrophytes, halophytes, xerophytes and mesophytes.
- List the adaptations in plants to cope with low and high temperatures

10.5-Support In Plants

- Describe the turgor pressure and its significance in providing support to herbaceous plants.
- Describe the structure of supporting tissues in plants.

10.6-Growth and Development in Plants

- Define growth and explain primary and secondary growth in plants.
- Justify the formation of annual rings
- Explain the influence of apical meristem on the growth of lateral shoots.
- Outline the role of important plant growth regulators.

10.7-Growth Responses in Plants

- Explain the types of movement in plants in response to light, force of gravity, touch and chemicals.
- Define photoperiodism.
- Classify with examples plants on the basis of photoperiodism and describe the mechanism of photoperiodism with reference to the mode of action of phytochrome.
- Explain the role of low temperature treatment on flower production especially to biennials and perennials.



Chapter 11

HOLOZOIC NUTRITION

Students will learn about:

The structure and function of the digestive system of human.

Common dietary and infectious diseases.

In this chapter

(12 Periods)

- Digestive System of Man

(10)

Alimentary canal: Structural and functional details,

- Role of Accessory Gland

(02)

MAJOR CONCEPTS AND LEARNING OUTCOMES

11.1-Digestive System of Man

(Alimentary canal: Structural and functional details)

- Describe digestion; discuss mechanical and chemical digestion in the oral cavity.
- Explain the process of swallowing. Explain peristalsis.
- Illustrate with diagram, the structure of the stomach and relate each component with the mechanical and chemical digestion in the stomach.
- Identify the role of the nervous system and gastrin hormone on the secretion of gastric juice.
- Describe the major actions carried out on food in the three regions of the small intestine.
- Trace the absorption of digested products from the small intestine, lumen to the blood capillaries and lacteals of the villi.
- Describe the component parts of large intestine with their respective roles.
- Correlate the involuntary reflex for egestion in infants and the voluntary control in adults.

11.2-Role of Accessory Gland

- Explain the storage and metabolic role of the liver.
- Describe composition of bile and relate its constituents with respective roles.
- Outline the structure of pancreas and explain its function as an exocrine gland.
- Relate the secretion of bile and pancreatic juice with the secretin and cholecystokin in hormones.



Chapter 12

GASEOUS EXCHANGE

Students will learn about:

The structure and function of the Respiratory System of Human and important Respiratory disorders. Important health issue associated with hazardous effects of smoking.

In this chapter

(12 Periods)

- | | |
|-----------------------------------|------|
| • Respiratory System of Man | (07) |
| • Mechanism of Transport of Gases | (03) |
| • Respiratory Disorders | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

12.1-Respiratory System of Man

- Define the respiratory surface and list its properties
- Describe the main structural features and functions of the components of human respiratory system.
- Explain the ventilation mechanism in humans.

12.2-Mechanism of Transport of Gases

- Discuss the transport of oxygen and carbon dioxide through blood and outline the role of respiratory pigments in it.

12.3-Respiratory Disorders

- State the causes, symptoms and treatment of upper Respiratory Tract Infections (sinusitis, otitis media) and lower Respiratory Tract Infections (pneumonia, pulmonary tuberculosis).
- Describe the disorders of lungs (emphysema and COPD)
- List the effects of smoking on respiratory system



Chapter 13

CIRCULATION

Students will learn about:

The structure and function of the Circulatory System of Human, Cardiovascular disorders and the lymphatic system.

In this chapter

(20 Periods)

- | | |
|--|------|
| • Circulation and Components of Circulatory System | (03) |
| • Circulatory System of Man | (06) |
| • Blood Vessels | (03) |
| • Blood Pressure and Its Measurement | (02) |
| • Cardiovascular Disorders | (03) |
| • Lymphatic System of Man | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

13.1-Circulation and Components of Circulatory System

- Define circulatory system and its types, explain the components of human circulatory system

13.2-Circulatory System of Man

- State the location of heart and describe the role of pericardium, explain the structure of the walls of heart and rationalize the thickness of the walls of each chamber.
- Trace the flow of blood through the heart as regulated by the valves.
- State the phases of Heartbeat.
- Explain the role of SA node, AV node and Purkinje fibers in controlling the heartbeat.
- List the principles and uses of Electrocardiogram.

13.3-Blood Vessels

- Describe the detailed structure of arteries, veins and capillaries.
- Describe the role of arterioles in vasoconstriction and vasodilation.
- Describe the role of pre-capillary sphincters in regulating the flow of blood through capillaries.
- Trace the path of the blood through the pulmonary and systemic circulation (coronary hepatic portal and renal circulation).
- Compare the rate of blood flow through arteries, arterioles, capillaries, venules and veins.

13.4-Blood Pressure and Its Measurement

- Define blood pressure and explain its periods of systolic and diastolic pressure.
- State the role of baroreceptors and volume receptors in regulating the blood pressure.



13.5-Cardiovascular Disorders

- Define the term thrombus and differentiate between thrombus and embolus.
- Identify the factors Causing atherosclerosis and arteriosclerosis.
- Categorize Angina pectoris, heart attack, and heart failure as the stages of cardiovascular disease development.
- State the congenital heart problem related to the malfunctioning of cardiac valves.
- Describe the principles of angiography.
- Outline the main principles of coronary bypass, angioplasty and open-heart surgery.
- Define hypertension and describe the factors that regulate blood pressure as hypertension and hypotension.
- List the changes in lifestyles that can protect man from hypertension and cardiac problems.

13.6-Lymphatic System of Man

- Describe the formation, composition and function of intercellular fluid.
- Compare the composition of intercellular fluid with that of lymph.
- Explain the structure and role of lymph capillaries, lymph vessels and lymph ducts.
- Describe the functions of lymph nodes and state the role of spleen as containing lymphoid tissue.”



XII

Chapter 14

IMMUNITY

Students will learn about:

The body's immune response to pathogens, including the role of white blood cells, antibodies, and the complement system and how vaccines work and the importance of herd immunity.

The genetic factors can affect susceptibility to disease and examples of inherited diseases.

The mechanisms of immune tolerance and autoimmunity and their impact on human health.

The role of vaccines in preventing disease and the mechanism of action of various vaccine types, including live attenuated, inactivated, and subunit vaccines.

In this chapter

(18 Periods)

- First Line of Defense (Skin, Digestive tract, Air passageway) (04)
- Second Line of Defense (The non-specific Defense) (06)
- Third Line of Defense (The specific Defense) (08)

MAJOR CONCEPTS AND LEARNING OUTCOMES

14.1-First Line of Defense

- List the structural features of human skin that make it an impenetrable barrier against invasion by microbes.
- Explain how sebaceous (oil secreting) and sweat glands within the epidermis inhibit the growth and also kill microorganisms.
- Recognize the role of the acid of the digestive tract as killing bacteria present in food.
- Explain the role of the ciliated epithelium of the nasal cavity, the mucous of the bronchi and bronchioles in trapping airborne microorganisms.

14.2-Second Line of Defense

- Describe the role of monocytes, macrophages, dendritic cells and neutrophils.
- Explain how Natural Killer (NK) cells kill infected and cancerous cells.
- State the way proteins of the complement system kill bacteria and that interferon inhibits viruses from infecting cells.
- State the events of the inflammatory response as a generalized, non-specific defense.
- Outline the release of pyrogens and their effect on the hypothalamus to boost the body's temperature.
- List the ways that fever affects microbes.



14.3-Third Line of Defense

- Define the specific immune system as providing specific defense and acting as the most powerful means of resisting infection.
- Identify T-cells, and B-cells as components of the immune system.
- State inborn and acquired immunity as the two basic types of immunity.
- Differentiate between active and passive immunity as the two types of acquired immunity.
- Describe the role of T-cells in cell-mediated immunity.
- Describe the role of B-cells in antibody-mediated immunity.
- Discuss the role of T-cells and B-cells in transplant rejections.
- Identify the process of vaccination as a means to develop active acquired immunity.
- Describe the types of antibodies and their role (Tabulated form). Draw the structure of IgG antibody.
- Explain the role of memory cells in long term immunity.
- Define allergies and correlate the symptoms of allergies with the release of histamines.
- Describe the autoimmune diseases with examples.



Chapter 15

HOMEOSTASIS

Students will learn about:

The Human body maintains homeostasis and the role of feedback mechanism.

The structure and function of the excretory system of human and disorders of excretory system

In this chapter

(15 Periods)

- | | |
|------------------------------|------|
| • Homeostasis | (02) |
| • Osmoregulation | (02) |
| • Excretion | (01) |
| • Urinary System of Man | (05) |
| • Disorders of Urinary Tract | (03) |
| • Thermoregulation | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

15.1-Homeostasis

- Describe homeostasis and three elements i.e. receptors, control center and effectors which operate homeostatic mechanisms.
- Relate the homeostatic mechanisms with the negative and positive feedback systems.

15.2-Osmoregulation

- Define osmoregulation.
- Differentiate between osmoconformers and osmoregulators.
- Explain the problems faced by osmoregulators.
- Explain the different methods of osmoregulation found in freshwater, marine water and terrestrial animals.

15.3-Excretion

- Describe urinary system and need of excretion.
- Enlist various nitrogenous compounds excreted during the process of excretion. Explain the nature of excretory products in relation to habitat.

15.4-Urinary System of Man

- Enlist different organs of the urinary system.
- Describe the structure of kidney
- Relate the structure of the kidney with its function.
- Explain the detailed structure of a nephron.
- Explain the processes of glomerular filtration, selective re-absorption and tubular secretion and counter current exchange as the events in kidney functioning.
- Explain regulatory mechanism involved in concentration of urine
- Justify the functioning of kidneys as both excretion and osmoregulation.



- Compare the function of two major capillary beds in kidneys i.e. glomerular capillaries and peritubular capillaries.

15.5-Disorders of Urinary Tract

- List urinary tract infections and the bacteria responsible.
- Explain the causes and treatments of kidney stones.
- Outline the causes of kidney failure.
- Explain in detail the mechanism and problems related to dialysis.
- Describe the principles and the problems associated with kidney transplant.

15.6-Thermoregulation

- Define thermoregulation and explain its need.
- Classify animals on the basis of the source of body heat i.e. ectotherms and endotherms.
- Describe the regulatory strategies in man for thermoregulation



Chapter 16

SUPPORT AND MOVEMENT

Students will learn about:

The structure and function of the Skeletal System of human, disorders of skeleton and muscular system of human

In this chapter

(16 Periods)

- Human Skeleton (07)
- Disorders of Skeleton (03)
- Muscles (06)

MAJOR CONCEPTS AND LEARNING OUTCOMES

16.1- Human Skeleton

- Describe the structure of bone and compare it with that of cartilage.
- Explain the functions of osteoblasts, osteoclasts and osteocytes.
- Identify the main divisions of the human skeleton. and list the bones of the appendicular and axial skeleton of man.
- Describe three types of joints i.e. fibrous joints, cartilaginous joints and synovial joints and give example of each.

16.2-Disorders of Skeleton

- Describe the disorders of human skeleton (disc-slip, spondylosis, sciatica, arthritis, osteoporosis) and their causes.
- State different types of fractures (simple, compound and complicated) and describe the repair process of simple fractures.
- Describe the injuries in joints (dislocation and sprain) and their first aid treatment.

16.3-Muscles

- Compare smooth muscles, cardiac muscles and skeletal muscles.
- Annotate the ultrastructure of the skeletal muscle.
- Explain the sliding filaments theory of muscle contraction.
- Describe the action of antagonistic muscles in the movement of knee joint.
- Explain muscle fatigue, cramps and tetany.
- Differentiate between tetanus and muscle tetany



Chapter 17

NERVOUS COORDINATION

Students will learn about:

The structure and function of the nervous system, including the central and peripheral nervous systems.

The role of neurons in transmitting and processing information.

The process of neurotransmission and how it affects the functioning of the nervous system.

The nervous system regulates and coordinates body functions, including the role of reflex arcs.

In this chapter

(20 Periods)

- Nervous System of Man (10)
 - Steps involved in Nervous System
 - Neurons
 - Nerve Impulse
 - Transmission of Action potential between cells and synapse.
 - Basic Organization of Human Nervous System and Sensory receptors.
- Effect of Drugs on Nervous Coordination (05)
- Disorders of Nervous system and Diagnostic tests (05)

MAJOR CONCEPTS AND LEARNING OUTCOMES

Nervous System of Man

17.1- Steps Involved in Nervous Coordination

- Recognize receptors as transducers sensitive to various stimuli.
- Trace the path of a message transmitted to the CNS (central nervous system) for processing.
- Identify muscles and glands as the effectors.

17.2- Neurons

- Describe the detailed structure of neuron and explain types of neuron as sensory neuron, associative and motor neuron
- Differentiate between myelinated and unmyelinated neurons.
- Explain reflex action with the help of reflex arc (monosynaptic and polysynaptic).

17.3- Nerve Impulse

- Define nerve impulse. Describe the generation and transmission of nerve impulse.
- Describe the factors responsible for the resting membrane potential of neuron.
- Evaluate from a graph the phenomena of polarization, depolarization and hyperpolarization of neurolemma.
- Compare the velocities of nerve impulse in the axon membrane and in the synaptic cleft.
- Describe the role of local circuits in saltatory conduction of nerve impulse.

17.4- Synapse

- Outline the structure of synapse. Describe the synaptic transmission of nerve impulse.
- Classify neurotransmitters as inhibitory and excitatory and list some common examples.



17.5- Basic Organization of Human Nervous System

- Identify the main components of the nervous system.
- Describe the architecture of human brain, explain its major divisions and subdivisions of brain along with their vital functions.
- Explain peripheral nervous system, Sketch out cranial and spinal nerves in human.
- Explain the structure, types and functions of autonomic nervous system.
- Explain the structure and function for smell, taste, vision, hearing, touch and pain receptors.

17.6- Effect of Drugs on Nervous System

- Define narcotic drugs as agents that interact with normal nervous activities.
- Compare the use and abuse of drugs with respect to nicotine, caffeine, opium, cannabis, heroine, alcohol and inhalants like nail polish remover and glue.
- Explain the terms; drug addiction and drug tolerance with reference to caffeine and nicotine and their adverse effects on the nervous system.
- Describe the way how analgesic can reduce or numb pain. Discuss how these can be addictive.

17.6- Disorders of Nervous System and Diagnostic Tests

- Classify nervous disorders their symptoms into vascular (stroke), infectious (encephalitis and meningitis) structural (tumor), functional (headache, epilepsy) and degenerative (Alzheimer and Parkinson's).
- Explain the principles of the important diagnostic tests for nervous disorders i.e. EEG, CT scan and MRI.



Chapter 18

CHEMICAL COORDINATION

Students will learn about:

The structure and function of the human endocrine system, including the role of hormones in regulating body functions.

The process of hormone secretion, including the role of the hypothalamus and pituitary gland.

The effects of hormones on various target tissues, including the growth and development of cells and tissues.

The role of hormones in regulating metabolism and energy balance, including the regulation of glucose and insulin levels

In this chapter

(15 Periods)

- | | |
|-------------------------------------|------|
| • Hormones (The Chemical Messenger) | (05) |
| • Endocrine System of Man | (08) |
| • Feedback Mechanism | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

18.1-Hormones (The Chemical Messenger)

- Define chemical messengers. Define pheromones and hormones as chemical messengers.
- Describe the chemical nature of hormones and correlate it with important human hormones.

18.2-Endocrine System of Man

- Locate the major endocrine glands in human body name the hormones they release and their functions; (pituitary, pineal, thyroid, parathyroid, thymus, pancreas, adrenal, gonads.)
- Enlist hormones of other endocrine tissues.
- Relate the problems associated with the imbalance of these hormones.
- Explain the neuro secretory role of hypothalamus.

18.3-Feedback Mechanism

- Outline the concept of Feedback mechanism of hormones. Describe positive feedback with reference to Oxytocin and negative feedback with reference to Insulin and Glucagon



Chapter 19

REPRODUCTION

Students will learn about:

The processes of reproduction in organisms, including asexual and sexual reproduction.

The role of meiosis in producing genetically diverse offspring.

The structure and function of gametes and the role of fertilization in sexual reproduction.

In this chapter

(13 Periods)

- | | |
|------------------------------------|------|
| • Human Reproductive System | (09) |
| • Disorders of Reproductive System | (02) |
| • Sexually Transmitted Diseases | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

19.1- Human Reproductive System

- Describe the structures of the male reproductive system and identify their functions
- Outline the hormones which influence male reproductive system.
- Explain common disorder related to male reproductive system.
- Explain the structures of female reproductive system and describe their functions
- Describe the menstrual cycle and its hormonal control.

19.2-Disorders of Reproductive system

- Explain common disorders related to female reproductive system

19.3-Sexually Transmitted Diseases

- Describe common STDs (Gonorrhea, syphilis, herpes and HIV infection)



Chapter 20

ORGANIC EVOLUTION

Students will learn about:

The concept of organic evolution.

The mechanisms of genetic variation and inheritance

Evidences for organic evolution, concept of convergent and divergent evolution.

Endo symbiotic theory

In this chapter

(15 Periods)

- Lamarckism, Darwinism and Neo-Darwinism (06)
- Causes of Evolution (03)
- Evidences of Evolution from Molecular Biology, homology & analogy (04)
- Evolution of eukaryotes from prokaryotes. (02)

MAJOR CONCEPTS AND LEARNING OUTCOMES

20.1-Lamarckism, Darwinism and Neo-Darwinism

- Explain the theory of organic evolution in the light of Lamarckism and Darwinism with their drawbacks.
- Concept of Neo-Darwinism.

20.2-Causes of Evolution

- Explain that evolution happens due to variation in organisms and the selection pressures that organisms face.

20.3-Evidences of Evolution from Molecular Biology, Homology & Analogy

- Analyze the evidence of evolution that comes from molecular biology.
- Differentiate between convergent and divergent evolution on the basis of inheritance of the homologous and analogous structures.

20.4-Evolution of Eukaryotes from Prokaryotes.

- Describe the Endo symbiotic theory about the mechanism of evolution of eukaryotes from prokaryotes



Chapter 21

INHERITANCE

Students will learn about:

The patterns of inheritance, including dominant and recessive traits, and how they are influenced by genes and chromosomes.

How genetic variation and mutations can lead to evolutionary change.

The central dogma of molecular biology, which outlines the flow of genetic information from DNA to RNA to protein.

The basic structure and function of genes, including the role of codons and introns.

Distinguish between different types of inheritance patterns, including dominant and recessive traits, and sex-linked traits.

In this chapter

(23 Periods)

- | | |
|---|------|
| • Laws of Mendel | (03) |
| • Incomplete Dominance, Multiple Alleles and Co-dominance | (03) |
| • ABO Blood Group System | (02) |
| • Rh Blood type system and Erythroblastosis Foetilis | (02) |
| • Polygenic Inheritance and Epistasis | (03) |
| • Gene Linkage and Crossing Over | (02) |
| • Sex determination | (02) |
| • Sex Linked Inheritance | (06) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

21.1-Laws of Mendel

- Define inheritance, describe gene as unit of inheritance.
- Explain the Law of Segregation and Independent Assortment, using suitable example of pea plant.
- Relate the Law of Independent Assortment to random orientation of chromosomes during meiosis.
- Express limitations of Independent Assortment and its usefulness.

21.2-Incomplete Dominance, Multiple Alleles and Co-dominance

- Describe the exceptions to the Mendel's Laws of Inheritance.
- Explain incomplete dominance and exemplify it through the inheritance of flower colour in 4 O' clock plant.
- Describe coat colour in cattle as an example of co-dominance and differentiate between incomplete dominance and co-dominance.

21.3-ABO Blood Group System

- Define multiple alleles with the example of ABO blood groups.
- Investigate the reasons for O-ve individual as the Universal donor and AB +ve as the Universal recipient.
- Enlist various human blood group systems.



21.4-Rh Blood type system and Erythroblastosis Foetilis

- Relate the positive and negative blood types with the presence and absence of Rh factor.
- Justify why Rh incompatibility could be a danger to the developing foetus and mother.
- Suggest measures to counter the problem of Erythroblastosis foetalis before it occurs.

21.5- Polygenic Inheritance and Epistasis

- Define gene interaction and relate the terms polygenic inheritance and epistasis.
- Describe polygenic inheritance using suitable examples from plants (grain colour in wheat) and animals (skin colour in man).
- List at least five polygenic traits discovered in human.
- Describe coat color in Labrador retrievers and pigment phenotype in foxgloves; justify modified Mendelian ratios.

21.6- Gene Linkage and Crossing Over

- Compare the terms gene linkage and crossing over.
- Explain that gene linkage counters Independent Assortment and crossing-over modifies the progeny.
- Suggest that linkage can be observed / evaluated only if the number of progeny is quite large.

21.7-Sex determination

- Explain the mechanisms of sex determination in animals.
- Identify male and female individuals from the karyotype of man.
- Solve the genetics problems related to XX-XY sex determination.

21.8-Sex Linked Inheritance

- Describe the concept of sex-linked inheritance.
- Explain the inheritance of sex linked traits (eye colour) in *Drosophila*.
- Define sex-linked inheritance in human as X-linked and Y-linked. Explain X-linked disorders in human (colour blindness and haemophilia).
- Describe the Y-linked inheritance in human and explain holandric genes.
- Explain the techniques employed for embryonic screening e.g. Amniocentesis and Chorionic Villus Sampling.



Chapter 22

CHROMOSOME AND DNA

Students will learn about:

The concept of DNA as hereditary material and metabolic processes involved in gene expression and regulation.

In this chapter

(16 Periods)

- | | |
|----------------------------------|------|
| • DNA as the Hereditary Material | (02) |
| • DNA Replication | (05) |
| • Gene Expression | (04) |
| • Regulation of Gene Expression | (03) |
| • Mutation | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

22.1-DNA as the Hereditary Material

- Narrate the experimental work of Griffith; Avery, McCarty, Macleod and Hershey-Chase, proved DNA as the hereditary material.

22.2-DNA Replication

- Define DNA replication and explain the three models proposed about the mechanism of DNA replication.
- Narrate the work of Meselson and Stahl to justify the semi conservative replication as the method of replication.
- Describe the events of the process of DNA replication.
- Describe DNA stability and variability as two characters of the replicating DNA molecule.
- Describe the characteristics of genetic code (universal, triplet, non-overlapping, co-linearity, unambiguous, degenerate, and has no punctuation).

22.3-Gene Expression

- Differentiate between the terms genetic code and codon.
- Define Central dogma, describe the mechanism of protein synthesis.
- Explain the mechanism of transcription.
- Explain why the length of transcribed mRNA molecule (in Eukaryotes) shortens as it enters the cytoplasm for translation.
- Differentiate between protein synthesis in prokaryotes and eukaryotes.
- Suggest possible ways in which the synthesized protein can be used within or outside a cell that synthesized it.



22.4-Regulation of Gene Expression

- State the importance of the regulation of gene expression.
- Explain mechanism of positive and negative gene expression through activator and repressor protein, respectively.

22.5-Mutation

- Define mutation and identify its causes.
- Differentiate between natural and induced mutations.
- Justify most mutations are harmful.
- Rationalize that mutations might be a contributing factor towards evolution.
- Describe the symptoms and causes of the chromosomal mutations. (Down's syndrome, Klinefelter's syndrome and Turner's syndrome)
- Describe the symptoms and causes of some of the gene mutations.



Chapter 23

BIOTECHNOLOGY

Students will learn about:

The application of biotechnology in various fields, including medicine, agriculture, and industry.

The principles of genetic engineering and recombinant DNA technology, including gene cloning, PCR, and sequencing.

The process of gene cloning and how it is used in biotechnology.

The use of biotechnology in producing therapeutic proteins, including vaccines, monoclonal antibodies, and growth hormones.

The history and current state of biological warfare and its impact on society.

The mechanisms by which pathogens are used as weapons, including delivery methods, transmission routes, and virulence factors.

The types of modern-day biological weapons, including biotoxins, bioregulators, and biovectors.

The principles of biodefense, including vaccine development, disease surveillance, and countermeasure research.

In this chapter

(16 Periods)

- | | |
|--|------|
| • Recombinant DNA Technology | (05) |
| • Genetically modified organism | (03) |
| • Gene Amplification and DNA Profiling | (03) |
| • Biological warfare | (02) |
| • Genomics | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

23.1-Recombinant DNA Technology

- Introduce genetic engineering.
- Describe plasmid as vector prokaryotes and explain how recombinant plasmids can be formed
- Outline the Function of Restriction Enzymes.

23.2-Genetically modified Organisms

- Define Genetically modified organism (GMO).
- Explain the formation of human insulin protein in bacteria.
- Describe how vertical food farms (soil free) work.
- Compare and contrast the advantages of vertical food farms with general agricultural practices prevalent in Pakistan.

23.3- Gene Amplification and Profiling

- Explain polymerase chain reaction (PCR)
- Describe DNA sequencing and DNA profiling.

23.4-Biological warfare

- Explain the role of biological warfare with examples.
- Explain how pathogens are used as weapons and types of modern-day biological weapons, including bio-toxins, bio-regulators, and bio-vectors.



- Describe how Bio-defenses could work to protect from biological warfare with examples (vaccine development, diseases surveillance and countermeasure research).
- Describe the ethical and societal implications of biological weapons and biodefense, including issues related to biosecurity, international regulations, and dual-use research.

23.5-Genomics

- Examine the hype behind the comics “genomics, transcriptomics, proteomics metabolomics”, to what extent is it valid or overblown?
- Explain synthetic biology with examples.



Chapter 24

ENVIRONMENTAL BIOLOGY

Students will learn about:

The role of living organisms in their environment, including the relationships between and among biotic and abiotic factors.

The structure and function of ecosystems, including biomes, communities, populations, and individuals.

The effects of human activities on the environment and the impact on biodiversity.

The methods used to monitor and manage environmental resources, such as habitat restoration and conservation.

The processes that drive the cycling of matter and energy in ecosystems, including photosynthesis, cellular respiration, and decomposition.

In this chapter

(16 Periods)

- | | |
|--------------------------------|------|
| • Components of ecosystem. | (02) |
| • Biogeochemical cycle | (02) |
| • The Flow of Energy | (02) |
| • Ecological succession | (02) |
| • Population dynamics | (04) |
| • Human Impacts on environment | (02) |
| • Major ecosystems | (02) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

24.1-Components of Ecosystem.

- Define environment, population, community, habitat, ecosystem and biosphere.
- Describe the various modes of nutrition in an ecosystem.
- Identify plants as producers that convert light energy into chemical energy and production of biomass.

24.2-Biogeochemical Cycle

- Define biogeochemical cycles and locate the primary reservoirs of the chemicals in these cycles.
- Describe the water cycle in detail.
- Define the terms aquifers and water table.
- Discuss the nitrogen cycle in detail.

24.3-The Flow of Energy

- Define different trophic levels.
- Describe the loss of energy between trophic levels.
- Describe productivity in terms of gross primary productivity (GPP) and net primary productivity (NPP).
- Interpret the pyramids of number, biomass, and energy.



24.4-Ecological Succession

- Define ecological succession as the process by which ecosystems transform from simple to complex.
- Describe primary and secondary succession.
- Differentiate between xerarch and hydrarch succession. Explain the xerarch succession on a bare rock starting from the small patches of lichens to the vegetation of flowering plants.

24.5-Population Dynamics

- Describe characteristics of a population, such as growth, density, distribution, carrying capacity, minimum/viable size.

24.6-Human Impacts on Environment

- Explain the effect of growth of the human population on the ecosystem.

24.7-Major Ecosystems

- Describe the major ecosystems of Pakistan



Chapter 25

CLIMATIC CHANGE

Students will learn about:

The role of greenhouse gases in the earth atmosphere and their impact on climate change.

The evidence for and against the existence of climate change, including data from temperature records, ice cores, and other sources.

The potential impacts of climate change on various ecosystems and species, including changes in distribution, migration patterns, and extinction risk.

The role of human activities, such as deforestation and fossil fuel burning, in contributing to climate change.

The mitigation and adaptation strategies used to reduce the impacts of climate change on biodiversity and ecosystems.

In this chapter

(08 Periods)

- | | |
|----------------------------|------|
| • Impact of climate change | (03) |
| • Endangered species | (02) |
| • Greenhouse effect | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

25.1-Impact of Climate Change

- Describe how climatic change impacts flora and fauna.
- Describe how climate change can impact ocean biology in terms of its temperature and pH as harmful effects.

25.2-Endangered Species

- Enlist species that have gone endangered and extinct due to climatic change in Pakistan.

25.3-Greenhouse Effect

- Define greenhouse gases. Explain the greenhouse effect, providing examples of gases that demonstrate this behavior.
- Describe the harmful effects of greenhouse gases on the environment.
- Explain how coral reefs are used as a barometer for the health of an aquatic ecosystem concerning ocean acidification



Chapter 26

PHARMACOLOGICAL DRUGS

Students will learn about:

The mechanism of action of various drug classes, including pain relievers, antidepressants, and antibiotics.

The factors that determine drug efficacy and toxicity, including dose, route of administration, and pharmacokinetics.

The side effects and potential drug interactions of various drugs.

The principles of drug design and development, including target selection, lead optimization, and clinical trials.

The role of pharmacology in the treatment of diseases, including the use of drugs to prevent diagnoses and treat a range of medical conditions

In this chapter

(10 Periods)

- | | |
|-----------------------------|------|
| • Drug Discovery | (03) |
| • Antibiotics and Antiviral | (03) |
| • Monoclonal Antibodies | (04) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

26.1-Drug Discovery

- Explain the drug discovery and development process.

26.2-Antibiotics and Antiviral

- Define 4 classes of antibiotics (penicillin, Tetracycline, Fluriquinolones and Sulfonamides) and describe their mode of action.
- Define antivirals and Antiretroviral

26.3-Monoclonal Antibodies

- Describe advantages of monoclonal antibodies and compared to other drug classes.



Chapter 27

STRUCTURAL BIOLOGY AND COMPUTATIONAL BIOLOGY

Students will learn about:

The study of the three – dimensional structures of biological molecules, including proteins, DNA and RNA.

The techniques used in structural biology, including X-ray crystallography, nuclear magnetic resonance spectroscopy and cryo-electron microscopy.

The role of structural biology in understanding biological function and disease.

The computational biology and explain its role in biology.

The application of computational methods in various areas of biology, including genetics, genomics, systems biology and evolution.

In this chapter

(10 Periods)

- | | |
|--|------|
| • Structural Biology | (03) |
| • Structural Determination of Biomolecules | (04) |
| • Computational Biology | (03) |

MAJOR CONCEPTS AND LEARNING OUTCOMES

27.1-Structural Biology

- Define structural biology.

27.2-Structural determination of Biomolecules

- Explain that structure determination of biomolecules are important
- Describe how X-ray crystallography works.

27.3-Computational Biology

- Outline the online databases where biomolecule structures are available.
- Describe computational Biology.
- Understand biological structures using computational methods in agricultural biotechnology, including crop improvement and pest management.
- Define Sequence and structural Homology.



Chapter 28

BIostatISTICS AND DATA HANDLING

Students will learn about:

The biostatistics and explain its role in biology.

The process of collecting, organizing, and analyzing data in biology.

The various statistical methods used in biology, including descriptive statistics, inferential statistics, and hypothesis testing.

The importance of proper data management, including data accuracy and data security.

The data can be represented graphically, including bar graphs, histograms, and scatterplots.

In this chapter

(18 Periods)

- Introduction to Biostatistics (03)
- Central Tendency (05)
- Data Visualization and Experimental Design (10)

MAJOR CONCEPTS AND LEARNING OUTCOMES

28.1-Introduction to Biostatistics

- Define biostatistics and its use.

28.2-Central Tendency

- Define mean, median, mode, standard deviation, range, percentile.
- Calculate mean, median, mode, standard deviation, range, percentile from a given set of data.

28.3-Data Visualization and Experimental Design

- Sketch a bar diagram for the given set of data.
- Sketch error bars based on range or standard deviation for a given set of data on a bar diagram.
- Evaluate the appropriate type of figure or diagram for a given set of data from experiment (bar diagram, pie diagram, x-y axis data graph etc.).
- Design an appropriate experiment with a control group and dependent, independent and control variables.
- Make the appropriate chart with proper title, labeled axis, legend, axis units.



ASSESSMENT AND EVALUATION

Being an integral part of the learning process, assessment and evaluation tool is an important chapter of the curriculum document. Assessment tool enables teachers not only verify students' learning but also diagnose the shortcomings in the learning process.

Continuous Assessment Tools:

The learning process in the classroom ought to include constant assessment. The following tools might be used to accomplish the above goals.

- ✓ **Lab completion**
- ✓ **Identification**
- ✓ **Objective enhancement-worksheets, quizzes, and tests**
- ✓ **Diagram completion**
- ✓ **Observation**
- ✓ **Review questions**
- ✓ **Classroom discussions**

Every curriculum-based target should be covered by the cumulative, all-inclusive continuous assessment. The usage of assessment tools covering the expectations as outlined by the curriculum objectives to assess the students.

Evaluation Strategy:

At the completion of the course, an external examination should be conducted. Every learning domain should be assessed by this evaluation so that the goals accomplishment may be tracked. The following table shows the distribution and relative importance of the various learning domains:

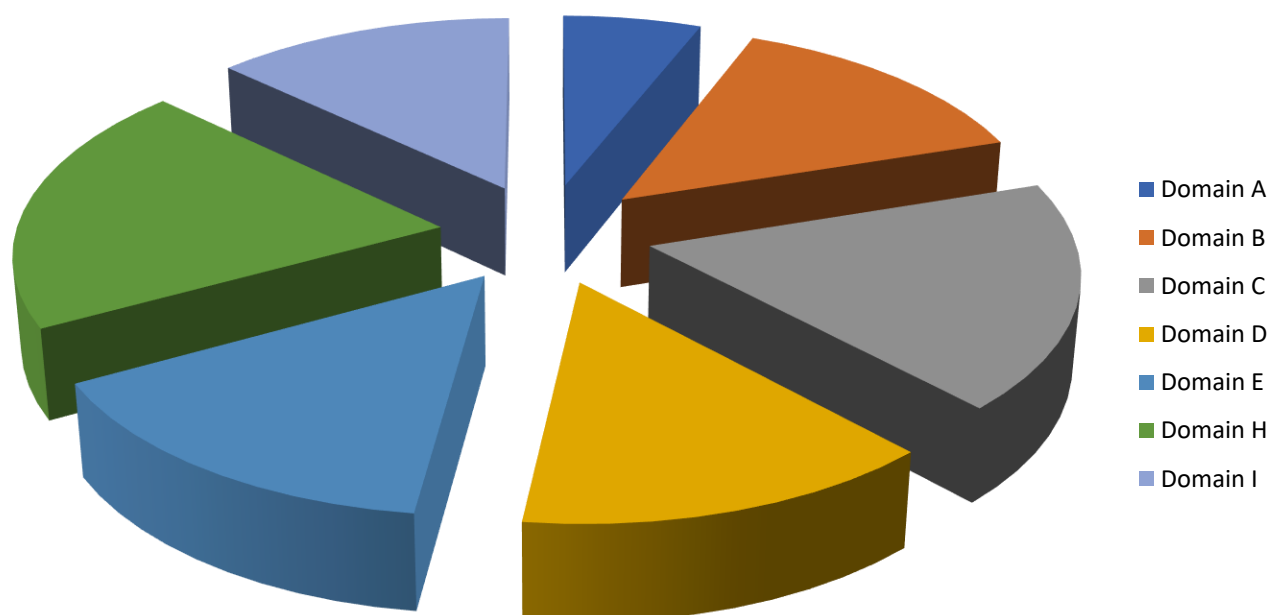
Learning Domains for Assessment	Weightage in Evaluation
• Knowledge, Comprehension, Analysis, Evaluation, Synthesis, Application:	85%
• Skills of Communication, Initiating and Planning, Designing Experiments and Interpreting Data:	05%
• Sensory motor Skills (Performing Lab Work):	10%



The following weighting is advised for the learning outcomes final evaluation:

For the Grade IX

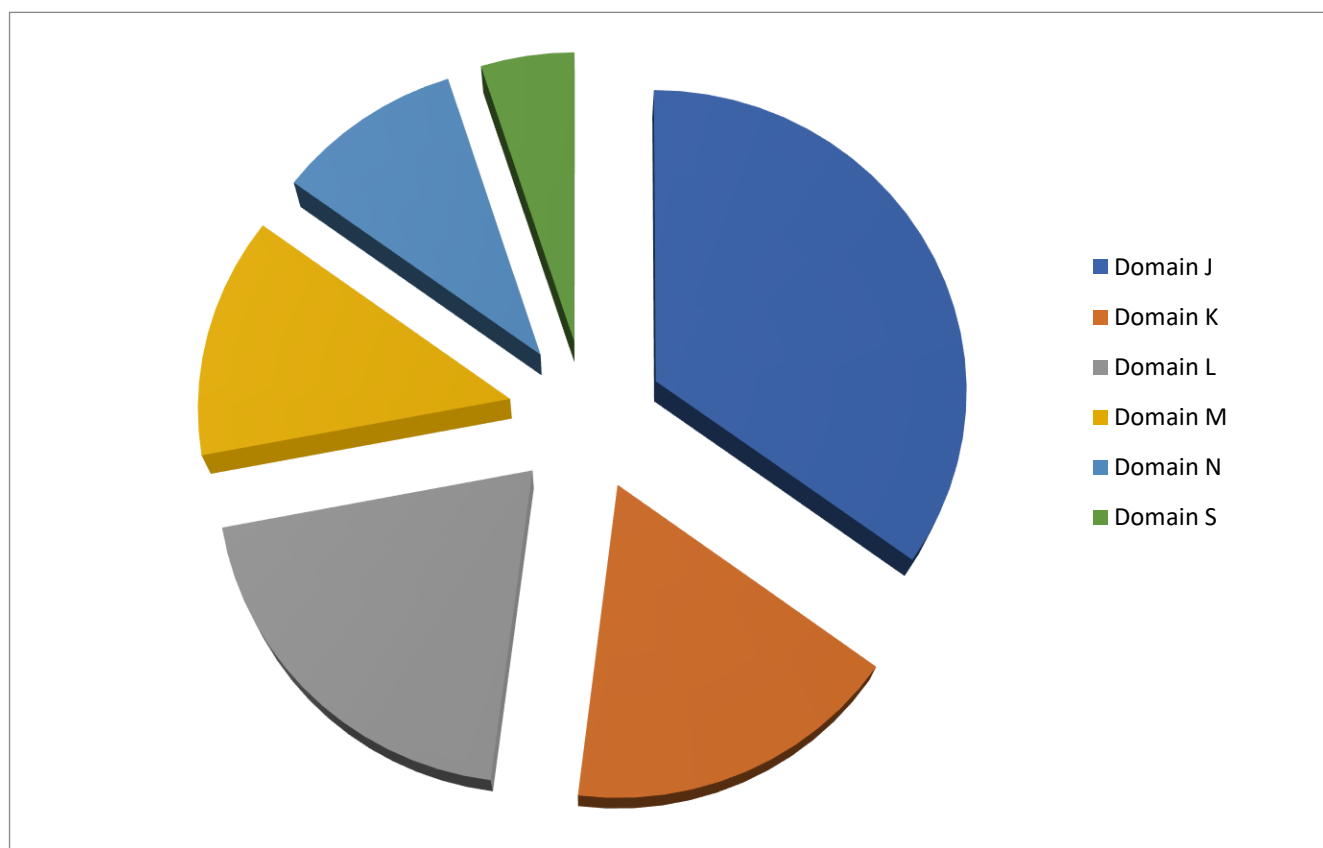
Learning Domains for Assessment	Weightage in Evaluation
Domain A: Nature of Science in Biology	6%
Domain B: Molecular Biology	14%
Domain C: Cell and Its Organelles	18%
Domain D: Tissues, Organs and Systems	14%
Domain E: Evolution, Biodiversity and Classification	15%
Domain H: Forms and Functions of Plant	20%
Domain I: Metabolism	13%
Total	100%





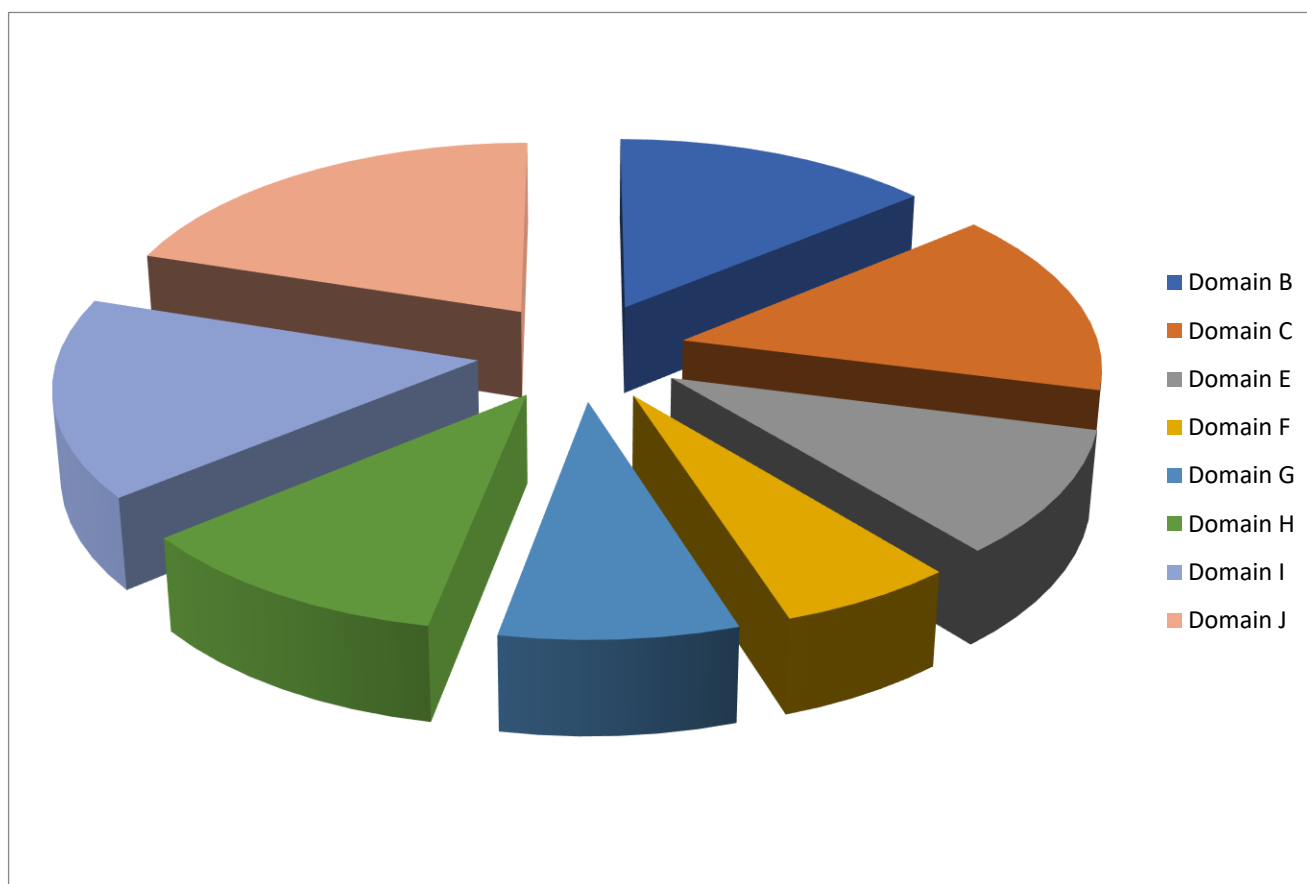
For the Grade X

Learning Domains for Assessment	Weightage in Evaluation
Domain J: Human Physiology	35%
Domain K: Coordination and Control	17%
Domain L: Reproduction and Inheritance	20%
Domain M: Diseases and Immunity	13%
Domain N: Biotechnology	10%
Domain S: Biostatistics and Data handling	5%
Total	100%



**For the Grade XI**

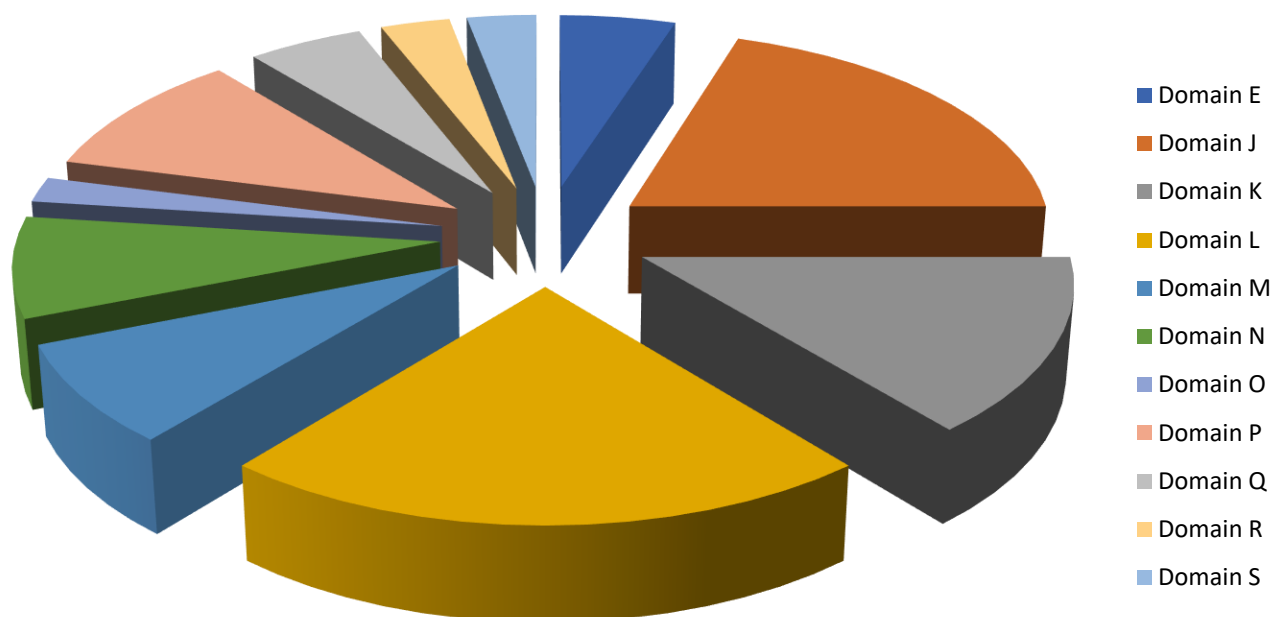
Learning Domains for Assessment	Weightage in Evaluation
Domain B: Molecular Biology	14%
Domain C: Cell and its Organelles	15%
Domain E: Evolution, Biodiversity and Classification	10%
Domain F: Acellular Life	6%
Domain G: Prokaryotes, Protista and Fungi	8%
Domain H: Forms and Functions of Plant	11%
Domain I: Metabolism	16%
Domain J: Human Physiology	20%
Total	100%





For the Grade XII

Learning Domains for Assessment	Weightage in Evaluation
Domain E: Evolution, Biodiversity and Classification	5%
Domain J: Human Physiology	20%
Domain K: Coordination and Control	14%
Domain L: Reproduction and Inheritance	22%
Domain M: Diseases and Immunity	8%
Domain N: Biotechnology	8%
Domain O: Pharmacological drugs	2%
Domain P: Environmental Biology	10%
Domain Q: Climate Change	5%
Domain R: Structural biology and Computational Biology	3%
Domain S: Biostatistics and Data Handling	3%
Total	100%





- ✓ The Examination Boards' requirements, regulations, and procedures govern the assessment pattern.
- ✓ The question paper will not be based on a specific textbook, but rather on the curriculum.
- ✓ The ability to solve problems and perform higher-order thinking tasks may be evaluated by asking questions about experiences from everyday life or novel situations. Candidates will receive enough information in their responses to these questions to enable them to comprehend the circumstances or background. In order to solve the problems, candidates are expected to apply the information and abilities covered in the syllabus.
- ✓ SI terminology and units will be utilized generally.



INSTRUCTIONS AND SUGGESTIONS

Implementing the Curriculum:

For Students:

Higher expectations for performance translate into more options as students go on to higher grades.

For Parents:

Thorough awareness of the educational opportunities their kids should have, the ways they can help them learn, the goals of these activities, and the rewards their kids will receive for their accomplishments

For Teachers and Schools:

Clarity regarding the goals that education should pursue for each student; adaptability to use professional judgment when organizing activities and programs to meet the requirements of specific individuals

For the Education System

A duty to guarantee that the goals and principles outlined in the curriculum are fully reflected in the qualifications and that teaching, learning, and assessment are focused toward accomplishing them; an obligation to guarantee that teachers' initial training and ongoing professional development adequately prepare them for their role

For Society:

Assurance that kids are being given the tools they need to succeed to the greatest extent possible and become responsible citizens, self-assured individuals, successful learners, and valuable members of society

Instructions for Textbook Writing

- The literary material should not be developed by a team of twelve or more authors. As a result, the novel loses its consistency and cohesion. It is best to assign the work of creating a textbook to two or three authors who can organize the material so that each section is consistent and makes sense. There are one or two authors for every biology book in the O-level and A-level series.
- Attempts should be made to involve the same textbook authors who created the learning objectives for that specific grade and subject in the curriculum.
- Before the process begins, the curriculum wing should be able to teach the textbook's authors and editors.



- In order to provide teachers and students with up-to-date information on the curriculum, addresses of pertinent websites and online learning centers should be included at the conclusion of each chapter.
- Textbook boards should offer colour acetate transparencies of the lessons for grades IX–X and XI–XII, which teachers can use to augment lectures in the classroom.
- The textbook board ought to release additional educational resources, such as;

1. Laboratory Manual

It should provide numerous learning tools and be consistent with the text. Along with exercises on the scientific method, cladistics, ecological and evolutionary principles, and animal anatomy and function, it should have pictures and illustrations.

2. Instructor's Manual

It ought to include reading lists and lesson plans for the course with different emphasis points. A thorough outline, goal, objectives, important terms, summary, and resources for computer software and audiovisual materials should also be included.

The following are things that authors should consider when crafting the books' content.

The textbook authors should retain and limit the textual material as prescribed in the learning outcomes details. The contents must be time factor controlled as per periods allotted to the concepts I topics.

The following are things that authors should consider when crafting the books' content.

- The textual content should be limited and kept as specified in the specifics of the learning outcomes by the textbook authors. The contents ought to be time-factor managed according to the ideas I themes' designated periods.
- A succinct summary of the chapter's contents should follow a brief recall statement at the beginning of each chapter. The introduction should then be continued with an understanding of the subject matter.
- Every chapter should conclude with a recommendation for more reading and online addresses to help readers form the habit of continuously learning new things.
- Concept continuity ought to be achieved in a manner similar to how science is used in practical settings.
- Science concepts should be explained in a way that is both engaging and simple to comprehend.
- Examples should be carefully chosen so that students can relate them easily
- To keep students interested, a textbook should be visually appealing and feature vibrant pictures.
- Ayats from the Quran may be cited when applicable.
- Before every chapter begins, there ought to be a chapter-outline that details the goal of the chapter.
- There should be biology tidbits in every chapter. It will give them practical knowledge that might not be included in the curriculum.
- Every chapter ought to include the Think Tank as part of its activity. It is made up of open-ended questions that inspire critical and imaginative thinking in the kids.
- A technical words glossary ought to be included at the book's conclusion.



- **Concept Mapping:** To help students relate new material to what they already know, concept maps should be created to illustrate the relationships between concepts within a topic.

Chapter Organizing System: Using a consistent numbering scheme, students are guided through each chapter at first glance, then by conceptual headings that are used throughout, and lastly by a summary of the most important ideas at the end. The following structure should be followed for each chapter:

Criteria for the Selection of Learning Material:

Curriculum Development Team (Biology) recommends the following parameters to be considered while selecting the learning material.

1. *Do the materials focus on big ideas and/or essential questions?*
2. *Do the materials require learners to be thoughtful, reflective and use high-level skills?*
3. *Do the materials include valid and varied assessments- both traditional and performance based?*
4. *Do the materials contain effective and engaging activities?*
5. *Do the materials continually revisit big ideas?*
6. *Do the materials reflect a "developmentally appropriate" approach to student learning?*
7. *Are the materials geared to the diverse abilities, interests and needs of students?*
8. *Is the curriculum program based on text alone, or does it include many different types of materials, including technology-based learning?*
9. *Do the materials encourage interdisciplinary connections?*
10. *Are outside experiences, including family involvement, part of the learning experience?*

Electronic Instructional Material:

In today's digital age, electronic learning resources are increasingly prevalent. Educational technology providers are successfully promoting courseware that encompasses professional development, personalized learning pathways, assessments, and instructional management. Educators now have swift and easy access to extensive collections of curriculum-linked instructional videos. However, in countries like Pakistan and other developing nations, the lack of resources, particularly in schools, could hinder the growth of electronic publishing as a viable alternative to or supplement for print publications.

A significant number of intermediate school students now have access to computers. It is crucial to provide them with opportunities for self-directed learning, rather than merely browsing content. This can be achieved by converting the IX-X and XI-XII textbooks into electronic formats, such as modern digital platforms like USB drives or online sources.

In subjects like biology, diagrams and images are vital for conveying complex concepts. Printed textbooks struggle to present three-dimensional diagrams effectively. Conversely, animations can provide students with a comprehensive understanding of real-world phenomena. Therefore, it is recommended to publish diagrams, images, and animations in an electronic format, which can be used in conjunction with printed textbooks. Additionally, software for student assessment and evaluation, such as exams, quizzes, and educational games, should be included in these digital resources.



Suggestions for Assessment and Evaluation Tools:

More Emphasis should be on;	Less Emphasis should be on;
Assessing what is most highly valued	Assessing what is easily measured
Assessing rich, well-structured knowledge	Assessing discrete knowledge
Assessing scientific understanding and reasoning	Assessing scientific knowledge
Assessing to learn what students do understand	Assessing to learn what students do not know
Students engaged in ongoing assessment of their work and that of others	Assessing only achievement
Teachers involved in the development of external assessments	End of term assessments by teachers
More Emphasis should be on;	Development of external assessments by experts alone

Teaching-Learning Program

Depending on the demands of teachers and students, topics or objectives within topics can be taught in any order. Teaching strategies and resources should:

- show biology as a process of scientific inquiry rather than a rhetoric of conclusions;
- use inquiry-based teaching strategies whenever possible; and
- be student-centered, helping students draw their own conclusions from the evidence and offering opportunities for hands-on practice to improve their motor skills and reasoning abilities.
- demonstrate the idea using a local case.
- Provide extremely direct, tangible experience when starting a new field of study through fieldwork, laboratories, and classroom settings, or the best alternative in the event that direct experience is not possible.
- offer fulfilling chances to apply scientific knowledge and methods of thinking to problems, particularly common ones;
- offer chances to hone concepts through discussion with others and collaborate with them in ways that will promote cooperative abilities;
- offer chances to hone written and oral communication skills; and
- use testing as a diagnostic as well as an achievement tool.

Teachers' Training and Refresher Courses

The teacher, who is the main driver behind the shift, must be sufficiently prepared both methodologically and content-wise in order to ensure biology education that is both relevant and effective. Teachers may benefit from in-service trainings by learning about a range of techniques for effectively delivering the curriculum.

- offer chances for the improvement of oral and writing communication skills;
- employ testing as a diagnostic as well as an achievement instrument.



All phases of education involve ongoing curriculum development and modification, as does the process of upgrading pre-service and in-service teacher education programs. The curriculum transaction would not be acceptable and the learning would be insufficient if the instructor is not completely prepared and qualified to handle the new curricula. The following actions are necessary for teacher training:

Pre-service teacher training institutions be strengthened and their curricula be revised to meet the demands of fast changing and developing world

Both content and methodology should be covered in in-service trainings. In order to teach biology effectively, content needs to be updated immediately. Particular emphasis should be placed on techniques that are activity- and learner-centered. In-service training programs ought to include a lot of laboratory exercises, classroom presentations, student engagement, and field encounters. There should be more frequent and regular workshops, seminars, and extension courses, especially during the summer months.

To provide teachers in need with immediate assistance, training facilities should set up well-equipped resource centers.

SALIENT FEATURES OF THE CURRICULUM

The curriculum will provide us a big boost in realizing our goal for the kids and is completely in line with the national priorities.

Configuration with the Restructured Scheme of Study: Restructuring the National Schemes of Study was a laborious process undertaken by the Ministry of Education. The Curriculum Development Team kept a concrete configuration with the reorganized study plans while creating the curriculum, choosing the course materials, defining the learning objectives (including practical skills), and offering the deadlines and assessment techniques.

The Focused Areas: The curriculum's emphasis has been on giving pupils challenges and delight, depth, breadth, progression, customization and choice, coherence, and relevance.

Reduction in Load: The Team decided to exclude topics if the following conditions were met: the topic had no direct relevance to the student, i.e., it was not contextual; the content was repetitive across stages with no change in expected understanding; the topic was in isolation with no obvious horizontal or vertical linkages; and the quality of biology education at the higher secondary level was not compromised in any way.

A comprehensive look at the secondary to higher secondary curriculum was used to determine the breadth of each topic for the higher secondary level. Both the overuse of technical words and the overuse of instances were minimized.



The suggested curriculum gives students a thorough introduction to the professional and career options in industry, research, teaching, medicine, and agriculture.

Abstraction and mathematical reasoning start to take center stage in secondary and upper secondary grades. We must refrain from attempting to be all-inclusive. There is no attempt to be exhaustive in the current revision.

A significant amount of knowledge consolidation within themes is also observed at this level. As a result, a motif can appear frequently in an IX-X but not in an XI-XII



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