BIOLOGY

For Class IX

The question paper of Biology for Class IX will be based on the SLOs of the following chapters:

1. INTRODUCTION TO BIOLOGY
2. SOLVING A BIOLOGICAL PROBLEM
3. BIODIVERSITY
4. CELLS AND TISSUES
5. CELL CYCLE
6. ENZYMES
7. BIOENERGETICS
8. NUTRITION
9. TRANSPORT

BIOLOGY

For Class X

The question paper of Biology for Class X will be based on the SLOs of the following chapters:

10. GASEOUS EXCHANGE
11. HOMEOSTASIS
12. COORDINATION
13. SUPPORT AND MOVEMENT
14. REPRODUCTION
15. INHERITANCE
16. MAN AND HIS ENVIRONMENT
17. BIOTECHNOLOGY
18. PHARMACOLOGY

National Curriculum for

BIOLOGY

Grades IX – X

2006

GOVERNMENT OF PAKISTAN
MINISTRY OF EDUCATION
ISLAMABAD

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BIOLOGY

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NATIONAL CURRICULUM

BIOLOGY

IX-X

2006

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NATIONAL CURRICULUM FOR BIOLOGY IX-X

INTRODUCTION:

The National Curriculum for Biology-2006 for grades IX and X recognizes the primacy of students' experiences, their voices and their active involvement in the process of learning. Learning experiences at school 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 National Curriculum Biology targets. In essence, our aspiration is to;

"Enable all students to develop their capacities as successful learners, confident individuals, responsible citizens and effective contributors to society."

Chapter 1:

RATIONALE:

The Federal Ministry of Education, Islamabad aspired to review the National Curriculum for Biology to make it more vibrant and responsive to the modern socio-economic, technical, professional and labor market needs of the country and comparable with international standards. The Ministry went for it through;

- Analysis of current practice and comparative review with materials from other selected countries
- Formulation of policies and development of strategies
- Setting up an institutional and organizational structure
- Development of the national curriculum Framework

The National Curriculum Development Team for Biology for grades IX-XII was framed involving scholars, subject experts and teachers. The Team held several meetings and deliberated on the ideas reflected in the meetings with the Ministry of Education and formulated the curriculum framework.

THE STRATEGY ADOPTED:

The Curriculum Development Team evolved a scientific methodology of designing / revising the curriculum that included undertaking basic research for developing new model of curriculum planning, implementation and evaluation. The Team established rapport with educational organizations; like major public and private schools and colleges, teacher training institutes and other academic institutions. Involvement of professionals from the world of work has been one of the salient features in taking appropriate decisions in curriculum design / review. Following strategy was adopted in designing/revising the curriculum.

- Identification of potential areas of study
- Identification of standards and benchmarks for communicating the potential areas
- Arriving at competency profile, based on comprising knowledge, skills and attitudes
- Deriving curriculum areas from competency profile
- Preparation of detailed contents in the light of competencies to be developed
- Preparation of study and evaluation scheme for implementing the curriculum
- Working out local and non-local available resources required (physical, human, information) for effective implementation of curriculum

The team followed the **"Context, Input, Process and Product model"** to obtain feedback in respect of each component, identifying gaps and take decisions for bringing about modification.

COMPARATIVE ANALYSES:

The Team carried out comparative analyses with the following curricula and textbooks while formulating the themes and structuring the chapters.

Curricula:

- Existing Curriculum of the Government of Pakistan
- Curricula of various States of USA
- Australian curricula
- O-level curricula of London University
- Senior Cambridge and HSC courses of the Cambridge University
- Curricula of Korea
- Grade 9-12 curricula of Ontario (Canada)
- Malaysian curricula
- Hong Kong curricula for School Education
- National Curriculum for Secondary and Higher Secondary classes, India

Textbooks:

- Pacific Science Series, Singapore
- The Inquiry into Life, USA
- FEP Modern Science Series, Singapore
- Malaysian Textbooks
- O-level textbooks of UK

NEED ASSESSMENT:

The National Curriculum Development Team went through a number of case studies encompassing the needs on which the curricula should be revised. A comprehensive feedback survey for the purpose of need assessment was carried out through school teachers and other stakeholders. Data about the current trends in the process of curriculum revision / development the world over was collected and analyzed. Newspaper articles / reports / NEWS were collected to ensure a reflexive involvement of stakeholders.

The Team worked out the focusing areas, through this need assessment. It suggested the curriculum should;

- **Reduce over-crowding in the curriculum and make learning more enjoyable**
- **Develop better linkage between the various stages of the curriculum from VI to XII**
- **Equip young people with the skills they will need in tomorrow's workforce**
- **Make sure that examination system supports learning**
- **Allow more choice to meet the needs of individual young people**

Importantly, there has to be adequate time for carrying out activities, followed by discussion. The learner also needs time to reflect on the classroom experience. This is possible only if the content load is well balanced with the learning time available.

Students are naturally curious. Given the freedom, they often interact and experiment with things around them for extended periods. These are valuable learning experiences, which are essential for imbibing the spirit of scientific inquiry, but may not always conform to adult expectations. It is important that any program of study gives students the needed space and not ties them down with constraints of a long list of ‘topics’ waiting to be ‘covered’. Denying them this opportunity may amount to freezing their spirit of inquiry. To repeat an oft-quoted saying: “It is

better to uncover a little than to cover a lot." Our ultimate aim is to help children learn to become autonomous learners.

In essence, it must be inclusive, be a stimulus for personal achievement and, through the broadening of pupils' experience of the world, be an encouragement towards informed and responsible citizenship.

Web-based access was made to the following organizations for valuable guidelines.

- **The Daily Dawn; Karachi**
  - Reflective Feedbacks about the Shortcomings in the curriculum policies
  - www.**dawn**.com
- **Education and Manpower Bureau, Government of Hong Kong**
  - The Aims of a Successful Curriculum
  - www.emb.gov.hk
- **The Curriculum Review Group, Ministry of Education Scotland**
  - The Characteristics of the Curriculum of Excellence
  - www.**scotland**.gov.uk/library5/**education**
- **National Institute of Health (NIH) and Howard Hughes Medical Institute, USA**
  - Transforming Undergraduate Education for Future Research Biologists
  - www.nap.edu/books
- **The Curriculum Council; Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan**
  - National Curriculum Standards Reforms
  - www.**mext**.go.jp/english
- **Department of Education, USA**
  - National Science Education Standards (K-12)
  - www.nap.edu/html/nses

THE PROBLEMS RECOGNIZED:

Most importantly, although the curriculum revised in 2000 has many strengths, a significant proportion of students are not achieving all that they are capable of. We need a curriculum which will enable all young people to understand the world they are living in, reach the highest possible levels of achievement, and equip them for work and learning throughout their lives.

1. Often, curricula – especially those in science – tend to be at once over-specified and under-specified.
    - They are over-specified in that they attempt to enumerate items of content knowledge, which could easily have been left open.
    - They are underspecified because the listing of 'topics' by keywords such as 'Transport' fails to define the intended breadth and depth of coverage. Thus there is a need to change the way in which a syllabus is presented.
2. The case studies on the teaching of science – supported by a large body of research on science education – recommend a pedagogy that is hands-on, minds-on and inquiry-based. While this is widely accepted at the idea level, practice in Pakistan has tended to be dominated by chalk and talk methods.
3. To make in any progress in the desired direction, some changes have to be made at the level of the syllabi. In a hands-on way of learning science, we start with things that are directly related to the student's experience, and are therefore specific. From this we progress to the general. This means that 'topics' have to be reordered to reflect this. Some indication of the learning outcomes that could go into the development of a 'topic' would make the curriculum a useful document.

THE DESIGN OF THE CURRICULUM:

- The new curriculum emphasizes reasoning and conceptual grasp at every stage. The new approach uses hands-on experiences and utilization of resources available in the student's environment.
- Built on the ideas introduced at lower levels, the curriculum introduces the contemporary areas of Biology stressing on connections of study of Biology to real life problems covering use of discoveries / innovations in everyday life - in environment, industry, medicine, health and agriculture. It unfolds the underlying principles that are common to both animals and plants, as well as the inter-relationships of Biology with other areas of knowledge. The new curriculum permits clear and sequential flow of concepts without jarring jumps.

  The exercise of revising the syllabus for Biology has been carried out with;
    - ☛ "Learning without burden" as a guiding light and
    - ☛ "Latest trends in curriculum development" as points of reference

- In each chapter "***Science, Technology and Society Connections****"* are given. These will serve as a guide for evaluating the student's skills gained from the chapter knowledge and his abilities to apply this knowledge to his surroundings.
- The teaching time in terms of number of periods is indicated for each chapter. These should be especially considered at the textbook writing stage to avoid overburdening and expansion beyond available teaching time.
- Each chapter in the theory course carries suggestions for skills. It is expected that the practical aspects will be integrated into the chapters in the textbook such that the rationale for doing them is evident and the understanding gained from them would help in furthering the understanding of the concepts. These experiments should be in the form of investigative reporting and be given along with the text.
- The young student would get an exposure to the various branches of Biology in a more contextual and friendly manner as they studied various chapters of the curriculum.

- The description of the diverse/various tools and techniques used in the study of Biology has not been collated to form a distinct chapter in the curriculum. It is envisaged that the teachers who teach this curriculum and the textbooks prepared based on it, will discuss techniques in a contextual manner rather than distanced from real experimental situations.

> **"The aim is to make the syllabus an enabling document for the creation of textbooks that are interesting and challenging without being loaded with factual information. Overall, Biology has to be presented as a live and growing body of knowledge rather than a finished product."**

The format of the curriculum has been evolved to address the under-specification mentioned above. Instead of merely listing 'topics' and the overall 'learning outcomes' of each topic, the curriculum is presented in an inclusive form e.g;

- Main 'themes' were identified,
- Each theme has been targeted by constructing 'chapters' in it,
- The structuring of a chapter involves;
  - Presenting its Overview
  - Drawing its Conceptual Linkages
  - Creating indicators for previous knowledge Recalling
  - Creating a hierarchy of Major Concepts for the chapter
  - Devising the learning outcomes with instantly recognizable domains of;
    - Knowledge
    - Comprehension
    - Analysis
    - Synthesis and
    - Evaluation
  - Formulating the skill outcomes with instantly recognizable domains of;
    - Initiating and Planning,
    - Analyzing and Interpreting,
    - Performing and Recording and
    - Communication
  - Signifying the Science-Technology-Society connections for each major concept.
- Chapter-wise weightage and number of periods has been proposed for each chapter.
- Assessment strategies for the overall learning have been described.
- A separate chapter-wise list of practical work has been mentioned.
- An overall list of the required apparatus, chemicals, prepared slides, charts, and models has been included.
- General instructions to authors have been included.

STANDARDS, BENCHMARKS AND LEARNING OUTCOMES:

In the 21st century, students will remain the most important natural resource to ensuring the continual improvement and ultimate progress of humankind. It is critical that all involved in education prepare students to meet the challenges of a constantly changing global society. It is time to call for a raising in the expectations of student learning.

Preparing students for success in the new millennium and beyond, calls for increasing rigor and relevance in the curriculum. In adult roles, individuals are expected to work with others in a team setting, have an acquired knowledge base, be able to extend and refine knowledge, be able

to construct new knowledge and applications and have a habit of self-assessing their assimilation of each dimension in their everyday decision making process.

The curriculum of Biology IX-X is built upon Standards, Benchmarks, and Learning Outcomes for the benefit of student growth and progress.

STANDARDS are what students should know and be able to do. Standards are broad descriptions of the knowledge and skills students should acquire in a subject area. The knowledge includes the important and enduring ideas, concepts, issues, and information. The skills include the ways of thinking, working, communication, reasoning, and investigating that characterize a subject area. Standards may emphasize interdisciplinary themes as well as concepts in the core academic subjects.

Standards are based on:

- ***Higher Order Thinking:***
  It involves students in manipulating information and ideas by synthesizing, generalizing, explaining or arriving at conclusions that produce new meaning and understanding for them.

- ***Deep Knowledge:***
  It addresses central ideas of a topic or discipline with enough thoroughness to explore connections and relationships and to produce relatively complex understanding.

- ***Substantive Conversation:***
  Students engage in extended conversational exchanges with the teacher and / or peers about subject matter in a way that builds an improved and shared understanding of ideas or topics.

- ***Connections to the World Beyond the Classroom:***
  Students make connections between substantive knowledge and either public problems or personal experiences.

BENCHMARKS indicate what students should know and be able to do at various developmental levels. Overall the benchmarks are built as per the restructured schemes of study and are split into 5 developmental levels:

- ✡ Kindergarten to Grade 3
- ✡ Grade 4 to Grade 5
- ✡ Grade 6 to Grade 8
- ✡ Grade 9 to Grade 10
- ✡ Grade 11 to Grade 12

LEARNING OUTCOMES indicate what students should know and be able to do for each topic in any subject area at the appropriate developmental level. The Learning Outcomes sum up the total expectations from the student.

The Standards and the accompanying Benchmarks will assist in the development of comprehensive curriculum, foster diversity in establishing high quality Learning Outcomes, and provide an accountability tool to individuals involved in the education marketplace. These provide a common denominator to determine how well students are performing and will assure that all students are measured on the same knowledge and skills using the same method of assessment.

Chapter 2:

AIMS AND OBJECTIVES:

AIMS:

The curriculum for Biology for grades IX-X aims to help individual students develop:

- **A scientific understanding of the living world**
- **Mental and motor abilities appropriate to the acquisition and use of biological understanding**
- **An appreciation of the products and influences of science and technology, balanced by a concern for their wise application**
- **An understanding of the nature and limitations of scientific activity**
- **An ability to apply biological understanding to appropriate problems (including those of everyday life) and to approach those problems in rational ways**
- **Respect for evidence, rationality and intellectual honesty**
- **Capacities to express themselves coherently and logically, both orally and in writing, and to use appropriately modes of communication characteristic of scientific work**
- **An ability to work effectively with others.**

OBJECTIVES:

A statement of objectives relevant to each of the general aims is listed below. The sequence of objectives used here should not be taken as indicating relative weightings.

Understanding the Living World:

Students should understand the scientific concepts inherent in the theme for each chapter to be covered well enough to be able to:

- state, exemplify and interpret the concept
- use appropriately, fundamental terms and classifications related to the concept
- cite, and explain or interpret, scientific evidence in support of the concept.

Appropriate Mental and Motor Abilities:

Students should show some ability to:

- formulate questions that can be investigated by gathering first or second-hand data
- find relevant published background information
- formulate hypotheses and make predictions from them
- plan an investigation and carry out the planned procedures
- use the motor skills required to carry out investigations
- observe phenomena, and describe, measure and record these as data
- classify, collate and display data
- interpret and construct visual representations of phenomena and relationships (diagrams, graphs, flow charts, physical models etc.)
- analyze data and draw conclusions
- evaluate investigative procedures and the conclusions drawn from investigations.

Understanding the Nature and Limitations of Scientific Activity:

For each of the facets of scientific activity selected for study, students should:

- describe and exemplify it

- use appropriately any fundamental terms and classifications related to it
- recognize that the problem-solving nature of science has limitations
- acknowledge that people engaged in science, a particularly human enterprise, have the characteristics of people in general.

Appreciation of the Influences of Science and Technology:

Students should:

- recognize that the technology resulting from scientific activity influences the quality of lifestyle and economic development through or by improvements in medical/health care, nutrition, agricultural techniques
- understand that these influences may be the result of unforeseen consequences, rapid exploitation or rapid cultural change
- realize that advances in technology require judicious application.

Ability to apply Understanding to Problems:

Students should:

- recognize that biological knowledge and scientific approaches have relevance to many situations in everyday life
- recognize when biological knowledge is relevant to a problem
- recognize when a scientific approach is relevant to a problem
- select and apply appropriate biological knowledge and skills to clarify and help produce solutions to problems, especially the personal and social problems of everyday life to which such knowledge and skills can apply
- use thoughtful, rational strategies for decision-making in those everyday situations to which both biological knowledge and value positions are relevant.

Respect for Evidence, Rationality and Intellectual Honesty:

- Given the number of emotive issues in the area of biology, students should display respect for evidence, rationality and intellectual honesty.

Capacities to Communicate:

Students should:

- comprehend the intention of a scientific communication, the relationships between its parts and its relationship to what they already know
- select the relevant parts from a communication
- translate information from communications in particular modes (e.g. spoken word, written word, tables, graphs, flow sheets, diagrams) to other modes
- structure information and use appropriate modes (including the spoken word, writing and diagrams) to communicate it.

Ability to work with Others:

Students should participate in group work in such a way that he or she:

- shares the responsibility for achieving a group task
- shows concern for the fullest possible participation of each group member.

Chapter 3:

STANDARDS AND BENCHMARKS: BIOLOGY IX-X:

STANDARDS:

1. USING SCIENTIFIC KNOWLEDGE

Students of biology are better able to understand and appreciate the biotic and a-biotic world around them and are also better able to make calculated decisions and take informed actions. Activities that beg scientific thought include the ***description*** and ***explanation*** of the living objects, systems, or events; the ***prediction*** of future events or observation; and ***design*** of systems or courses of action that help individuals adapt to and modify (for better) the living around them.

In biology the specification of real-world objects often focuses on biodiversity and life processes.

Standard 1.a

Students will be able to understand the principles of biology, diversity in life forms, structure and functions of cells, the processes of life, continuity in life, how living things interact with each other and their environment and the applications of biology for human welfare.

BENCHMARKS:

Students will be able to understand the principles of biology and diversity in life forms. They will be able to;

1. Describe the parameters of the study of life and the levels of organization of life and relate the study of life with the scientific methodology.

2. Describe the aims and principles of classification systems and binomial nomenclature.

Students will be able to understand the structure and functions of cells. They will be able to;

1. Describe the usage of microscopy and staining, and state the structure and functions of organelles and properties of tissues.

2. Explain cell cycle with details of interphase and division phases.

3. Explain what characteristics of enzymes make their identification and how enzymes are so specific.

4. Outline the mechanism of photosynthesis and respiration.

Students will be able to understand the processes of life. They will be able to;

1. Describe nutrients in terms of their sources and roles and describe the functions and abnormalities of the alimentary canal.

2. Explain the process of transportation in plants and in human and describe cardiovascular diseases.

3. Outline gaseous exchange in plants, list the components of the air passage way in man and describe respiratory disorders.

4. Describe the adaptations in plants for excretion and osmotic adjustments and state the structure and functioning of human kidney along with the brief introduction of kidney stones and kidney failure.

5. Explain the components of human nervous and endocrine system, describe the structure and functioning of eyes and ears and describe nervous disorders.

6. Describe human skeleton and joints; analyze antagonistic muscles and describe arthritis and osteoporosis.

Students will be able to understand the continuity in life. They will be able to;

1. Describe different methods of asexual reproduction and sexual reproduction in plants, state the parts of human reproductive systems and describe AIDS and comprehend the importance of population planning.

2. Describe the concept of genes and relate it to Mendel's laws, variation and evolution.

Students will be able to understand how living things interact with each other and their environment. They will be able to;

1. Describe ecosystem, explain the interactions found in ecosystems and flow of materials and energy. Analyze the impacts of human on environment.

Students will be able to understand the technologies used in the applications of biology for human welfare. They will be able to;

1. Explain the principles and objectives of fermentation and genetic engineering with emphasis on single cell proteins and distinguish between medicinal and addictive drugs.

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Standard 1.b

Students will be able to understand the processes of scientific investigation. They will be able to identify a problem, design and conduct experiments and communicate their findings using a variety of conventional and technological tools.

BENCHMARKS:

Students will observe and identify. They will be able to;

1. Identify cellular structures from prepared slides and preserved specimens.

Students will design and conduct experiments. They will be able to;

1. Investigate and/or demonstrate the phenomena of life e.g. enzyme action, photosynthesis, transpiration, respiration, circulation, lung capacities, nervous coordination, plant propagation.

Students will communicate the findings. They will be able to;

1. Present the data in graphical forms and evaluate graphs.

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2. CONSTRUCTING NEW SCIENTIFIC KNOWLEDGE

Students of biology possess the ability to ***ask*** questions about life and can also ***develop solutions*** to problems that they encounter or questions they ask, by using their knowledge and techniques. In the process of finding solutions, students may use their ***own knowledge and reasoning*** abilities, seek out ***additional knowledge*** from other sources, and engage in the ***empirical investigation*** of the living world. These students can also learn by ***interpreting*** text, graphs, tables, pictures, or other representations of biology data and knowledge. Finally such students can ***remember*** key points and use sources of information to ***reconstruct*** previously learned knowledge, rather than try to remember every detail of what they study. Finally they can describe ***the limitations*** of their own knowledge and biology knowledge in general.

Standard 2.a

Students will be able to display a sense of curiosity and wonder about the natural world and demonstrate an increasing awareness that this has led to new developments in science and technology.

BENCHMARKS:

Students will display a sense of curiosity and wonder about the natural world. They will be able to;

1. Generate scientific questions about the living world based on observation.

Students will demonstrate an increasing awareness that this has led to new developments in science and technology. They will be able to;

1. Evaluate the strengths and weaknesses of claims, arguments or data.
2. Describe limitations in personal knowledge.
3. Describe the historical developments of biological concepts and principles.
4. Develop an awareness of and sensitivity to the living world.

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3. REFLECTING ON SCIENTIFIC KNOWLEDGE

Students of biology are able to "step back" and analyze or reflect on their own knowledge. One such analysis is the ***justification*** of personal knowledge or beliefs using either theoretically or empirically based arguments. The students also ***show an appreciation*** for scientific knowledge and the patterns it reveals the living world. They are also able to take ***a historical and cultural perspective*** on biology concepts and theories or to discuss institutional relationships among ***science, technology and society***.

Standard 3.a

Students will be able to demonstrate an understanding of the impact of science and technology on society and use science and technology to identify problems and creatively address them in their personal, social and professional lives.

BENCHMARKS:

Students will demonstrate an understanding of the impact of science and technology on society. They will be able to;

1. Describe the advantages and disadvantages / risks of new technologies.

Students will use science and technology to identify problems and creatively address them in their personal, social and professional lives. They will be able to;

1. Show how common themes of science, mathematics and technology apply in surrounding world.

2. Explain how science and technology has been used to identify and solve problems.

3. Rationalize the contributions made in biology by cultures and individuals of diverse backgrounds.

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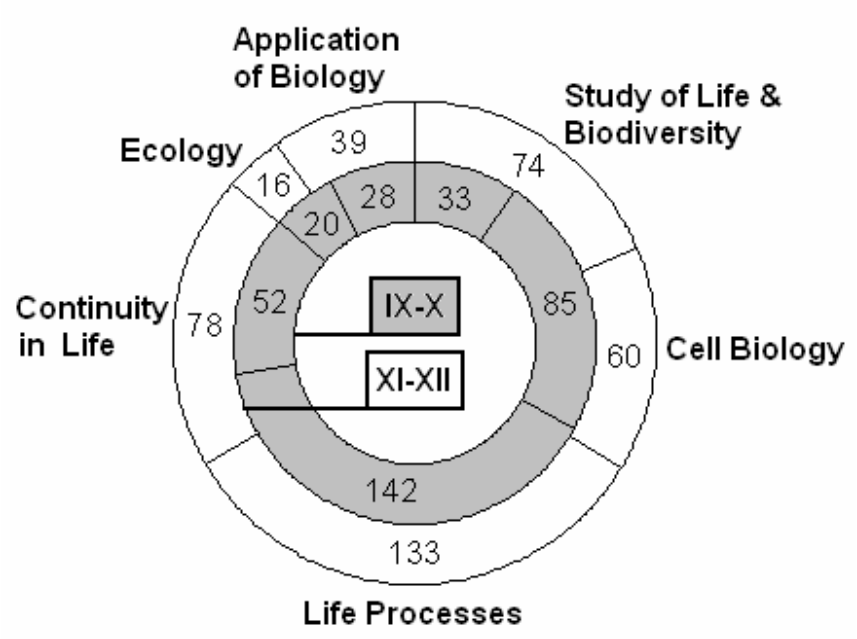
The Themes in Biology Curriculum:

There is general agreement that Biology content up to grade X should not be framed along disciplinary lines, but rather organized around themes that are potentially cross-disciplinary in nature. In the present revision exercise, it was decided that the same set of themes would be used, right from grades IX and X. The themes finally chosen are; Study of Life & Biodiversity, Cell Biology, Life Processes, Continuity in Life, Ecology and Application of Biology. While these run all through, in the higher grades there is a consolidation of content which leads to some themes being absent, e.g. Study of Life from grade XI.

The themes are largely self-explanatory and close to those adopted in the 2000 curriculum for grades IX-X; nevertheless, some changes have been made.

Weightage of Themes in IX-X & XI-XII:

(in terms of number of periods)



Chapter 4:

CONTENTS IX – X:

Ch: Chapter, MC: Major Concept, ST: Sub-Topic

Ch	MC	ST	BIOLOGY IX-X
			SECTION 1: STUDY OF LIFE & BIODIVERSITY
1			**INTRODUCTION TO BIOLOGY**
	⦿ 1.1		Introduction to Biology
		▶ 1.1.1	Definition of Biology
		▶ 1.1.2	Divisions and Branches of Biology
		▶ 1.1.3	Relation of Biology to other sciences
		▶ 1.1.4	Quran instructs to reveal the study of Life
	⦿ 1.2		The Levels of Organization
2			**SOLVING A BIOLOGICAL PROBLEM**
	⦿ 2.1		Biological Method
		▶ 2.1.1	Scientific problem, Hypotheses, Deductions and Experiments
		▶ 2.1.2	Theory, Law and Principle
		▶ 2.1.3	Data organization and Data analysis
		▶ 2.1.4	Mathematics as an integral part of the Scientific Process
3			**BIODIVERSITY**
	⦿ 3.1		Definition and Introduction of Biodiversity
	⦿ 3.2		Aims and Principles of Classification
	⦿ 3.3		History of Classification Systems
		▶ 3.3.1	Two-Kingdom Classification System
		▶ 3.3.2	Three-Kingdom Classification System
		▶ 3.3.3	Five-Kingdom Classification System
	⦿ 3.4		The Five Kingdoms
	⦿ 3.5		Binomial Nomenclature
	⦿ 3.6		Conservation of Biodiversity

SECTION 2: CELL BIOLOGY

4 CELLS AND TISSUES

- ⦿ **4**.1 Microscopy and the Emergence of Cell Theory
  - ▶ 4.1.1 Light microscopy and Electron microscopy
  - ▶ 4.1.2 History of the formulation of cell theory
- ⦿ 4.2 Cellular Structures and Functions
  - ▶ 4.2.1 Structures and Functions of cell Organelles
  - ▶ 4.2.2 Relationship between cell Function and cell Structure
  - ▶ 4.2.3 Difference between Prokaryotic and Eukaryotic cells
  - ▶ 4.2.4 Relationship between cell Size and Shape and Surface Area to Volume ratio
- ⦿ 4.3 Passage of Molecules Into and Out of Cells
- ⦿ 4.4 Tissues (types of Plant Tissues and types of Animal Tissues)

5 CELL CYCLE

- ⦿ 5.1 Cell Cycle (Interphase and Division)
- ⦿ 5.2 Mitosis
  - ▶ 5.2.1 Phases of Mitosis
  - ▶ 5.2.2 Significance of Mitosis
- ⦿ 5.3 Meiosis
  - ▶ 5.3.1 Phases of Meiosis
  - ▶ 5.3.2 Significance of Meiosis
- ⦿ 5.4 Necrosis and Apoptosis

6 ENZYMES

- ⦿ 6.1 Definition & Characteristics of Enzymes
- ⦿ 6.2 Mechanism of Enzyme Action (Lock-n-Key Model)
- ⦿ 6.3 Specificity of Enzymes

7 BIOENERGETICS

- ⦿ 7.1 Introduction and the Role of ATP
- ⦿ 7.2 Photosynthesis
  - ▶ 7.2.1 Introduction and Equation
  - ▶ 7.2.2 Role of Chlorophyll and Light
  - ▶ 7.2.3 Limiting Factors in Photosynthesis
  - ▶ 7.2.4 Adaptations in Leaf Structure for Photosynthesis
- ⦿ 7.3 Respiration
  - ▶ 7.3.1 Aerobic Respiration, Anaerobic Respiration
  - ▶ 7.3.2 Mechanism of Respiration (Glycolysis, Krebs Cycle, Electron Transport Chain)

SECTION 3: LIFE PROCESSES

8 NUTRITION

- 8.1 Introduction
- 8.2 Nutrition in Plants
  - 8.2.1 Nutrition and Nutrients (Plant Nutrients and Modes of Nutrition)
  - 8.2.2 Mineral Nutrition in Plants (Role of Nitrates and Magnesium and effects of their deficiencies)
- 8.3 Nutrition in Man
  - 8.3.1 Major Components of Food (Carbohydrates, Proteins and Fats)
  - 8.3.2 Effects of Vitamins (A, C and E) in terms of their; sources, metabolic functions and deficiencies
  - 8.3.3 Effects of Minerals (Calcium and Iron) in terms of their; sources, metabolic functions and deficiencies
  - 8.3.4 Effects of Water and Dietary fibers in terms of their; sources and metabolic functions
  - 8.3.5 Balanced Diet (Concept, Diet related to age, sex and activity)
  - 8.3.6 Problems related to Nutrition
    - 8.3.6.1 Protein Energy Malnutrition
    - 8.3.6.2 Mineral Deficiency Diseases (Scurvy, Rickets, Night blindness)
    - 8.3.6.3 Famine (Unequal distribution, Drought, Flooding, Increasing population)
- 8.4 Digestion in Man
  - 8.4.1 Ingestion, Digestion, Absorption, Assimilation and Egestion
  - 8.4.2 Identification and Functions of the main regions of human Alimentary Canal
  - 8.4.3 Role of liver in digestion, glucose and amino acid metabolism and formation of urea
  - 8.4.4 Absorption of Food (Structure of Villus, Role of capillaries and lacteals)
- 8.5 Disorders of Gut (Diarrhea, Constipation, Appendicitis, Threadworm diseases)

9 TRANSPORT

- 9.1 Introduction
- 9.2 Transport in Plants
  - 9.2.1 Water and ion uptake (Structure and function of root hairs)
  - 9.2.2 Transpiration
    - 9.2.2.1 Introduction and Significance
    - 9.2.2.2 Factors affecting the rate of Transpiration
  - 9.2.3 Transportation of Food and Water
    - 9.2.3.1 Pathway of water and food in stem
    - 9.2.3.2 Structure and function of Xylem and Phloem
- 9.3 Transport in Man
  - 9.3.1 Blood
    - 9.3.1.1 Components of Blood and their Functions
    - 9.3.1.2 Blood Groups and Blood Transfusion
    - 9.3.1.3 Disorders of Blood (Leukemia and Thalassemia)
  - 9.3.2 Human Heart
    - 9.3.2.1 Structure of Heart
    - 9.3.2.2 Functioning of Heart (Circulation through heart, Heartbeat, Heart rate)
  - 9.3.3 Blood Vessels
  - 9.3.4 General Plan of Human Blood Circulatory System

- ▶ 9.3.5 Cardiovascular Disorders (Atherosclerosis, Arteriosclerosis, Myocardial Infarction)

10 GASEOUS EXCHANGE

- ⦿ 10.1 Introduction
- ⦿ 10.2 Gaseous Exchange in Plants
- ⦿ 10.3 Gaseous Exchange in Man
  - ▶ 10.3.1 Air Passage Way and Lungs
  - ▶ 10.3.2 Mechanism of Breathing
- ⦿ 10.4 Respiratory Disorders and their Causes (Asthma, Bronchitis, Pneumonia, Lung Cancer)
- ⦿ 10.5 Effects of Smoking

11 HOMEOSTASIS

- ⦿ 11.1 Introduction
- ⦿ 11.2 Homeostasis in Plants
- ⦿ 11.3 Homeostasis in Man
- ⦿ 11.4 Urinary system of Man
  - ▶ 11.4.1 Structure and Functioning of Human Kidney
    - ▶ 11.4.1.1 Structure of Kidney
    - ▶ 11.4.1.2 Structure of Nephron
    - ▶ 11.4.1.3 Functioning of Nephron
- ⦿ 11.5 Disorders of Human Excretory System
  - ▶ 11.5.1 Kidney Stones and Treatment
  - ▶ 11.5.2 Kidney Failure and Dialysis

12 COORDINATION

- ⦿ 12.1 Introduction
- ⦿ 12.2 Types of Coordination (Nervous and Chemical Coordination)
- ⦿ 12.3 Human Nervous System
  - ▶ 12.3.1 Components of Nervous System
  - ▶ 12.3.2 Structure and Function of Neuron
  - ▶ 12.3.3 Reflex Action and Reflex Arc
- ⦿ 12.4 Receptors of Man (Eyes and Ears)
- ⦿ 12.5 Endocrine System
  - ▶ 12.5.1 Important Endocrine Glands (Pituitary, Thyroid, Pancreas, Adrenal, Gonads)
- ⦿ 12.6 Nervous Disorders (Paralysis and Epilepsy)

13 SUPPORT AND MOVEMENT

- ⦿ 13.1 Introduction
- ⦿ 13.2 Human Skeleton (Axial Skeleton and Appendicular Skeleton)
- ⦿ 13.3 Ball-n- Socket and Hinge Joints
- ⦿ 13.4 Action of Antagonistic Muscles at a Hinge (Elbow) Joint
- ⦿ 13.5 Disorders of Skeletal System (Arthritis and Osteoporosis)

SECTION 4: CONTINUITY IN LIFE

14 REPRODUCTION

- ⦿ 14.1 Introduction
- ⦿ 14.2 Reproduction in Plants
  - ▶ 14.2.1 Asexual Reproduction in Plants
  - ▶ 14.2.2 Sexual Reproduction in Plants
- ⦿ 14.3 Asexual Reproduction in Animals
- ⦿ 14.3 Sexual Reproduction in Rabbit
  - ▶ 14.3.1 Male Reproductive System
  - ▶ 14.3.2 Female Reproductive System
- ⦿ 14.4 Population Planning
- ⦿ 14.5 Sexually Transmitted Diseases (AIDS)

15 INHERITANCE

- ⦿ 15.1 Introduction
- ⦿ 15.2 Chromosomes and Genes
- ⦿ 15.3 Law of Segregation
- ⦿ 15.4 Law of Independent Assortment
- ⦿ 15.5 Variation and Evolution

SECTION 5: ECOLOGY

16 MAN AND HIS ENVIRONMENT

- 16.1 The Ecosystem: Levels of Ecological Organization; Components
- 16.2 Flow of materials and energy in the ecosystem
- 16.3 Biogeochemical Cycles (Carbon Cycle & Nitrogen Cycle)
- 16.4 Interactions in the Ecosystem (Competition; Predation; Symbiosis)
- 16.5 Ecosystem Balance and Human impact on environment (Population growth, Urbanization, Industrialization, Deforestation)
- 16.6 Pollution, its Consequences and Control
- 16.7 Conservation of Nature

SECTION 6: APPLICATION OF BIOLOGY

17 BIOTECHNOLOGY

- 17.1 Introduction
- 17.2 Fermentation and Baking Industry
- 17.3 Genetic Engineering
- 17.4 Single Cell Protein and its Uses

18 PHARMACOLOGY

- 18.1 Introduction
- 18.2 Medicinal Drugs and Addictive Drugs
- 18.3 Antibiotics and Vaccines

Chapter 5:

LEARNING OUTCOMES:

The development of a major concept is a complex process, therefore we must necessarily abandon the notion that acquisition of a specified learning outcome will be the outcome of any single classroom transaction, whether it is a lecture or an activity. A number of learning outcomes may be touched upon in a single lecture or activity and similarly more than one activity or lecture may be required to get a single learning outcome.

The caption of Skill lists experiments, as normally understood in the context of science, as well as other classroom processes in which children may be actively engaged, including discussion. When we teach science in a hands-on way, activities are not add-ons; they are integral to the development of the subject. Most activities would have to be carried by students in groups. The learning expectations can be achieved through alternate activities as well. When someone reads the learning outcomes of the domain of skills together with the learning outcomes of the domain of understanding, the reader finds that they delineate the breadth and depth of coverage expected.

This curriculum is based on the assumption that a low-cost science kit for the secondary classes is accessible in schools. The National Curriculum Team recommends government and other agencies to make it certain, assuming that children will perform the experiments themselves, in groups.

SECTION 1 :

STUDY OF LIFE & BIODIVERSITY

Chapter 01

INTRODUCTION TO BIOLOGY

11 Periods

Overview:
Students have an idea about what is science and what are its major divisions. In grade IX they will understand how comprehensiveness of knowledge leads to various fields of biology.

This chapter deals with the introduction of biology and the organization of life.
The major concepts in this chapter are;

- Biology (06 Periods)
- Levels of Organization (05 Periods)

Conceptual Linkages:
This chapter is built on;

- Characteristics of living things (Grade IV & V)
- Cellular Organization (Grade VI)

This chapter leads to;

- Man and Biology (Grade IX-X)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Biology

Understanding
Student will:

- Define biology its major divisions i.e. botany, zoology and microbiology.
- Define the branches of biology i.e. morphology, anatomy, physiology, embryology, taxonomy, cell biology, histology, paleontology, environmental biology, biotechnology, socio-biology, parasitology, immunology, entomology, genetics, pharmacology.
- Link the study of biology with that of physics, chemistry, mathematics, geography and economics.
- Explain how the study of biology can lead to Medicine / Surgery, Fisheries, Agriculture, Animal husbandry, Biotechnology, Horticulture, Farming, Forestry.
- Identify that living organisms are divided in five groups i.e. prokaryotes, protists, fungi, plants and animals.
- Relate at least three verses from Holy Quran, instructing for the study of the origin and the characteristics of life, with the modern scientific achievements.
- Relate the contributions of Jaber Bin Hayan, Abdul Malik Asmai and Bu Ali Sina with the current knowledge about plants and animals.

2- Levels of Organization

Understanding
Student will:

- Describe bioelements as the most the most basic level of biological organization.
- Define biomolecules and distinguish them as micromolecules and macromolecules.
- Describe the level of organization of life (organelles, cells, tissues, organs and organ systems and individuals).
- Explain division of labor among cells and tissues in a multicellular organism.
- Compare cellular organization in organisms i.e. unicellular organization (*Amoeba*), colonial organization (*Volvox*) and multicellular organization (mustard and frog). (Only brief comparison referreing to cellular organization is required. Details of organs and organs-systems of frog and mustard should be avoided).

Skills
(Performing and Recording)
Student will:

- Identify different organs and organ systems in a dissected frog.
- Draw a linkage chart connecting different organs with the relative organs systems.

Analyzing and Interpreting)
Student will:
- Identify different tissues in the photomicrographs of different organs.

↗ STS Connections
Student will:
- Identify and evaluate the impact of scientific ideas and/or advancements in technology on society.
- List organs of human body that some notorious diseases of today damage and specify the ones, which can be transplanted.

Chapter 02

SOLVING A BIOLOGICAL PROBLEM

04 Periods

Overview:

Students have an idea about what is biology and what are its major divisions.

This chapter deals with the methods of solving a biological problem.

The major concepts in this chapter are;

- Biological Method (04 Periods)

Conceptual Linkages:

This chapter is built on;

- Introduction of Biology (Grade IX-X)

This chapter leads to;

- Application of Biology (Grade IX-X)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Biological Method

↗ Understanding

Student will:

- Describe the steps involved in biological method i.e. recognition of a biological problem, observation and identification, building up hypotheses, drawing deductions, devising experiments and inferring results (malaria as an example).
- Describe the use of ratio and proportion in solving biological problems.
- Explain the importance of data analysis for confirming, modifying, or rejecting a hypothesis.
- Justify mathematics as an integral part of the scientific process.

↗ Skills

(Initiating and Planning)

Student will:

- Identify and pose meaningful, answerable scientific questions.
- For a given biological problem;
    - Formulate and test a working hypothesis.
    - Write instructions for conducting investigations or following a procedure.
    - Select appropriate instruments and materials to conduct an investigation.
    - Describe safe laboratory procedures.
    - Organize data appropriately using techniques such as tables and graphs.
    - Analyze data to make predictions, decisions, or draw conclusions.
    - Confirm, modify, or reject a hypothesis using data analysis.
    - Use ratio and proportion in appropriate situations to solve problems.

Chapter 03

BIODIVERSITY

12 Periods

Overview:

This topic addresses the need of classification system for all living organisms, its principles and basic details of Binomial nomenclature. While introducing biodiversity it also deals with the challenges posed by human interaction and subsequent conservation issues. The major concepts discussed in this chapter are as follows;

- Introduction (01 Period)
- Aims and Principles of Classification System (02 Periods)
- History of Classification System (01 Period)
- Diagnostic features of Five Kingdoms (02 Periods)
- Binomial Nomenclature (01 Period)
- Conservation issues in Pakistan and conservation of biodiversity (05 Periods)

Conceptual Linkages:

This chapter is built on;

- Classification of Living Things (Grade V)
- Environment (Grade VII)

This chapter leads to;

- Cell and Organization of Life (Grade IX-X)
- Ecology (Grade IX-X)
- Biodiversity (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Introduction

Understanding

Student will:

- Define biodiversity.
- Describe the major variety of life on the planet earth.
- Relate the importance of biodiversity with natural ecosystem through examples.

2-Aims and Principles of Classification

Understanding

Student will:

- Describe the bases of classification of living organisms.
- Explain the aims and principles of classification, keeping in view its historical background.
- Identify the contributions of Aristotle as the founder of biological classification.

Skills

(Performing and Recording)

Student will:

- Describe the distinguishing taxonomic characters of fresh and preserved specimens kept in laboratory.

3- History of Classification Systems

Understanding

Student will:

- Explain the bases for establishing 5 kingdoms.
- Compare Two-kingdom and Five-kingdom classification systems.
- Rationalize that Five-kingdom classification system better explains diversity of living organisms.
- Describe the contributions of Abu Usman Umer Aljahiz in describing the characteristics of animal species.

4- The Five Kingdoms

↗ Understanding

Student will:

- Describe the diagnostic characteristics of the five kingdoms.
- Describe the acellular structure of virus and justify why virus are excluded from the Five-Kingdom classification system.

↗ Skills

(Analyzing and Recording)

Student will:

- Examine some living or preserved plants and animals.
- Classify representative animals and plants into their respective kingdoms, using data.

5-Binomial Nomenclature

↗ Understanding

Student will:

- Describe the aims and principles binomial nomenclature keeping in view the historical background.
- Describe using local examples, the importance of Binomial nomenclature.

↗ Skills

(Initiating and Planning)

Student will:

- Find out from books / internet the biological names of some local plants and animals and sort out the generic and specific names.

(Analyzing and Interpreting)

Student will:

- Match the binomials of some common local organisms from a two column list on the basis of generic name and specific epithet.

6- Conservation of Biodiversity

↗ Understanding

Student will:

- Define the concept of conservation.
- Explain the impact of human beings on biodiversity.
- Identify causes of deforestation and its effects on biodiversity.
- Enumerate the reasons for conservation of biodiversity.
- Describe some of the issues of conservation in Pakistan (especially with regard to deforestation and hunting).

↗ Skills

(Initiating and Planning)

Student will:

- Evaluate graphs of a population of an insect, which is endangered (due to excessive use of insecticides) and interpret the reasons for its endangered status.
- Describe ways in which society benefits from biodiversity.
- Describe the reasons why a named animal species becomes endangered due to human interference. (e.g., *Houbara bustard,* blind dolphin and Marco polo sheep).

↗ STS Connections

Student will:

- Write a short article for publication in newspaper about endangered species.
- Analyze the impact of human beings on biodiversity.
- Determine the importance of scientific investigation in classifying organisms.
- Evaluate how taxonomy has helped in the classification of organisms.
- Associate advancements in scientific understanding with classification of organisms to develop a more reliable system.
- Apply the knowledge of classification to assess the characteristics of different organisms when visit to zoos, herbaria, and gardens.
- Explain the importance of binomial nomenclature in developing a more comprehendible sharing of scientific research.
- Describe the importance of research workers after whose names, organisms have been named e.g., *Bauhinia variegata.*

SECTION 2:

CELL BIOLOGY

Chapter 04

CELLS AND TISSUES

29 Periods

Overview:

This chapter aims at inculcating scientific attitude in students. The said theme will be focused while narrating the scientific accomplishments that led to the development of cell theory. Further, the outcomes in the domains of analysis, synthesis and evaluation are expected through the reinforcement of learning in the subject area of cell structure and function. The major concepts discussed in this chapter are as follows;

- Microscopy and the Emergence of Cell Theory (06 Periods)
- Cellular Structures and Functions (10 Periods)
- Active and Passive Transport of matter (06 Periods)
- Tissues (07 Periods)

Conceptual Linkages:

This chapter is built on;

- Microscope (Grade VI)
- Cellular Organization of Plants and Animals (Grade VI)

This chapter leads to;

- Cell Structure and Function (Grade XI-XII)
- Prokaryotes (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Microscopy and the Emergence of Cell Theory

↗ Understanding

Student will:

- Explain the concepts of light microscopy and electron microscopy.
- Explain the relationship between developments in imaging technology and the current understanding of the cell.
- Trace the development of the cell theory: from Aristotle to Hooke, Pasteur, Brown, and Schwann and Schleiden.
- Rationalize that there are sub-cellular particles, such as viruses and prions, which have some characteristics of living things.
- Construct a time line that traces the development of the cell theory from the first observations by Robert Hooke to our current understanding of cell structure.

↗ Skills

(Performing and Recording)

Student will:

- Use instruments effectively and accurately for collecting data *e.g.,*
  - *Use a microscope to observe movement of small objects*
- Estimate quantities *e.g.,*
  - *Compare sizes of various types of cells under the microscope*

2- Cellular Structures and Functions

↗ Understanding

Student will:

- Identify the structure and describe, in general terms, the functions of the components of plant and animal cell.
- Justify how the cells of the leaf system have a variety of specialized structures and functions.
- State the relationship between cell function and cell structure (for absorption - root hair cells; conduction and support - xylem vessels; transport of oxygen - red blood cells).
- Describe the cell as a functioning open system.
- Determine ways in which various types of cells contribute to the healthy functioning of the

human body *(e.g., describe the roles of individual cells in nerves, muscle, blood, skin and bone).*

- Assess the capabilities of animal and plant cell types, owing to the presence or absence of chloroplasts and cell wall.
- Describe the differences in the structure and function of Prokaryotic and Eukaryotic Cells.
- Assess the capabilities of Prokaryotic and Eukaryotic Cells, owing to the presence or absence of nucleus and mitochondria.
- Describe cell size and shape as they relate to surface area to volume ratio.
- Explain how surface area to volume ratio limits cell size *(e.g., compare nerve cells and blood cells in animals, or plant root hair cells and chloroplast-containing cells on the surface of leaves).*

↗ Skills
(Initiating and Planning)
Student will:

- Compare the parts of the cells to the human body. For example, the nucleus is the brain of the cell while the endoplasmic reticulum is the cell's circulatory system, mitochondria are the lungs of the cell etc.

(Performing and Recording)
Student will:

- Practice the most basic techniques in cell studies i.e. examine under the microscope an animal cell (e.g. from frog's blood) and a plant cell (e.g. from onion epidermis), using an appropriate temporary staining technique, such as iodine or methylene blue.
- Draw diagrams to represent observations of the cells.
- Identify, from fresh preparations or on diagrams or photomicrographs, the cell membrane, nucleus and cytoplasm in an animal cell.
- Identify, from diagrams or photomicrographs, the cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts in a plant cell.
- Draw diagrams to represent differences between plant and animal cells.
- Draw diagrams to represent differences between prokaryote and eukaryote.

(Communication and Teamwork)
Student will:

- Describe the function of cell organelles and structures in a cell, in terms of life processes, and use models to explain these processes and their applications.

3- Active and Passive Transport of matter

↗ Understanding
Student will:

- Describe the phenomena of diffusion, facilitated diffusion, osmosis, filtration, active transport, endocytosis and exocytosis.
- Compare passive transport of matter by diffusion and osmosis with active transport (e.g. Diffusion of glucose from intestine to villus epithelium and active transport of Sodium ions from nerve cell to outside.)
- Define turgor and describe its importance.
- Describe the phenomena of plasmolysis and explain its relationship with osmosis.
- Describe the role of the cell membrane in maintaining equilibrium while exchanging matter.

↗ Skills
(Initiating and Planning)
Student will:

- State a prediction and a hypothesis based on available evidence and background information *e.g.,*
    - *Hypothesize how biochemical interconversions of starch and glucose might regulate the turgor pressure of guard cells*
- Formulate operational definitions of major variables *e.g.,*
    - *Define concentration gradient, define osmosis in terms of hypotonic, hypertonic and isotonic solutions*

(Analyzing and Interpreting)
Student will:

- Carry out procedures, controlling the major variables *e.g.,*
    - *Perform an experiment to determine the effect of tonicity on plasmolysis and deplasmolysis in plant cells or in Red Blood Cell.*
- Use models to explain and visualize complex processes like diffusion and osmosis
- Compile and display the evidence and information in a variety of formats, including diagrams, flow charts, tables and graphs *e.g.,*
    - *Collect data on the number of stomata per unit area on various plant leaves that grow in areas of differing humidity, and compile this data in a spreadsheet and graph it to determine whether there is a relationship between the variables.*

4- Tissues

↗ Understanding
Student will:

- Define tissue as the group of similar cells, performing the same function.
- Describe the major animal tissues (epithelial, connective, muscular and nervous) in terms of their cell specificities, locations and functions.
- Describe the major plant tissues i.e. simple tissues (meristematic tissues, permanent tissues) and compound tissues (xylem tissues and phloem tissues) in terms of their cell specificities, locations and functions.
- Relate the function of a particular tissue to its structure and ultimately to the structure and function of the cells constituting it.
- Justify why a colony of cells does not get tissue level of organization, in spite of having many cells.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Identify different animal and plant tissues from photomicrographs or from observation of prepared slides under microscope.
- Draw the diagram of the tissues identified above.

(Performing and Recording)
Student will:

- Use instruments effectively and accurately for collecting data *(prepare wet mounts of tissue from flowering plants, and observe cellular structures specific to plant and animal cells)*

↗ STS Connections

Student will:

- Select and use appropriate modes of representation to communicate ideas, plans and results *e.g.,*
  - *Draw analogies between division of labour in cells and in communities*
- Describe how advancements in knowledge of cell structure and function have been enhancing and are increasing as a direct result of developments in microscope technology and staining techniques.
- Conceptualize how the developments in microscopy were related to the development of cell theory.
- Investigate the diagnostic and research applications of the electron microscope
- Investigate careers that require an understanding of cell biology
- Describe ways in which research about cells, organs and systems has brought about improvements in human health and nutrition *(e.g., development of medicines; immunization procedures; diets based on the needs of organs, such as the heart)*
- Describe how knowledge about semi-permeable or differentially permeable membranes, diffusion and osmosis is applied in various contexts *(e.g., separation of bacteria from viruses, purification of water, cheese making, use of honey as an antibacterial agent)*

Chapter 05

CELL CYCLE

15 Periods

Overview:

This chapter aims at bringing a comprehensive learning about the concept of cell cycle. The said learning will be imparted through the description of the phases of mitosis and meiosis, as well as through the concept of necrosis and apoptosis.

The outcomes in the domains of analysis and evaluation are expected through the identification of mitotic and meiotic stages.

The major concepts discussed in this chapter are as follows;

- Cell Cycle (03 Period)
- Mitosis (06 Periods)
- Meiosis (05 Periods)
- Necrosis and Apoptosis (01 Period)

Conceptual Linkages:

This chapter is built on;

- Structure of Cell (Grade VI)
- Reproduction (Grade VII)

This chapter leads to;

- Reproduction (Grade XI-XII)
- Development and Aging (Grade XI-XII)
- Cloning (Class XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Cell Cycle

↗ Understanding

Student will:

- Define Cell Cycle and describe its main phases i.e. Interphase and Division.
- Describe the sub-phases of the Interphase of Cell Cycle.
- Predict the importance of S-phase of the Interphase.
- Describe the two types of Cell Division in Eukaryotic cells i.e. Mitosis and Meiosis.

↗ Skills

(Analyzing and Interpreting)

Student will:

- Identify from prepared slides or charts, the main phase of cell cycle.

2- Mitosis

↗ Understanding

Student will:

- Enlist the events through which Mitotic Apparatus is formed in prophase in animal and plant cells.
- Describe the formation of metaphase plate and the division of centromere, during metaphase.
- State the separation of chromatids during anaphase.
- Describe the reformation of nuclei during telophase.
- Describe the physical division of cytoplasm during cytokinesis in animal and plant cells.
- Compare the details of events during mitosis in animal and plant cells.
- Describe the significance of mitosis as giving rise to genetically identical cells and state the role of mitosis in growth, repair of damaged tissues, replacement of worn out cells and asexual reproduction.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Arrange in correct sequence the various stages of mitosis shown in photomicrographs or slides.

(Communication)
Student will:

- Explain the events of each stage through hints observed in the prepared slides of these stages.

(Performing and Recording)
Student will:

- Prepare root tip smears and study stages of mitosis.

3- Meiosis

↗ Understanding
Student will:

- Describe the events of Prophase-I.
- Describe the events taking place in Metaphase-I.
- Explain what happens during Anaphase-I.
- Describe the events of Telophase-I.
- Explain the events occurring during the Second Meiotic Division.
- Compare the Second Meiotic division with mitosis.
- Describe the significance of meiosis as leading to the formation of haploid cells, that may function directly as gametes as in animals or may divide by mitosis as in plants, fungi and many protists.
- Describe the significance of meiosis with reference to the recombination of genes that leads to variations.
- Contrast mitosis and meiosis, emphasizing the events that lead to different outcomes.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Identify different stages of meiosis through observation of prepared slides / flash cards, and draw observations in sequential order.

(Communication)

- Explain the events of each stage through hints observed in the prepared slides of these stages.

4- Necrosis and Apoptosis

↗ Understanding
Student will:

- Describe Necrosis and Apoptosis.
- Correlate Necrosis and Apoptosis with cell cycle.

↗ STS Connections

Student will:

- Describe the inability of some mature cells (nerve cells) to divide and the uncontrolled division of certain cells (tumors).

Chapter 06

ENZYMES

11 Periods

Overview:
Some processes in cells are catabolic that release energy and some are anabolic which require energy. All these processes are dependent on enzymes, which play a pivotal role for completing these processes. These enzymatic reactions in their turn ensure the survival of the cell.

Keeping this important role of enzymes in cells, the following concepts are developed which will enable the students to comprehend and analyze and will also impart knowledge and skill.

- Definition and Characteristics of Enzymes (04 Periods)
- Mechanism of Enzyme Action (02 Periods)
- Specificity of Enzyme (05 Periods)

Conceptual Linkages:
This chapter is build on;
- Working of Human Body (Grade VII)

This chapter leads to;
- Maintenance of life (Grade IX-X)
- Enzymes (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Definition and Characteristics of Enzymes

↗ Understanding

Student will:

- Define metabolism and differentiate between catabolism and anabolism.
- Describe enzymes as the proteins that speed up biochemical reactions.
- Categorize enzymes as intra and extracellular.
- Comprehend that enzymes increase rate of reaction.
- State that small quantity of enzyme is effective for large amount of substrate.
- Infer that enzymes are specific for specific substrates.
- State that some enzymes require co-factor for their functioning.
- Describe the concept of energy of activation and how it is lowered by enzyme.
- Explain the effect of pH, temperature and concentration of substrate on the activity of an enzyme.

↗ Skills
(Analyzing, Interpreting, Communication)

Student will:

- Draw graphs showing the effects of temperature, pH & concentration of substrate on the rate of enzyme catalyzed reactions.
- Illustrate through a diagram, the lowering of energy of activation by enzyme.

2- Mechanism of Enzyme Action

↗ Understanding

Student will:

- Describe, through equation, that enzyme substrate complex is formed and release of enzyme takes place after completing the reaction.
- Describe the action of enzyme through Lock-n-Key Model.

↗ Skills
(Initiating, Planning and Interpreting)

Student will:

- Build or design model of enzyme to demonstrate the working of an enzyme.

3- Specificity of Enzyme

↗ Understanding

Student will:

- Describe the specificity of different enzymes for different substrates.
- Relate that specificity of enzyme is due to its shape.
- Categories that proteases will act on proteins only and lipases will act on lipids or fats only.

↗ Skills

(Performing and Recording)

Student will:

- Perform experiment to show working of enzyme in vitro e.g., pepsin working on meat in test tube.
- Put diastase in a starch solution in test tube at 37°C and after fifteen minutes perform iodine test for presence of starch.

Chapter 07

BIOENERGETICS

20 Periods

Overview:
This chapter targets the domains of knowledge, analysis and evaluation through the learning of energy conversions in metabolism.
The said aims would be achieved while grasping the basics of photosynthesis and respiration, as well as through the concept of ATP.
The major concepts discussed in this chapter are as follows;

- Introduction and the Role of ATP (02 Periods)
- Photosynthesis (11 Periods)
- Respiration (07 Periods)

Conceptual Linkages:
This chapter is built on;

- Enzymes (Grade IX-X)
- Respiration (Grade VI)
- Photosynthesis (Grade VI)

This chapter leads to;

- Nutrition (Grade IX-X)
- Bioenergetics (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Bioenergetics and ATP

↗ Understanding
Student will:

- Define Bioenergetics as the study of energy relationships and energy conversions in living organisms.
- Describe the importance of Oxidation-Reduction reactions for the flow of energy through living systems.
- Explain ATP as a molecule that is the chief energy currency of all cells.
- Describe the synthesis and breaking of ATP through ATP-ADP cycle.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Design the molecular model of ATP using low-cost no-cost materials and label its components and high-energy P-P bonds.

2- Photosynthesis

↗ Understanding:
Student will:

- State that photosynthesis is the fundamental process by which plants manufacture carbohydrates from raw materials.
- State the equation (in words or symbols) for photosynthesis.
- Reason out that all forms of life are completely dependent on photosynthesis.
- Describe that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage.
- Outline the processes (Light and Dark reactions) involved in photosynthesis.
- Describe, in general terms, the intake of carbon dioxide and water by plants.
- Explain the concept of limiting factors in photosynthesis.
- State the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Identify and label the cellular and tissue structure in the cross section of a leaf through observation under the microscope.
- Design a model of light and dark reactions by low-cost no-cost materials.

(Performing and Recording)
Student will:

- Demonstrate an experiment to show the process of photosynthesis using an aquatic plant, like *Hydrilla.*
- Investigate the necessity for chlorophyll, light and carbon dioxide for photosynthesis, using appropriate controls.

3- Respiration

↗ Understanding
Student will:

- Describe anaerobic respiration by means of word and symbol equation.
- Describe the importance of Anaerobic Respiration.
- Describe aerobic respiration by means of word and symbol equation.
- Outline the mechanism of respiration while defining Glycolysis, Krebs cycle and Electron Transport Chain.
- Compare aerobic and anaerobic respiration with reference to the amount of energy released.
- List ways in which respiratory energy is used in the body.
- Compare respiration and photosynthesis.

↗ Skills
(Performing and Recording)
Student will:

- Investigate the release of carbon dioxide during aerobic respiration in germinating seeds.
- Verify by experiments that heat is given out during aerobic respiration.

SECTION 3:

LIFE PROCESSES

Chapter 08

NUTRITION

21 Periods

Overview:
Students already have the very basic ideas about photosynthesis and heterotrophic modes of nutrition in plants and about the digestive system of man. The goal here is to fortify the ideas so as to bring in all the domains of cognitive learning through awareness about malnutrition, famine and disorders of the digestive system etc.

This way the learning process would augment the skills of synthesis and application. The major concepts discussed in this chapter are as follows;

- Mineral Nutrition in Plants (03 Periods)
- Nutrition in Man
  - Components of Human Food (09 Periods)
  - Balanced Diet (02 Periods)
  - Problems related to Nutrition (03 Periods)
  - Ingestion, Digestion and Absorption of Food in Man (05 Periods)
  - Disorders of Gut (02 Periods)

Conceptual Linkages:
This chapter is built on;
- Food and Health (Grade IV)
- Nutrition in Plants and Animals (Grade VI)
- Digestion in Man (Grade VII)
- Bioenergetics (Grade IX-X)

This chapter leads to;
- Nutrition in Man (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Mineral Nutrition in Plants

↗ Understanding
Student will:
- Define mineral nutrition in plants.
- Categorize minerals nutrients into macronutrients and micronutrients.
- State that nitrogen is important in protein synthesis and magnesium for chlorophyll formation.
- State the effect of lack of nitrate and magnesium ions on plant growth.
- Describe the importance of fertilizers (manure and chemical) in agriculture.
- Discuss environmental hazards related to chemical fertilizers' use.

2- Components of Human Food

↗ Understanding
Student will:
- Distinguish among carbohydrates, proteins and fats in terms of their sources, energy values and metabolic functions.
- Specify the food sources and metabolic functions of Vitamins A, C and D.
- Describe the food sources and metabolic functions of Calcium and Iron.
- Describe the deficiency symptoms of Vitamins A, C and D and of Calcium and Iron.
- Specify the sources and metabolic functions of Water and Dietary fibers.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Investigate and present in a tabulated data form his daily food intake (in terms of nutrients and calories).

↗ Skills
(Performing and Recording)
Student will:

- Perform tests for: starch (iodine in potassium iodide solution); reducing sugars (Benedict's solution); protein (biuret test); fats (ethanol emulsion test).

3- Balanced Diet

↗ Understanding
Student will:

- Describe the concept and need for a balanced diet.
- Explain the components of a balanced diet with relation to age, sex and activity.
- Explain why diet, especially energy intake, should be related to age, sex and activity of an individual.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Record a weekly chart of daily diet. Compare it with the balanced diet requirements.

4- Problems related to Nutrition

↗ Understanding
Student will:

- Describe the problems of Protein Energy Malnutrition (PEM), Mineral Deficiency Diseases (MDD), and Over Intake of Nutrients (OIN).
- State the effects of malnutrition in relation to starvation, heart disease, constipation and obesity.
- Rationalize the unequal distribution of food, drought and flooding, and increasing population as the factors that contribute to famine.

↗ Skills
(Analyzing and Interpreting)
Student will:

- In the comparative chart of daily diet and balanced diet requirements, mention the visible symptoms caused by nutrient deficiencies.

5- Ingestion, Digestion and Absorption of Food in Man

↗ Understanding
Student will:

- Describe the needs of ingestion, digestion, absorption, assimilation and egestion.
- Identify and describe the structures of the main regions of the alimentary canal and the associated organs.
- Describe the main functions of these parts in relation to ingestion, digestion, absorption, assimilation and egestion of food.
- Describe swallowing and peristalsis.
- Sort out the action of enzymes in specific regions of alimentary canal, with respect to their substrates and products.
- State the role of the liver in the metabolism of glucose and amino acids, and in the formation of urea.
- Describe the structure of a villus, including the roles of capillaries and lacteals.
- Describe the significance of villi in increasing the internal surface area.
- State the function of the hepatic portal vein as the route taken by most of the food absorbed from the small intestine.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Identify the villus; epithelium, capillary network and lacteal while examining the transverse section of small intestine.

6- Disorders of Gut

↗ Understanding
Student will:

- State the signs and symptoms, causes, treatments and preventions of the disorders of gut i.e. diarrhea, constipation, and ulcer.

↗ STS Connections
Student will:

- Explain why farmers use chemical fertilizers for better growth of their plants.
- Describe ways in which research about nutrition has brought about improvements in human health (e.g., development of nutritional supplements, and diets based on the needs of age, sex and activity).
- Exemplify the societies suffering from famine due to unequal distribution of food and due to over-population.
- Explain how the customary food habits contribute to digestive tract disorders (e.g. diarrhea, constipation).

Chapter 09

TRANSPORT

36 Periods

Overview:
Students already have the very basic idea about transportation in plants and about the blood circulatory system of man. This chapter will deal with the same but with more breadth and depth. The learning expectations would be turned more analytical and applicable, through knowledge about the transpiration pull, pressure flow mechanism, and problems of blood circulatory systems. The very basic ideas of the composition of blood and of the structure of heart would be strengthened. The major concepts discussed in this chapter are as follows;

- Transport in Plants (17 Periods)
- Transport in Man
  - Blood (07 Periods)
  - Human Heart (05 Periods)
  - Blood Vessels (03 Periods)
  - General Plan of Human Blood Circulatory System (02 Periods)
  - Cardiovascular Disorders (02 Periods)

Conceptual Linkages:
This chapter is built on;
- Plant Organs systems (Grade VI)
- Transport in Man (Grade VII)
- Transport of Matter across cell membrane (Grade IX-X)

This chapter leads to;
- Plant Physiology (Grade XI-XII)
- Transport (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Transport in Plants

↗ Understanding
Student will:
- Conceptualize transport and its needs.
- Explain the internal structure of root and root hair.
- Describe how roots take up water and mineral salts by active and passive absorption.
- Define transpiration and relate this process with cell surface.
- Relate transpiration with stomatal opening and closing.
- Describe temperature, wind and humidity as the factors affecting the rate of transpiration.
- Describe the significance of transpiration.
- Describe transpiration as a necessary evil.
- Relate wilting with excessive transpiration.
- Describe the pathway of water and food in stem.
- Explain the movement of water in terms of transpirational pull.
- Explain the mechanism of food translocation by the theory of Pressure Flow Mechanism.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Identify root hairs on a growing root of onion, carrot etc.
- Describe the structure and number of stomata after microscopic observation of an epidermal peel of a leaf.
- Investigate wilting in a potted plant.

(Performing and Recording)
Student will:
- Investigate by a simple experiment using cobalt chloride paper the rate of water loss at the two surfaces of a leaf.

- Observe and investigate transpiration in potted plant under a bell jar / polythene bag.
- Identify xylem and phloem tissues in the prepared slides of stem, root and leaf.
- Investigate, using a suitable stain, the pathway of water in a cut stem.

Transport in Man

2- Blood

↗ Understanding

Student will:

- List the functions of the components of blood.
- Describe the blood groups in ABO and Rh blood group systems, with reference to the presence / absence of antigens and antibodies.
- State the risk of incompatibility in blood transfusion due to antigen-antibody reactions.
- List the appropriate donors and recipients for each of the four blood groups.
- State the signs and symptoms, causes and treatments of the diseases of blood (leukemia and thallassemia).

↗ Skills
(Analyzing and Interpreting)

Student will:

- Identify red and white blood cells as seen under the light microscope on prepared slides (or in diagrams and photomicrographs).

3- Human Heart

↗ Understanding

Student will:

- Describe the major pathway of blood through circulatory system.
- Describe the external and internal structure of human heart.
- Describe the circulation of blood through atria and ventricles of the heart, explaining the role of the bicuspid, tricuspid and semilunar valves.
- Describe the low-pressure circulation to the lungs and a high-pressure circulation to the body tissues and relate these differences to the different functions of the two circuits.
- Explain how the heart is structurally adapted to its functions.
- Define the terms heartbeat, heart rate and pulse rate.

↗ Skills
(Analyzing and Interpreting)

Student will:

- Identify in a diagram of the heart the right atrium, right ventricle, left atrium, left ventricle, bicuspid valve, tricuspid valve, semi-lunar valves, pulmonary artery, pulmonary vein, aorta, superior and inferior vena cava and septum.
- Investigate the effect of physical activity on pulse rate and make a tabular representation.

4- Blood Vessels

↗ Understanding

Student will:

- Compare the structure and function of an artery, a vein and a capillary.
- Describe the transfer of materials between capillaries and tissue fluid.

↗ Skills

(Analyzing and Interpreting)

Student will:

- Perform an experiment to show the capillary flow in a fishtail or fin or frog's web.

5- General Plan of Human Blood Circulatory System

↗ Understanding

Student will:

- Describe the origins, locations and targets areas of main arteries i.e. Pulmonary arteries, Aorta with Hepatic artery, Renal arteries and Femoral arteries.
- Describe the originating areas, locations and target heart chambers of main veins i.e. Pulmonary veins, Superior vena cava, Inferior vena cava with Femoral veins, Renal veins and Hepatic vein.
- Identify the main arteries and veins in charts, diagrams, models etc.
- Describe the contributions of Ibn-al-Nafees and William Harvey in revealing the knowledge about the circulation of blood in human body.

6- Cardiovascular Disorders

↗ Understanding

Student will:

- Define cardiovascular disorders and differentiate between Atherosclerosis and Arteriosclerosis.
- State the causes, treatments and prevention of Myocardial infarction.

↗ STS Connections

Student will:

- State vascular surgery as one of the major fields in the careers.
- Identify that cardiovascular disorders are the major cause of sudden non-accidental deaths.
- Explain the social as well as personal factors that contribute to cardiovascular disorders in Pakistan.

Chapter 10

GASEOUS EXCHANGE

17 Periods

Overview:

The theme of this chapter is exchange of oxygen and carbon dioxide to and from the body and environment. This chapter also discusses evermore pressing problems of smoking, enlightening the students with dire consequences of smoking so that they may refrain from it.

The following concepts are developed in this chapter;

- Introduction and Gaseous Exchange in Plants (02 Periods)
- Gaseous Exchange in Humans
  - Air Passage Way, Lungs and Mechanism of Breathing (03 + 07 Periods)
  - Respiratory Disorders (05 Periods)

Conceptual Linkages:

This chapter is built on;

- Respiration (Grade VI)

This chapter leads to;

- Gaseous Exchange (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Introduction and Gaseous Exchange in Plants

↗ Understanding

Student will:

- Differentiate among respiration, gas exchange and breathing.
- Describe the process of gaseous exchange in plants by comparing photosynthesis and respiration.

↗ Skills

(Analyzing and Interpreting)

Student will:

- Draw diagram of stomata of a leaf indicating the movement of gases.

(Performing and Recording)

Student will:

- Investigate the effect of light on the net gaseous exchange from leaf, by using bicarbonate as the indicator.

Gaseous Exchange in Humans

3- Air Passage Way, Lungs and Mechanism of Breathing

↗ Understanding

Student will:

- Describe the roles of the parts of air passageway and of lungs.
- Describe the mechanism of breathing in term of movements of ribs and diaphragm.
- State the rate of breathing at rest and after exercise.
- Differentiate between the composition of inspired and expired air.

↗ Skills

(Analyzing and Interpreting)

Student will:

- Draw diagram of organs of human respiratory system from model/chart.
- Identify the structure of air sac in humans by slide/photomicrograph.
- Identify larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries in the chart of human respiratory system.

(Performing and Recording)
Student will:

- Investigate the breathing rate at rest and after exercise.
- Find out how much air a person can take into his lungs.
- Demonstrate through experiment of breathing out air into limewater that carbon dioxide is exhaled during respiration.
- Use model to show the action of Diaphragm and ribs.

4- Respiratory Disorders

↗ Understanding
Student will:

- Describe briefly diseases related to respiratory system like bronchitis, emphysema, pneumonia, asthma, and lung cancer.
- Describe the biological consequences of smoking in relation to the lungs and circulatory system.

↗ Skills
(Initiating, Recognition and Communication)
Student will:

- Establish the importance of breathing in fresh air.
- Establish the importance of keeping nasal and oral cavity clean to avoid diseases.

↗ STS Connections
Student will:

- Evaluate the effects of tilling on roots for better exchange of gases with the soil air.
- Outline the concept of Artificial Ventilator for artificial breathing in patients.
- Interpret the dangers of breathing in exhausts of fossil fuels (Petrol and others).
- Rationalize the importance of cross ventilation in homes.
- Assess the adverse effects associated with smoking on health.
- Point out bad social aspects of smoking.

Chapter 11

HOMEOSTASIS

14 Periods

Overview:
Students have gone through the introduction of the excretory system of man while learning about the working of human body in grade VII. This chapter will not only foster their learning of the human excretory system but also nurture the idea of homeostasis and osmoregulation with reference to excretion and the disorders of kidney.
The major concepts discussed in this chapter are as follows;

- Homeostasis in Plants (02 Periods)
- Homeostasis in Man (02 Periods)
- Urinary System of Man (06 Periods)
- Disorders of Kidney (04 Periods)

Conceptual Linkages:
This chapter is built on;

- Human Organ Systems (Grade VIII)

This chapter leads to;

- Homeostasis (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Homeostasis in Plants

↗ Understanding
Student will:

- Define homeostasis and describe its importance.
- Describe the mechanisms / adaptations in plants for the excretion / storage of CO_2, H_2O, O_2, latex, resins and gums.
- Explain osmotic adjustments in plants.

2- Homeostasis in Man

↗ Understanding
Student will:

- State skin, lungs and kidneys as the major organs involved in homeostasis.
- Explain the role of skin in regulating body temperature.
- Describe how lungs keep the carbon dioxide concentration down to certain level.
- Explain that kidneys control the blood composition.

↗ Skills
(Initiating and Planning)
Student will:

- Hypothesize why the dogs hang their tongues out and pant?

3- Urinary System of Man

↗ Understanding
Student will:

- Identify the different organs of urinary system.
- Relate the structure of kidney with its function.
- State that nephron is the excretory unit of kidney.
- Locate the different parts of nephrons and relate them with their function.
- State that main role of kidney is urine formation.
- Describe that urine formation involves three processes i.e. filtration, reabsorption and secretion.
- Explain that kidney plays an important role in osmoregulation.

↗ Skills
(Initiating and Planning)
Student will:
- Predict about the functioning of body without a kidney.
- Relate too much sugar intake by a diabetic with the functioning of kidney.

(Performing and Recording)
Student will:
- Examine the structure of kidney (sheep kidney / model).
- Trace the movement of a molecule of urea from blood to urethra using a flow chart diagram.

4- Disorders of Kidney

↗ Understanding
Student will:
- Identify the causes of kidney stone.
- Identify lithotripsy and surgery as the methods to remove kidney stones.
- Outline the causes of kidney failure.
- Explain that dialysis is one of the treatments in kidney failure.
- Describe the types of dialysis.
- Describe the contributions of Al-Farabi and Abul-Qasim in introducing the method of removing stone from the urinary bladder.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Rationalize why dialysis machine is considered as artificial kidney.
- Design dialysis apparatus by cellophane paper and empty photographic film case.

↗ STS Connections
Student will:
- Realize the importance of drinking plentiful water daily.
- Predict how the kidney helps overcome the problem of dehydration.
- Recognize the right treatments of kidney problems and will refuse to accept the medical myths.

Chapter 12

COORDINATION AND CONTROL

25 Periods

Overview:
The topic of coordination and control deals with the nervous and hormonal bases of reception of stimuli from and their responses to the environment. It also relates to the functioning of receptors like eyes and ears for the reception of light and sound.

The following concepts are developed in this chapter;

- Types of Coordination (03 Period)
- Component parts of Nervous system (07 Periods)
- Major Receptors of the Human Body (09 Periods)
- Endocrine system (04 Periods)
- Disorders of the Nervous system (02 Periods)

Conceptual Linkages:
This chapter is built on;

- Human Organ Systems (Grade VIII)
- Cell (Grade IX-X)

This chapter leads to;

- Coordination (Grade XI-XII)
- Homeostasis (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Introduction and Types of Coordination

↗ Understanding
Student will:

- Explain what coordination means.
- Identify the two main types of coordination in living organisms, i.e., Nervous and Hormonal (chemical).
- Differentiate between the modes of coordination i.e., electrical in case of nervous and chemical in case of hormonal.
- Identify the main organs responsible for coordination and control.
- State that receptors receive stimuli and transmit information to effectors through CNS.

↗ Skills
(Recording)
Student will:

- Compare the two types of coordination in tabular form.
- Record the difference in quickness of response of the two types of coordination (by asking a student to say a few words in front of the class and observe the change in heartbeat).
- Analyze why plants (like sunflower) have a very slow response to stimuli.

2-Human Nervous System

↗ Understanding
Student will:

- Label the diagram of human brain.
- Explain the function of these parts of brain; cerebrum, cerebellum, pituitary gland, thalamus, hypothalamus, medulla oblongata.
- Differentiate between the cross sectional views of brain and spinal cord, with reference to white and grey matter.
- Define neuron and describe the structure of a general neuron.
- Define reflex action and reflex arc.
- Name the three types of neuron involved in reflex action.
- Trace the path of a nervous impulse in case of a reflex action.

↗ Skills
(Initiating and Planning)
Student will:

- Visualize nervous and hormonal coordination by comparing electrical transmission in wires with the transmission of nerve impulse in neurons and by comparing convection currents in liquids to the hormonal transmission in blood.

(Performing and Recording)
Student will:

- Perform an experiment in which a scale held at its lower end between the thumb and index finger is allowed to fall and then recording the time taken to catch it again.

3. Receptors of the Human Body (Eye and Ear)

↗ Understanding
Student will:

- Describe the structure of human auditory and visual receptors.
- Describe the pupil reflex in dim and bright light.
- State how short and long sightedness can be treated.
- Associate the role of Vitamin A with vision and effects of its deficiency on retina.
- Explain the role of ear and eye in maintenance of homeostasis through balance and accommodation.
- Relate the contribution of Ibn-al-Haitham and Al-Ibn-Isa with knowledge about the structure of eye and treatment of various ophthalmic diseases.

↗ Skills
(Performing and Recording)

- Identify different parts and draw a labeled diagram of the longitudinal section of the eye of sheep or bull.
- Perform an experiment in which the shin muscle of a frog is made to contract in a Petri dish filled with methylene blue and using 12 V DC current.
- Check the vision of a friend to diagnose whether he/she is suffering from long or short-sightedness.
- Perform an experiment in which one student flashes a spotlight into the eye of another and record the time taken for the eye to contract its pupil.

4- Endocrine System

↗ Understanding
Student will:

- Define the terms; hormone and endocrine system.
- Outline the parts of endocrine system; major glands of this system (Pituitary, Thyroid, Pancreas, Adrenal, Gonads) and names of their respective hormone.
- Describe the term “Negative feedback” with reference to Insulin and glucagon.
- Explain how adrenaline may be involved in exercise and emergency conditions and use gained knowledge to apply to different hormones.

↗ Skills
(Analyzing and Interpreting)
Student will:

- Compare the BGC (blood glucose concentration) of healthy person with a patient suffering from Diabetes mellitus. *(Data/ graph to be given in the textbook)*

5-Disorders of the Nervous System

Understanding

Student will:

- Explain the two common kinds of nervous disorders (Vascular i.e. paralysis and Functional i.e. epilepsy).
- Enlist some of the symptoms and treatments of Paralysis and Epilepsy.

STS Connections

Student will:

- Explain the way nervous system helps to coordinate complex and intricate movements of hand to play a piano, or write alphabets.
- Analyze the way this knowledge has helped humans to train dogs and domesticated animals to perform specific tasks.
- Explain the reason for salivation of mouth when a favorite food item is imagined
- Justify the time difference between seeing the flash of lightening and hearing the roar of a thunderstorm.
- Explain why and how eyes are important to survival in wild animals.
- Explain how color blindness could be a hurdle for aircraft pilots.
- Conceptualize how scientific advancement has helped to solve the problem of diabetes.
- Write a paper on the changes in body while performing an exercise like running a 100m sprint race.
- Describe how genetic engineering has helped in the treatment of Diabetes mellitus.
- Relate how the knowledge of nervous system has helped humans to treat diseases like epilepsy, paralysis.

Chapter 13

SUPPORT AND MOVEMENT

13 Periods

Overview:
This chapter targets the domains of comprehension and application apart from knowledge in the process of learning. Students already have the basic knowledge about skeleton of a human being. The purpose here is to enable the students to analyze, synthesize and evaluate "support and movement" in animals to gain in depth knowledge of the process.
The following major concepts will be developed in this chapter:

- Human skeleton (04 Periods)
- Types of joints (04 Periods)
- Muscles and movement (01 Period)
- Disorders of skeleton system (04 Periods)

Conceptual Linkages:
This chapter is built on;

- Understanding Ourselves (Grade IV)
- Human Organ Systems (Grade VII)

This chapter leads to;

- Support and Movement (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Human Skeleton

↗ Understanding
Student will:

- Define skeleton and differentiate between cartilage and bone.
- Describe the role of skeleton in support and movement.
- Explain that skeleton system is actually a dynamic, living tissue that is capable of growth, adapts to stress and repairs itself after injury.
- Describe the main components of the axial skeleton and the appendicular skeleton.
- Describe the contribution of Vi Salius in describing the bones and muscles in human.

↗ Skills
(Performing and Recording)
Student will:

- Identify and draw labeled diagrams of different bones of the axial and appendicular skeleton from real specimen models or charts.

2- Types of Joints

↗ Understanding
Student will:

- Differentiate between moveable joints and immovable joints.
- State the role of ligaments and tendons.
- Describe the location and movement of hinge joints.
- Identify ball-n-socket joints in human body.

↗ Skills
(Performing and Recording)
Student will:

- Describe the movement of various human joints through observation of models.

3- Muscles and Movement

↗ Understanding

Student will:

- Define antagonism.
- Describe the action of flexors and extensors as a pair of opposing muscles selecting biceps and triceps as example.

↗ Skills

(Performing and Communicating)

Student will:

- Describe the movement of biceps and triceps through presentation of the movement of his/her elbow.

4- Disorders of Skeleton System

↗ Understanding

Student will:

- Describe the effect of by deficiency of calcium on bones and relate this deficiency with osteoporosis.
- Discuss the causes, symptoms, and treatment of arthritis.
- Relate the onset of arthritis with age and weight-bearing joints.

↗ Skills

(Performing and analyzing)

Student will:

- Investigate the nature of bone (by putting three pieces of rib bone of lamb in water, NaOH and dilute HCl).

↗ STS Connections

Student will:

- Relate the skeleton of his / her body with its functioning with daily life.
- Relate the principle of leverage to the action of elbow joint.
- State the principles of arthroplasty for the replacement of joints.

SECTION 4:

CONTINUITY IN LIFE

Chapter 14

REPRODUCTION

28 Periods

Overview:

Students are familiar with basic concepts about reproduction and its types. This chapter gives a closer look at the methods of reproduction in plants.

It is important that the topic of human reproduction is not being treated merely as a biological process; rather the learning outcomes in the arenas of understanding, skills and STS connections provide space for addressing social taboos too. The major concepts discussed in this chapter are as follows;

- Reproduction (01 Period)
- Asexual Reproduction in Plants (07 Periods)
- Sexual Reproduction in Plants (11 Periods)
- Asexual Reproduction in Animals (03 Periods)
- Sexual Reproduction in Animals (06 Periods)

Conceptual Linkages:

This chapter is built on;

- Reproduction in Plants (Grade VII)

This chapter leads to;

- Reproduction (Biology XI-XII)
- Plant Diversity (Biology XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Reproduction

↗ Understanding

Student will:

- Define reproduction and describe its importance.

2- Asexual Reproduction in Protists, Bacteria and Plants

↗ Understanding

Student will:

- Describe different types of asexual reproduction i.e. binary fission, budding, spore formation and vegetative propagation.
- Distinguish between vegetative propagation and artificial propagation.
- Explain vegetative propagation in plants (through stem, suckers and leaves).
- Describe the two methods of artificial vegetative propagation (stem cuttings and grafting).
- Rationalize how parthenogenesis is a type of asexual reproduction.
- Define cloning.

↗ Skills

(Analyzing and Interpreting)

Student will:

- Identify different stages of budding in the prepared slides / charts of yeast and draw diagrams.

(Performing and Recording)

Student will:

- Examine the specimens of onion, corn, ginger and potato and write the mode of their reproduction and describe their cultivation to get new plants.

3- Sexual Reproduction in Plants

↗ Understanding

Student will:

- Describe sexual reproduction in plants by explaining the life cycle of a flowering plant.
- Describe the adaptations in the structure of wind-pollinated and insect-pollinated flowers.

- Describe the structure of seed.
- Distinguish between epigeal and hypogeal germination.
- Describe the conditions necessary for germination of seeds.
- State the contributions of Theophrastus in the discovery of sex in plants.

↗ Skills
(Initiating and Planning)
Student will:
- Hypothesize why Mendel chose pea plant for his experiments.

(Performing and Recording)
Student will:
- Identify different parts of flower.
- Identify and draw the component of the seeds of pea or gram.
- List some of the ripened ovaries and ovules, which are eaten in daily life.
- Perform experiment to investigate the necessary conditions for seed germination.

4- Asexual Reproduction in Animals

↗ Understanding
Student will:
- Outline the binary fission, multiple fission, budding and fragmentation as asexual methods of reproduction in animals.

↗ Skills
(Performing and Analyzing)
Student will:
- Draw different stages of binary fission in amoeba after observing them through slides or charts.

5- Sexual Reproduction in Animals

↗ Understanding
Student will:
- Define fertilization and differentiate between external and internal fertilization.
- Describe different organs of the male and female reproductive systems of rabbit.
- Describe the processes of gametogenesis in rabbit.
- Rationalize the need for population planning.
- Explain AIDS as an example of sexually transmitted diseases.
- State the role of National AIDS Control Program and different NGOs in educating people with reference of AIDS.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Locate the different organs of rabbit's male and female reproductive systems on a chart or diagram.

↗ STS Connections

Student will:

- Grow plants at home using asexual reproduction methods.
- Describe commercially important applications of asexual reproduction in plants.
- Justify cloning as a form of asexual reproduction.
- State the advantages and disadvantages of having large families.
- Debate the social implications of AIDS and other sexually transmitted diseases.

Chapter 15

INHERITANCE

18 Periods

Overview:
The topic of inheritance deals with the Mandelian laws of inheritance and the DNA structure to ascertain that how that structure helps to carry information from one generation to the next. It also appraises the interconnection of genetics to variation, selection and evolution.
The following concepts are developed in this chapter;

- Introduction (01 Period)
- Chromosomes and Genes (05 Periods)
- Mendel's laws, Co-dominance and Incomplete Dominance (09 Periods)
- Variation and Evolution (03 Periods)

Conceptual Linkages:
This chapter is built on;

- Heredity in Organisms (Grade VIII)
- Cell Division (Grade IX-X)

This chapter leads to;

- Biotechnology (Grade IX-X & XI-XII)
- Molecular genetics (Grade XI-XII)
- Evolution (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1-Introduction to Genetics

↗ Understanding
Student will:

- Define genetics.
- Explain how genes control inheritance of characters.

2-Chromosomes and Genes

↗ Understanding
Student will:

- Describe the composition of chromatin material
- Define gene (a localized region of DNA that codes for a protein).
- State clearly the difference between a gene and an allele.
- Explain that gene is a unit of inheritance and that it can be copied and passed on to the next generation.
- Describe the central dogma stating the role of gene in protein synthesis.

↗ Skills
(Analyzing and Recording)

- Draw the chromosomes of a plant cell after observing in a preserved slide / unlabelled chart.

3-Mendel's Law of Segregation and Independent Assortment

↗ Understanding
Student will:

- Describe complete dominance using the terms dominant, recessive, phenotype, genotype, homozygous, heterozygous, P1, F1, F2 generations and proving it diagrammatically through a monohybrid genetic cross.
- Demonstrate that the 3:1 monohybrid F-2 phenotypic ratio is an evidence of segregation of alleles.
- State Mendel's law of Segregation.
- Demonstrate that 9:3:3:1 dihybrid F-2 phenotypic ratio is an evidence of independent assortment.
- State Mendel's law of Independent Assortment.

- Selecting the example of ABO blood group system, explain co-dominance.
- Explain incomplete dominance in Japanese 4 O' Clock plant.

↗ Skills
(Analyzing and Interpreting)
- Predict from pedigree charts the passage of genetic traits from one generation to another.
- Solve basic genetic problems, involving monohybrid crosses, incomplete dominance and co-dominance, using the Punnett square.

4- Variation and Evolution

↗ Understanding
Student will:
- Describe the sources of variation.
- Relate meiosis with variation.
- Describe variation and explain difference between continuous and discontinuous variation by giving examples like, height, weight, IQ, gender and blood groups in population.
- Define organic evolution and explain how variation can lead to evolution.
- Describe how variation leads to competition in a population and differential survival by best fitting the environment.
- Assess selection as a possible means of Evolution.
- Develop an understanding of artificial selection as a means of improvement of yield in economically important plants, like wheat, rice etc.

↗ Skills
(Initiating and Planning)
Student will:
- Plan an experiment (performance is not required) in which pure breeding tall plants can be crossed to pure breeding short plants to get tall variants predominantly, which are selected by environment.

(Analyzing and Interpreting)
Student will:
- Analyze a case study of variation and selection *e.g., peppered moth.*
- Interpret how artificial selection can lead to the development of crop plants with higher yield.

(Performing and Recording)
Student will:
- Record the height of class fellows to predict which kind of variation is it.
- Present the data of class fellows' heights in graphical form (either histogram or bar chart).

↗ STS Connections
Student will:
- Describe various possibilities if humans could be able to control the functioning of genes.
- Prepare a report using newspaper clippings of the recent advances and future possibilities in genetics.
- Rationalize life as a product of the diversity brought about by chromosomes, genes and DNA molecule.
- Outline the scientific findings and some of the technological advances that led to the modern concept of gene.

↗ STS Connections

Student will:

- Analyze the concept of a gene to produce various proteins of the body, examples could be related to both plants and animals.
- Appreciate, through genetic crosses, that science is linked to nature.
- Apply gained knowledge to related conditions to understand the basic underlying processes of genetics.
- Describe the importance of scientific investigation and mathematical know-how in genetics.
- Explain how genetics can help predict the progeny of two individuals, which are crossed.
- Describe the effects of environment that lead to the selection of a variant, which is more adapted to it.

SECTION 5:

ECOLOGY

Chapter 16

MAN AND HIS ENVIRONMENT

18 Periods

Overview:

This chapter deals with interrelationships of organisms with their biotic as well as abiotic environment. The emphasis will be on human interference with the environment and its consequences. Introduction to the concept of conservation of nature is also an important part of this chapter. The students taking up biology at secondary school are already familiar with some basic concepts of ecology. This chapter is based on students' prior knowledge of the environment.

Conceptual Linkages:

This chapter is built on;

- Living Things and Environment, Pollution, Feeding relationships & Interactions (Grade IV, V, VI, VII, VIII)

This chapter leads to;

- Man and His Environment (Grade XI-XII)

The major concepts discussed in this chapter are as follows;

- The Ecosystem: Levels of Ecological Organization; Components (03 Periods)
- Flow of materials and energy in the ecosystem (04 Periods)
- Biogeochemical Cycles (Carbon Cycle & Nitrogen Cycle) (02 Periods)
- Interactions in the Ecosystem (02 Periods)
- Ecosystem Balance and Human impact on environment: Population growth, urbanization, industrialization, deforestation (02 Periods)
- Pollution, its consequences and control (03 Periods)
- Conservation of Nature (02 Periods)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- The Ecosystem: Levels of Ecological Organization; Components of the Ecosystem

Understanding

Student will:

- Describe levels of ecological organization.
- Define ecosystem.
- Describe components of the ecosystem.
- Describe the interrelationships between different components of the ecosystem.

Skills

(Observing, Analyzing and Interpreting)

Student will:

- Identify and list producers and consumers in pond ecosystem and describe the interrelations among biotic and abiotic factors, involved here.

2- Flow of Materials and Energy in the Ecosystem 3 Biogeochemical Cycles

Understanding

Student will:

- Explain that the sun is the principal source of energy for all biological systems.
- Compare and contrast the flow of materials (cyclic) and the flow of energy (non-cyclic) in the ecosystem.
- Describe food chains and food webs.
- Describe and compare energy relations between different trophic levels.
- Interpret pyramids of numbers and biomass.

- Describe carbon and nitrogen cycles.
- Relate biogeochemical cycles with flow of energy and ecological balance.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Construct food chains, food webs through observation of the local pond or grassland ecosystem.

4- Interactions in the Ecosystem

↗ Understanding
Student will:
- Explain competition, predation and symbiosis (parasitism, mutualism, commensalisms).
- Relate competition, predation, and parasitism with population growth.

↗ Skills
(Analyzing and Interpreting)
Student will:
- Prepare lists showing predators and their preys, and parasites and their hosts.

5- Ecosystem Balance and Human Impact on Environment

↗ Understanding
Student will:
- Describe the importance of balance in nature.
- Explain the human impact on environment.
- Explain some global and regional environmental problems (population growth, urbanization, global warming, deforestation, acid rain).

6- Pollution, its Consequences and Control

↗ Understanding
Student will:
- Explain causes of air, water, and land pollution.
- Describe effects of pollution on plants, animals and human beings.
- Describe possible actions to control pollution

↗ Skills
(Analyzing and Interpreting)
Student will:
- Interpret the data about local environmental problems. (Data may be collected through surveys or literature search)
- Plan and carry out simple investigations to determine the nature and effects of pollutants.

7- Conservation of Nature

↗ Understanding
Student will:
- Explain conservation of nature.
- Explain different strategies for conservation of nature (reduced resource use, reuse and recycling of materials etc.)

↗ Skills
(Organizing, Analyzing and Interpreting)
- State the names of endangered and threatened species of Pakistan (data may be collected through internet or literature search).

↗ STS Connections

Student will:

- State that our city / town or village is an ecosystem and we are part of this ecosystem. Also describe his/her position and role in this ecosystem.
- Describe the possible consequences of competition (due to limited resources and over-population) in human society.
- Interpret population growth trends and its possible consequences on our society, through data from internet and literature search on population growth in Pakistan from 1990 to 2000.
- Identify environmental problems in your community. What are possible causes? Suggest measures to solve the problems.
- Become familiar with and be sensitive to local environmental problems.
- Actively participate in the community efforts for conservation of nature.
- Organize/ actively take part in poster or picture exhibition at school.

SECTION 6:

APPLICATION OF BIOLOGY

Chapter 17

BIOTECHNOLOGY

14 Periods

Overview:
Biotechnology – the use of living organisms for their products to enhance our lives and our environment- is a broad and complex discipline.
The introduction of biotechnology, genetic engineering, their processes, and the application of these processes in making useful products of daily use at commercial scale will enable students to comprehend and analyze the concept.
To achieve the intended level at this secondary stage following major concepts are discussed;

- Introduction (01 Period)
- Fermentation (06 Periods)
- Genetic Engineering and its Uses (06 Periods)
- Single cell Protein and its Uses (01 Period)

Conceptual Linkages:
This chapter is built on;

- Biotechnology (Grade VIII)

This chapter leads to;

- Biotechnology (Grade XI-XII)
- Chromosome and DNA (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Introduction

↗ Understanding
Student will:

- Define biotechnology and explain its importance.
- Relate biotechnology with genetic engineering and fermentation.

2- Fermentation

↗ Understanding
Student will:

- Define fermentation.
- Explain the method of fermentation by yeast and bacteria.
- Identify different fermentation products and their importance in daily life i.e. yogurt making, bread making, making of cheese and production of alcohol.
- Explain the use of fermenter in large-scale production of microorganisms and their products.
- Describe the procedure of using fermenters.
- Describe the advantages / profitability of using fermenters in preparing medical products.

↗ Skills
(Performing and Recording)
Student will:

- Investigate the role of yeast in the fermentation of flour.
- Investigate the role of bacteria in the fermentation of milk.

3- Genetic Engineering and its Uses

↗ Understanding
Student will:

- Define genetic engineering and describe its objectives.
- Describe how a gene is transplanted.
- Describe major achievements of genetic engineering with reference to improvement in agricultural crops (herbicide resistance, virus resistance and insect resistance).
- Describe major achievements of genetic engineering in curing animal diseases (foot-and-mouth

disease, Coccidiosis, Trypanosomiasis) and in animal propagation (animal cloning).
- Describe the application of genetic engineering in the production of human insulin and growth hormones.

4- Single-Cell Protein and its Uses

↗ Understanding

Student will:

- Describe single-cell protein and its importance.
- Describe the significance of single-cell protein in animal feed.
- State the significance of single-cell protein in human food.

↗ STS Connections

Student will:

- Apply knowledge to identify different products of animal and human food having single-cell proteins.
- Develop awareness of some social and ethical issues related to genetic engineering.
- Describe the ways in which society benefits from the knowledge of genetics and genetic engineering.
- Interpret data (collected from internet) on some viral resistant, insect resistant and high yielding varieties of agriculture crops in Pakistan.

Chapter 18

PHARMACOLOGY

10 Periods

Overview:

This chapter encircles different kinds of useful and harmful drugs, their modes of action, prognosis of disease symptoms and their treatments.

Narcotic drugs and their effects on human physiology are also emphasized and discussed in terms of discouraging youth from the use of addictive drugs.

The major concepts discussed in this chapter are as follows;

- Introduction and Medicinal Drugs (02 Periods)
- Addictive Drugs (04 Periods)
- Antibiotics and Vaccines (04 Periods)

Conceptual Linkages:

This chapter is built on;

- Microorganisms (Grade V)
- Biotechnology (Grade VIII)
- Nervous system (Grade VIII)

This chapter leads to;

- Human Physiology (Grade XI-XII)

MAJOR CONCEPTS AND LEARNING OUTCOMES

1- Introduction

↗ Understanding

Student will:

- Define Pharmacology as the detailed study of drugs.
- Define the term 'drug' (the substance or product that is used to modify physiological systems of the body).
- Enlist the various sources of drugs i.e. minerals, animals, plants, synthetics, microorganisms.
- Describe the principle usages of painkillers, antibiotics, vaccines and sedatives.
- State the contributions of Joseph Lister in the discovery of antiseptics and of Alexander Fleming in the discovery of penicillin.

2- Addictive Drugs

↗ Understanding

Student will:

- Categorize and describe the effects of addictive drugs (sedatives, narcotics and hallucinogens).
- Define hallucinogen (drugs that alter ordinary mental and emotional processes) and relate it with Marijuana.
- Define narcotics (drugs that produce semi-consciousness and sleep to get relieve from pain) and relate it with Morphine and Heroine (as the most widely used / abused).
- State the associated problems of drugs addictions i.e. severe social abandonment and crimes.
- Identify the symptoms of addiction.
- Name different plants, which are common in Pakistan and used for getting hallucinogens and narcotics.

3- Antibiotics and Vaccines

↗ Understanding

Student will:

- Categorize sulfonamides, tetracyclines and cephalosporins as the major groups of antibiotics being used.
- Categorize major antibiotics as per their bactericidal and bacteriostatic effects.
- Rationalize the resistance developed in bacteria against the widely used antibiotics.
- Describe the role of vaccines in producing immunity against specific diseases.

↗ STS Connections

Student will:

- Compile a list of various painkillers, antibiotics and sedatives being used in daily life.
- Summarize the antisocial effects of the usage of hallucinogens and narcotics.
- Justify the effects of probable over-dosage, under-dosage and drug interactions when using antibiotics without doctor's consultation.

ATTITUDE OUTCOMES

Along with the learning outcomes for knowledge, comprehension, skills etc. the National Curriculum Development Team desires to set up measures that can draw outcomes in the development of behavior / attitudes. Attitude outcomes are exhibited in a different way, as the attitude development is a lifelong process that involves the home, the school, the community and society at large.

Development of positive attitudes plays an important role in students' growth by interacting with their intellectual development and creating a readiness for responsible application of the learning. The curriculum expects the students to have developed;

1- **Interest in Science**
Enthusiasm and continuing interest in the study of science

2- **Mutual Respect**
Appreciation of the fact that scientific understanding evolves from the interaction of ideas involving people with different views and backgrounds

3- **Scientific Inquiry**
Support for active inquiry, problem solving and decision-making

4- **Cooperation and Teamwork**
Support for collaborative activity

5- **Custodianship**
Responsibility in the application of science and technology for a better Pakistan

6- **Safety**
A concern for safety in science and technology contexts

Chapter 6:

LIST OF PRACTICALS AND APPARATUS:

PRACTICALS IX-X

Chapter 1: Introduction to Biology

1. Study of different types of bacteria with the help of prepared slides and of *Amoeba*, *Paramecium, Volvox* from prepared slides/ fresh culture/charts
2. Study of external morphology of mustard plant and microscopic examination of root, stem, leaf, flower, fruit and seeds
3. Identification of major organs and organ systems in a dissected frog (Dissection by demonstrator / teacher)

Chapter 2: Solving an Biological Problem

- No Practical Activity

Chapter 3: Biodiversity

4. Observation of the apparent distinguishing taxonomic characters from fresh and preserved specimens and recognition of plants and animals on the basis of their taxonomic characters
5. Evaluation of graphs of a population of an insect, which is endangered (due to excessive use of insecticides) and interpret the reasons for its endangered status

Chapter 4: Cells and Tissues

6. Use of microscope to observe movement of water in plants and to compare sizes of various types of cells
7. Examination under the microscope an animal cell (e.g. from frog's blood) and a plant cell (e.g. from onion epidermis), using an appropriate temporary staining technique, such as iodine or methylene blue
8. Identify, from fresh preparations, the cell membrane, nucleus and cytoplasm in an animal cell and the cell wall, cell membrane, sap vacuole, cytoplasm, nucleus and chloroplasts in a plant cell
9. Preparation of the wet mounts of tissue from flowering plants and study of plant and animal tissues from charts and prepared slides
10. Determination of the effect of tonicity on plasmolysis and deplasmolysis in plant cells or in Red Blood Cell
11. Data collection on the number of stomata per unit area on various plant leaves that grow in areas of differing humidity, and compilation of data in a spreadsheet and graph it to determine whether there is a relationship between the variables

Chapter 5: Cell Cycle

12. Observation of various stages of mitosis and meiosis by slides, model and charts
13. Preparations of root tip squashes and study stages of mitosis

Chapter 6: Enzymes

14. Experiment to show working of enzyme in vitro e.g., pepsin working on meat in test tube

15. Experiment to test enzyme action by putting diastase in a starch solution in test tube at 37°C and after fifteen minutes performing iodine test for presence of starch

Chapter 7: Bioenergetics

16. Demonstration of the process of photosynthesis using an aquatic plant, like *Hydrilla*
17. Identification and labeling of the cellular and tissue structure in the CS of a leaf through observation under the microscope
18. Investigation of the necessity of chlorophyll, light, carbon dioxide, using appropriate controls
19. Experiment to demonstrate the process of respiration in germinating seeds by using limewater
20. Investigation of the release of carbon dioxide and heat during Aerobic Respiration in germinating seeds

Chapter 8: Nutrition

21. Food tests: Benedict's test for reducing sugar, iodine test for starch, spot test and emulsion test for fat, and Biuret test for protein in solution
22. Microscopic examination of a transverse section of the small intestine to show the villi

Chapter 9: Transport

23. Measurement of differences in length/weight of raw potato strips in concentrated salt solution and water
24. Observation of root hairs on a growing root of onion, carrot etc
25. Microscopic observation of the structure and number of stomata in an epidermal peel of a leaf
26. Investigation of the rate of water loss at the two surfaces of a leaf by a simple experiment using cobalt chloride paper
27. Investigation of transpiration in potted plant under a bell jar
28. Identification of xylem and phloem tissues in the prepared slides of stem, root and leaf
29. Investigation of the pathway of water in a cut stem, using a suitable stain
30. Identification of red and white blood cells under the light microscope on prepared slides and in diagrams and photomicrographs
31. Investigation of the effect of physical activity on pulse rate
32. Experiment to show the capillary flow in a fishtail or fin or frog's web

Chapter 10: Gaseous Exchange

33. Activity to compare the breathing rate at rest and after exercise
34. Experiment to find out how much air a person can take into his lungs
35. Demonstration through experiment of breathing out air into limewater that carbon dioxide is exhaled during respiration
36. Demonstration of the presence of tar in cigarette smoke and also by charts showing pictures of lungs of smokers and nonsmokers

Chapter 11: Homeostasis

37. Examination of the structure of kidney (sheep kidney / model)

Chapter 12: Coordination in Man

38. Observation and recording of the difference in quickness of response of the two types of coordination (by asking a student to say a few words in front of the class and observe the change in heartbeat)
39. Experiment to observe the contraction in the shin muscle of frog in a Petri dish filled with methylene blue and using 12 V DC current
40. Study of bull eye

Chapter 13: Support and Movement

41. Investigation of the nature of bone (by putting three pieces of rib bone of lamb in water, NaOH and dilute HCl)

Chapter 14: Reproduction

42. Observation of binary fission of ameba using slides, photomicrographs or charts
43. Observation of budding in yeast from prepared slides
44. Examination of a bulb (onion), corn (*Edocasia*), rhizome (ginger) or stem tuber (potato) and its cultivation to get new plants
45. Propagation by stem cuttings (rose or any locally available plant) and *Bryophyllum* leaf
46. Examination of Mustard flower, Gram seed and Maize grain
47. Investigation of the conditions for seed germination

Chapter 15: Inheritance

48. Recording the heights of class fellows to predict which kind of variation is it and presentation of the data of class fellows' heights in graphical form (either histogram or bar chart)

Chapter 16: Man and His Environment

49. Investigation of an ecosystem e.g. a balanced aquarium/pond

Chapter 17: Biotechnology

50. Investigation about the role of yeast and bacteria in the fermentation of flour and milk

Chapter 18: Pharmacology

☛ No Practical Activity

REQUIRED APPARATUSES, CHEMICALS, CHARTS AND MODELS

Sr. No.	APPARATUSES	Qty
1.	Aquarium	01
2.	Aquarium net	01
3.	Balance	10
4.	Beaker (50ml, 100ml, 250ml, 500ml, 1000 ml)	10 Each
5.	Bell jar	20
6.	Blades (Safety razor)	20
7.	Burner (Bunsen)	10
8.	Burner (Spirit Lamp)	20
9.	Conical Flask	20
10.	Cotton Wool	04
11.	Differential air Thermometer	10
12.	Dissecting Board	20
13.	Dissecting Box	20
14.	Dissecting Tray	20
15.	Dropper	20
16.	Funnel 4" and 6" dm	20 Each
17.	Glass Tube	04 Packets
18.	Incubator	01
19.	Inoculation Loop	06
20.	Insect Net	12
21.	Lens Paper	06
22.	Light Source	10
23.	Magnifying Glass	10
24.	Measuring Cylinder	10
25.	Microscope (Compound: 10X eye piece, 4X, 10X and 40X objectives)	20
26.	Microscope (Dissecting)	20
27.	Microscope Cover Slip	04 Packets
28.	Microscope Slide	04 Packets
29.	Petri Dish	20
30.	Pipette (10 ml)	10
31.	Plant Presser	04
32.	Plate (Glass)	06
33.	Potometer	04

34.	Preserved Specimens of representative animals	01 Each
35.	Reagent Bottles	20
36.	Specimen Jars	10
37.	Stop Watch	05
38.	Stopper (Cork)	20
39.	Syringe	10
40.	Test Tube Rack	08
41.	Thermometer	20
42.	Thermos Flask	20
43.	Tripod Stand	10
44.	Watch Glass	20

Sr. No.	PREPARED SLIDES	Qty
45.	Bacteria	02
46.	Cells of onion epidermis and *Hydrilla* Leaf	02
47.	Conjugation in *Paramecium*	02
48.	Mitosis and Meiosis in Onion root tip	02
49.	Nerve Cell	02
50.	Rhizopus and Mushroom	02
51.	Section of Mammalian kidney	02
52.	Sections of animal tissues	02
53.	Transverse Section of Artery, Vein and Capillary	02
54.	Transverse Section of Human Small Intestine	02
55.	Transverse Section of Leaf, Root and Stem of *Brassica*	02
56.	Transverse Section of Mammalian Air sacs	02
57.	Transverse Section of Woody stem	02

Sr. No.	CHEMICALS	Qty
58.	Acetic acid	2.5 Liter
59.	Alcohol	2.5 Liter
60.	Ascorbic acid	2.5 Liter
61.	Benedict's solution	2.5 Liter
62.	Bromothymol blue solution	2.5 Liter

63.	Chloroform	2.5 Liter
64.	Copper sulfate solution	2.5 Liter
65.	Diastase	2.5 Liter
66.	Distilled water	2.5 Liter
67.	Eosine	2.5 Liter
68.	Ethanol	2.5 Liter
69.	Formaline	2.5 Liter
70.	Glucose solution 01%	2.5 Liter
71.	Glycerine	2.5 Liter
72.	Hydrogen carbonate indicator	2.5 Liter
73.	Iodine solution 01%	2.5 Liter
74.	Lime water	2.5 Liter
75.	Methylene Potassium hydroxide blue 01%	2.5 Liter
76.	Starch	2.5 Liter
77.	Sudan III solution	2.5 Liter
78.	Trypsin	2.5 Liter
79.	Wax	2.5 Liter

Sr. No.	CHARTS	Qty
80.	Animal and Plant Cell	01
81.	Biodiversity	01
82.	Biogeochemical Cycles	01
83.	Cell Division	01
84.	Germination	01
85.	Human Body Systems	01
86.	Mandelian Genetics	01
87.	Mechanism of Enzyme Action	01
88.	Plant Propagation	01
89.	Reflex Arc	01
90.	Sexual Reproduction in Plants	01
91.	Structure of DNA	01
92.	Transport of Material in Plants	01

Sr. No.	MODELS	Qty
93.	DNA	01
94.	Human Brain	01
95.	Human Diaphragm and Intercostal Muscles	01
96.	Human Ear	01
97.	Human Eye	01
98.	Human Kidney	01
99.	Human Skeleton	01
100.	Neuron	01
101.	Pitcher Plant	01
102.	Sundew Plant	01

Chapter 7:

CHAPTER-WISE TIME ALLOCATION:

Chapter	Number of Periods	
	Teaching + Activities	Assessment
Chapter 1: Introduction to Biology	11	02
Chapter 2: Solving a Biological Problem	04	02
Chapter 3: Biodiversity	12	02
SECTION 1: STUDY OF LIFE & BIODIVERSITY		
Chapter 4: Cells and Tissues	29	04
Chapter 5: Cell Cycle	15	02
Chapter 6: Enzymes	11	02
Chapter 7: Bioenergetics	20	02
SECTION 2: CELL BIOLOGY		
Chapter 8: Nutrition	21	03
Chapter 9: Transport	36	04
Chapter 10: Gaseous Exchange	17	02
Chapter 11: Homeostasis	14	02
Chapter 12: Coordination	25	03
Chapter 13: Support and Movement	13	02
SECTION 3: LIFE PROCESSES		
Chapter 14: Reproduction	28	03
Chapter 15: Inheritance	18	03
SECTION 4: CONTINUITY IN LIFE		
Chapter 16: Man and His Environment	18	02
SECTION 5: ECOLOGY		
Chapter 17: Biotechnology	14	02
Chapter 18: Pharmacology	10	02
SECTION 6: APPLICATION OF BIOLOGY		
Grand Total	**316**	**44**

Total Time Allocation for BIOLOGY IX-X = 360 Periods

Chapter 8:

ASSESSMENT AND EVALUATION:

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

Continuous Assessment Devices:

The continuous assessment should be a part of the classroom learning. Following may be the devices on which the said objectives can be achieved.

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

The continuous assessment should be cumulative and comprehensive and cover all objectives as per the curriculum. Grading of students should be done through the use of assessment instruments that cover the expectations as defined by the objectives of the curriculum.

Evaluation Strategy:

An external examination is recommended at the end of the course. This evaluation should measure all the domains of learning and through it the attainment of the objectives can be measured. The weightage of the different domains of learning is given below;

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

For the final evaluation of the learning outcomes, following weightage is recommended for the contents of 6 sections:

Section	Weightage in Evaluation
• Section 1: Study of Life & Biodiversity (Chapter 1 – 3)	09 %
• Section 2: Cell Biology (Chapters 4 – 7)	23 %
• Section 3: Life Processes (Chapters 8 – 13)	40 %
• Section 4: Continuity in Life (Chapter 14 & 15)	14 %
• Section 5: Ecology (Chapter 16)	06 %
• Section 6: Application of Biology (Chapter 17 & 18)	08 %
Total	100

Suggestions for structuring 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
• Assessing achievement and opportunity to learn	• Assessing only achievement
• Students engaged in ongoing assessment of their work and that of others	• End of term assessments by teachers
• Teachers involved in the development of external assessments	• Development of external assessments by experts alone

- Assessment pattern is subject to the requirement, policies, and procedures of the Examination Boards.
- Question paper will be based on the curriculum not on a particular textbook.
- Questions involving unfamiliar contexts or daily-life experiences may be set to asses candidates' problem-solving and higher-order processing skills. In answering such questions, sufficient information will be given for candidates to understand the situation or context. Candidates are expected to apply their knowledge and skills included in the syllabus to solve the problems.
- In general, SI units and terminology will be used.

Chapter 9:

INSTRUCTIONS AND SUGGESTIONS:

Execution of the Curriculum:

The curriculum implies changes and developments, which will mean:

For Students:

- Higher standards of achievement through, leading through to broader choices as they progress to next grades; better progression from one level to the next; assessment which promotes learning and recognizes different types of achievements; scope for more enjoyment in learning

For Parents:

- A clear understanding of the learning opportunities their children should have, ways in which they can support their children's learning; the purposes of these activities; and the recognition which children will receive for their achievements

For Teachers and Schools:

- Clarity about what education is seeking to achieve for each student; flexibility to apply professional judgment in planning programs and activities to respond to the needs of individual students; a curriculum which is not overcrowded because of too much content; more teaching across and beyond traditional subject boundaries; time and space for innovative and creative teaching and learning

For the Education System:

- A responsibility to ensure that teaching, learning and assessment are directed to achieving the purposes and principles set out in the curriculum and that qualifications reflect this fully; a responsibility to ensure that initial training and continuing professional development of teachers and educators equip them fully for their task; and a commitment to a continuing program of refreshment and review of the curriculum

For Society:

- Confidence that children and young people are being enabled to reach the highest levels of achievement as successful learners, confident individuals, responsible citizens and effective contributors to society and at work

Instructions for Textbook Writing:

- A team of a dozen or more authors should not be engaged in developing the text material. It results in loss of coherence and consistency in the book. The task of developing a textbook should be given to **Two or Three authors** who can compile the book making each part of it coherent and developing **Consistency** in it. Each of all the O-level and A-level Biology books is written by one or two authors.

- It should be tried to engage the same experts in textbook writing who developed the **Learning Expectations in the Curriculum** of that particular subject and grade.

- The curriculum wing should manage to **train the Authors and Editors** of the textbook, before the onset of the task.

- At the end of each chapter addresses of relevant **Websites** and **Online Learning Centers** should be mentioned so that students and teachers can get update information about the concepts.

- For IX-X and XI-XII grades, Textbook boards should publish **Color Acetate Transparencies** of the lessons that teachers can use to supplement classroom lectures.

- Textbook board should develop a **Biology Test Item CD-ROM** for instructors and students. It should contain multiple-choice questions and the instructor's manual for each chapter.

- Textbook board should publish **supplementary learning materials** for example;

  1. **Laboratory Manual**
  It should be corollary to the text and should incorporate many learning aids. It should include illustrations and photographs, and activities on scientific method, cladistics, ecological and evolutionary principles, and animal structure and function.
  2. **Instructor's Manual**
  It should provide lesson plans/reading schedules for the course with various emphases. In addition, it should include detailed outline, purpose, objectives, key terms, summary, resources for audiovisual materials and computer software.

While developing the text material of the books, the authors should pay attention to the following points.

- **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 / topics.**
- Each chapter should be opened with a brief recalling statement, and then it should move to a brief introduction to its contents. Afterwards the introduction should be given continuity with knowledge and comprehension of the content.
- Relevant Quranic Ayats may be given wherever possible.
- Contributions of scientists, primarily Muslim scientists, should be highlighted in the relevant topics.
- Continuity of concepts should be in a way as the scientific process is carried out in the real world.
- Explanation of science concepts should be written in ways to make them interesting and easy to understand.
- Examples should be carefully chosen so that students can relate them easily.
- Textbook should be attractive and have colorful illustrations to captivate students.

- There should be a chapter-outline in the beginning of each chapter, describing the task to be achieved in the chapter.
- Biology Tits Bits should be provided in each chapter. It will provide children useful knowledge, which may not lie in the syllabus.
- Each chapter should have, in its exercise, the Think Tank. It consists of open-ended questions, which encourage students to think critically and creatively.
- Glossary of technical terms should be given at the end of the book.
- **Concept Mapping -** Concept map is a diagram that shows the relationship between concepts within a topic, making it easier to relate new information to what you already know. Concept maps are usually constructed from top to bottom. Each concept is placed in a box with the most inclusive concept near the top and more subordinate concepts near the bottom. The concept boxes are then connected by labeled lines that indicate the relationship between the linked concepts. When constructing a concept map; it is best to select a fairly well-defined topic on which to focus.
- **Chapter Organizing system -** It should be taken into account that a consistent numbering system leads the students through each chapter at a glance in the beginning to conceptual heading throughout and finally to the summary of key concepts at the end. Each chapter should be organized in the following pattern:

CHAPTER NAME

Outline:

Major Concepts:

- 1.1 :::::::::::::::
- 1.2 :::::::::::::::
- 1.3 :::::::::::::::

Introduction

1.1 MAJOR CONCEPT
(Depth of the topic should be kept with the teaching periods advised in the curriculum)

Tit Bits:

STS Connections:

Subheading #1.1.1

Subheading # 1.1.2

Critical Thinking:

Practical Activity:

EXERCISE:

The exercise should include;

- Multiple Choice Questions
- Short Questions
- Extensive Questions

(Questions should be made that can check learning outcomes in all the domains i.e. knowledge, comprehension, application, evaluation, synthesis and connection with technology and society.)

Criteria for the Selection of Learning Material:

National 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:**
   The materials should identify big ideas – concepts, themes, issues – and should also include provocative essential questions around which knowledge is examined.
2. **Do the materials require learners to be thoughtful, reflective and use high-level skills?**
   It should permit continual instruction and assessment and should provide opportunities for students to be thoughtful and reflective (explain, interpret, apply, give perspectives, empathize and explore their own self-knowledge). It should also provide ample opportunities of learning and using high-level skills (research, scientific inquiry, strategic reading, writing, problem solving and decision-making).
3. **Do the materials include valid and varied assessments- both traditional and performance based?**
   It should have a variety and balance between traditional and understanding-based performance assessments and between summative and formative assessments. It should have the connections between the assessments and the learning outcomes of the curriculum.
4. **Do the materials contain effective and engaging activities?**
   It should include activities that help students master understanding, inquire into essential questions, explain and explore their understanding, promote interaction between teachers and students, motivate student learning, and help students make meaning.
5. **Do the materials continually revisit big ideas?**
   It should "overarch" big ideas and questions to develop ideas in greater depth and inquire into them over time. There should be coherence in the material in the form of revisits, refinements, and reflection on ideas.
6. **Do the materials reflect a "developmentally appropriate" approach to student learning?**
   Look for materials that support rigorous academic learning of big ideas and essential questions, but are not so far above or below the current abilities of the learner that they stifle learning.
7. **Are the materials geared to the diverse abilities, interests and needs of students?**
   The materials should support the needs of students in a diverse classroom environment. It should also incorporate the multiple student intelligences and learning styles.

8. **Is the curriculum program based on text alone, or does it include many different types of materials, including technology-based learning**
   There should be multiple sources that allow for thoughtful understanding based learning and inquiry. The material should reflect the role of technology in promoting understanding based learning.
9. **Do the materials encourage interdisciplinary connections?**
   The materials should encourage interdisciplinary connections.
10. **Are outside experiences, including family involvement, part of the learning experience?**
    The authentic learning experiences should be an on-going part of the curriculum materials. There should be many opportunities for parents to work with their children in order to supplement understanding based learning experiences.

Electronic Instructional Material:

Electronic instructional material is gaining popularity in the developed world. Educational technology providers are successfully marketing courseware with instructional management, assessment, individualized learning paths and professional development. Growing numbers of teachers have convenient and immediate access to entire libraries of instructional video correlated to curriculum. As far the educational scenario in Pakistan and other developing countries is concerned, lack of resources (particularly in schools) would hold back the evolution of electronic publishing in place of or along with printing.

It may be considered that a good ratio of the students of intermediate grades has access to computer technologies. They should be given chances of self learning (rather exploring the knowledge) and it can be made true by converting the data of the IX-X and XI-XII textbooks into electronic formats e.g. CD-ROMs. The CD-ROMs should be made available at the retail outlets. Where students don't have computers at schools/colleges or at homes, they may explore the CD-ROM at internet café, as they are very much seen at internet cafés wasting their potential while chatting with friends, looking movies etc.

In biology subject diagrams and photographs are more important to convey the desired learning. Printed textbooks cannot tackle the diagrams that need 3-dimensional view for their understanding. Similarly a student can get comprehensive learning of a life phenomenon through animations. Diagrams, photographs and animations should be published in electronic format i.e. CD-ROM that can be made an accessory item with the printed textbook. Such a CD should also have installed software for students' assessment and evaluation in the form of tests, quizzes and games.

Teaching-Learning Program:

The topics, or objectives within topics, can be taught in any order in keeping with the needs of teachers and students.

It will be clear that achievement of the educational objectives requires thoughtfully designed teaching situations. It is assumed that students will achieve the educational objectives by way of ongoing interplay between theoretical information and practical experience; it therefore follows that the teaching approaches and materials used should:

- represent biology as part of the process of scientific inquiry (rather than a rhetoric of conclusions)
- use inquiry-based teaching strategies where possible
- be student-centered, assisting students to derive their own concepts from evidence and providing practical opportunities to develop individual reasoning abilities and motor skills

- exemplify the concept from local scenario.
- when beginning a new area of study, provide very direct, concrete experience – through classroom, laboratory and field work – or the next best substitute when direct experience is not feasible
- provide rewarding opportunities to apply scientific understanding and ways of thinking to problems, especially everyday ones
- provide opportunities to refine ideas through dialogue with others, and work with them in ways likely to foster cooperative abilities
- provide opportunities to develop skills of written and oral communications
- use testing as a diagnostic as well as an achievement tool.

Teachers' Training and Refresher Courses:

Effective and meaningful biology education can only be guaranteed if the teacher, the key pivot of the change, is developed enough in contents as well as methodology. In-service trainings may help the teachers to become familiar with a variety of strategies for successful delivery of the curriculum.

The curriculum development and revision is a continuous process in all stages of education so is the process of updating the teacher education programs at pre-service as well as at in-service stages. If the teacher is not fully equipped and trained to handle the new curricula, the curriculum transaction would not be appropriate and consequently, the learning will be inadequate. Teacher's training needs the following actions:

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

2. In-service trainings should cover contents and methodologies. Content upgrading in biology is an urgent need for effective teaching. Emphasis should specifically be laid on learner-centered and activity based approaches. Laboratory practices, classroom demonstrations, active participation by the students, and field interactions should become major components of in-service training programs. Workshops, seminars and extension lectures should be organized more frequently and regularly and particularly in summer vacation.

3. Well-equipped resource centers should be established at the training institutions for a ready help to the needy teachers.

Chapter 10:

SALIENT FEATURES OF THE CURRICULUM:

The Curriculum is fully in harmony with the National Priorities, and will provide an important momentum for achieving our vision for students.

Configuration with the restructured Schemes of Study:

The Ministry of Education went through an arduous exercise for restructuring the National Schemes of Study. The Curriculum Development Team; while designing the curriculum, selecting the syllabi contents, carving the learning outcomes (including practical skills) and suggesting the timeframes and evaluation strategies for the contents; maintained a concrete configuration with the restructured schemes of study.

The Focused Areas:

It has been focused that the curriculum provides to the students;

- Challenges and Enjoyment
- Breadth
- Progression
- Depth
- Personalization and Choice
- Coherence
- Relevance

Reduction in Load:

Since it was important that the quality of Biology education at the secondary level was not compromised in any way, the reduction in load from the syllabus required a very careful selection of topics to be taught. The Team chose to leave topics out if:

- **The question about why the student needs to study the topic at the particular stage could not be answered;**
- **The topic had no direct relevance to the student i.e. was not contextual;**
- **The content was repetitive across stages with no change in expected understanding, and**
- **Any topic was in isolation with no evident horizontal or vertical linkages**

The need for a network of ideas and cross-linking between the areas being identified was deemed very important. While deciding on the chapters/topics and the depth of each topic for the secondary level, a holistic view of the syllabus across all stages from the primary to the higher secondary and beyond was taken. Reducing the use of too many technical terms and avoiding very large numbers of examples will also help to make the content a little lighter. The importance of careful selection of illustrations and their use to make the concepts more explicit was stressed; in Biology the quality of illustrations can make or mar any attempt at good textbooks/teaching.

The Team faced a dilemma while considering the topic of animal physiology: whether to deal with ‘animal’ or ‘human’ physiology. But the moment the focus of discussion shifted - from the ‘subject’ dictated one to the child - and the available time was considered, it was evident that ‘human’ physiology was more appropriate at this stage. The student is closest to herself / himself and is curious about the functioning of the human body. The ‘science’ understood after a study of human physiology could be meaningfully applied to other organisms.

The curriculum also takes up issues pertaining to environment, health and other ethical issues that arise with any interference of human beings in the natural processes, which have great relevance from the societal point of view.

Reasoning Vs Comprehension:

In secondary and higher secondary grades, abstraction and quantitative reasoning come to occupy a more central place than in the primary and elementary grades. We have to avoid the attempt to be comprehensive. A topic can be made comprehensive in two ways;

1. Adding many more concepts than can be comfortably learnt in the given time frame
2. Enumeration of things or types of things, even where there is no strong conceptual basis for classification

In the present revision, no attempt is made to be comprehensive. Unnecessary enumeration is avoided. The process by which factual knowledge can be acquired is more important than the facts themselves.

At this stage the disciplines of physics, chemistry and biology are beginning to emerge. The child should be exposed to experiences as well as modes of reasoning that are typical of these subjects. This stage also sees a certain consolidation of knowledge within themes. As a result, a theme may get a lot of space in one grade (e.g. organization of life in Grade IX) while being absent from the higher grades.

Chapter 11:

GLOSSARY OF TERMS:

Attention is paid to the wording of learning outcomes to ensure it as concise and as unambiguous as possible. In many instances, Examiners are able to make appropriate allowance for an interpretation that differs, but acceptably so, from the one intended.

The Curriculum Development Team thinks it necessary to make clear the intended learning outcomes it has predicted. It can be so through explaining the meanings of important words stated in the learning outcomes. It is hoped that the glossary will prove helpful to teachers, evaluators and students as a guide (i.e. it is neither exhaustive nor definitive).

1. **Define (the term (s)...)** is intended literally, only a formal statement or equivalent paraphrase being required.
2. **What is meant by (the term (s)...)** normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in the light of the indicated mark value.
3. **State** implies a concise answer with little or no supporting argument (e.g. a numerical answer that can readily be obtained 'by inspection').
4. List requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should not be exceeded.
5. **(a) Explain** may imply reasoning or some reference to theory, depending on the context. It is another way of asking candidates to give reasons for. The candidate needs to leave the examiner in no doubt why something happens.

   (b) Give a reason/Give reasons is another way of asking candidates to explain why something happens.
6. **(a) Describe**, the data or information given in a graph, table or diagram, requires the candidate to state the key points that can be seen in the stimulus material. Where possible, reference should be made to numbers drawn from the stimulus material.

   (b) Describe, a process, requires the candidate to give a step by step written statement of what happens during the process.

   Describe and explain may be coupled, as may state and explain.
7. **Discuss** requires the candidate to give a critical account of the points involved in the topic.
8. **Outline** implies brevity (i.e. restricting the answer to giving essentials).
9. **Predict** implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information

may be wholly given in the question or may depend on answers extracted in an earlier part of the question.

Predict also implies a concise answer, with no supporting statement required.

10. **Deduce** is used in a similar way to predict except that some supporting statement is required (e.g. reference to a law/principle, or the necessary reasoning is to be included in the answer).
11. **Suggest** is used in two main contexts (i.e. either to imply that there is no unique answer (e.g. in chemistry, two or more substances may satisfy the given conditions describing an 'unknown') or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus').
12. **Find** is a general term that may variously be interpreted as calculate, measure, determine, etc.
13. **Calculate** is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.
14. **Measure** implies that the quantity concerned can be directly obtained from a suitable measuring instrument (e.g. length, using a rule, or mass, using a balance).
15. **Determine** often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.
16. **Estimate** implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about points of principle and about the values of quantities not otherwise included in the question.
17. **Sketch**, when applied to graph work, implies that the shape and/or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for.

    In diagrams, sketch implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

In the examining system, in all questions, the number of marks allocated are shown on the examination paper and should be used as a guide by students to how much detail to give. In describing a process the mark allocation should guide the student about how many steps to include.

Acknowledgement:
Extracted from Biology O Level 2007 of Cambridge University, England

Chapter 12:

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