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G.C.E. (Advanced Level)

Biology

Grade 12
Teachers' Guide
(Implemented from 2017)

Department of Science
Faculty of Science and Technology
National Institute of Education
Maharagama
www.nie.lk

Printing & Distribution : Educational Publications Department

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G.C.E. (A.L.)

Biology

Teachers' Guide

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First Print – 2018

www.alevelapi.com

Department of Science

Faculty of Science and Technology

National Institute of Education

Published By : The Educational Publications Department

Printed By : Print One (Pvt)Ltd,
No. 341/1/109, Palanwatta, Pannipitiya.

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Message from the Hon. Minister of Education

In fulfilling the task of providing a high-quality education to the children of Sri Lanka, which is the main function of the Ministry of Education, the contribution received from the teachers is invaluable. Teachers' responsibility in producing citizens who possess the capacity to handle the challenge of the rapidly changing society is very special.

Teacher Instructional Manuals, which help teachers in facilitating the teaching-learning process and in updating syllabi based on the timely needs, are an important tool in education. If a supportive learning environment can be built in the classroom, measures being implemented by the government to accomplish the global education objectives will be successful. Ministry of Education always institutes appropriate measures to strengthen the teacher in order to achieve that objective.

I commend the teachers for the valuable service they render in creating a future generation with a balanced personality by motivating them to explore new knowledge in the bursting knowledge society, being on the basis of the value systems of the traditional wisdom. I expect active support of the teachers to help children make our motherland an oasis enabling them to keep pace with the powerful countries in the world.

I would like to pay my compliments to the National Institute of Education and the panel of external scholars for the dedication in compiling this Teacher Instructional Manual and I also commend the strong contribution made by the Educational Publications Department in publishing it.

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Akila Viraj Kariyawasam

Minister of Education

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Message from the Director General…

With the primary objective of realizing the National Educational Goals recommended by the National Education Commission, the prevalent content based curriculum was modernized, and the first phase of the new competency based curriculum was introduced to the eight year curriculum of the primary and secondary education in Sri Lanka in the year 2007.

The second phase of the curriculum cycle thus initiated was introduced to the education system in the year 2015 as a result of a curriculum rationalization process based on research findings and various proposals made by stakeholders.

Within this rationalization process, the concepts of vertical and horizontal integration have been employed in order to build up competencies of students, from foundation level to higher levels, and to avoid repetition of subject content in various subjects respectively and furthermore, to develop a curriculum that is implementable and student friendly.

The new Teacher's Guides have been introduced with the aim of providing the teachers with necessary guidance for planning lessons, engaging students effectively in the learning teaching process, and to make Teachers' Guides help teachers to be more effective within the classroom. Further, the present Teachers' Guides have given the necessary freedom for the teachers to select quality inputs and activities in order to improve student competenci

The primary objective of this rationalized new curriculum, the new Teachers' Guides, and the new prescribed texts is to transform the student population into a human resource replete with the skills and competencies required for the world of work, through embarking upon a pattern of education which is more student centered and activity based.

I wish to make use of this opportunity to thank and express my appreciation to the members of the Council and the Academic Affairs Board of the NIE and the resource persons who contributed to compile of these Teachers' Guides and other parties for their dedication in this matter.

Dr.(Mrs.) JayanthiGunasekara
Director General
National Institute of Education
Maharagama.

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Foreword

Teachers are leading personalities among those who render a great service for the progression of the society. Teachers guide the children to mould their characters.

The Educational Publications Department takes measures to print and publish these Teacher Instructional Manuals to facilitate the teachers to carry out the teaching process successfully in accordance with the new syllabi to be implemented with effect from 2015. I strongly believe that this Teacher Instructional Manual compiled by the National Institute of Education will provide the required guidance to create a favourable learning environment for the children to learn.

This venture will achieve its success on the effort made to utilize the experience acquired by using this Teacher Instructional Manual in the teaching learning process. I bestow my gratitude on all those who dedicated themselves for this national endeavour.

I. M. K. B. Ilangasinghe
Commissioner General of Educational Publications,
Educational Publications Department,
Isurupaya,
Battaramulla.
02.04.2017

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Message from the Deputy Director General

Education from the past has been constantly changing and forging forward. In recent years, these changes have become quite rapid. The past two decades have witnessed a high surge in teaching methodologies as well as in the use of technological tools and in the field of knowledge creation.

Accordingly, the National Institute of Education is in the process of taking appropriate and timely steps with regard to the education reforms of 2015.

It is with immense pleasure that this Teachers' Guide where the new curriculum has been planned based on a thorough study of the changes that have taken place in the global context adopted in terms of local needs based on a student-centered learning-teaching approach, is presented to you teachers who serve as the pilots of the schools system.

An instructional manual of this nature is provided to you with the confidence that, you will be able to make a greater contribution using this.

There is no doubt whatsoever that this Teachers' Guide will provide substantial support in the classroom teaching-learning process at the same time. Furthermore, the teacher will have a better control of the classroom with a constructive approach in selecting modern resource materials and following the guidelines given in this book.

I trust that through the careful study of this Teachers' Guide provided to you, you will act with commitment to produce a greatly creative set of students capable of helping Sri Lanka move socially as well as economically forward.

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This Teachers' Guide is the outcome of the expertise and unflagging commitment of a team of subject teachers and academics in the field Education.

While expressing my sincere appreciation for this task performed for the development of the education system, my heartfelt thanks go to all of you who contributed your knowledge and skills in making this document such a landmark in the field.

M.F.S.P. Jayawardhana
Deputy Director General
Faculty of Science and Technology
National Institute of Education

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Guidance - Dr. (Mrs.) T.A.R.J. Gunasekara- Director General, National Institute of Education

Consultancy and Supervision - Mr. M.F.S.P. Jayawardhana
Deputy Director General
National Institute of Education

Supervision - Mr. R.S.J.P. Uduporuwa
Director, Department of Science
National Institute of Education

Subject Leadership - Mrs. H.M.Mapagunarathna
Senior Lecturer – Dept. of Science
National Institute of Education

Internal Resource Contribution –

Miss. P.T.M.K.C.Tennakoon- Assistant lecturer
National Institute of Education
Mr. P.Atchuthan - Assistant Lecturer
National Institute of Eduction
Mrs. D.A.H.U.Sumanasekara- Assistant Lecturer
National Institute of Education

Curriculum Committee Members

Mr. R.S.J.P. Uduporuwa	-	Director, Department of Science – NIE
Mrs. H. M. Mapagunaratne	-	Senior Lecturer , Department of Science- NIE
Prof. M.J.S. Wijeratne	-	Senior Professor of Zoology and Environment Management, University of Kelaniya
Dr. S.M.W. Ranwala	-	Senior Lecturer, Department of Plant Science University of Colombo
Prof. D.S.A. Wijesundara	-	Research Professor,Institute of Fundamental Studies
Mrs M.N.F. Nasriya	-	Assistant Director, Science Branch, Ministry of Education
Mrs. P.H.N. Kulathilake	-	Devi BalikaVidyalaya,Col-08
Mrs. Y.M.P.K. Yapa	-	Assistant Commissioner, Educational Publications Department
Prof B.G.D.N.K. De Silva	-	Senior Professor of Molecular Biology, University of Sri Jayawardanepura
Prof S. Abeysinghe	-	Head of the Department, Department of Botany, University of Ruhuna.

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External Resource Contribution

Mrs. B. Ganeshadas	-	SLTS-I, D.S.SenanayakeCollege, Colombo 07
Mrs. P.A.K.Perera	-	SLTS- (Rtd)
Mrs. H.L. Hemanathi	-	SLTS-I, Royal College, Colombo 07
Mrs. M.S.J. Jayasooriya	-	SLTS, Ladies College, Colombo 07
Mrs. M.R.P.R Basnayake	-	SLTS-I (Rtd)
Mr. A. Illaperuma	-	SLTS-I(Rtd)
Mrs. H.A.S. G. Perera	-	SLTS-II-I ,Sirimavo Bandaranaike College, Colombo -07
Mrs. A.M.S.D. N. Abeyakoon	-	SLTS-I-(Rtd)
Mrs. S.D.P.Bandara	-	SLTS-I-(Rtd)
Mrs. J.A. J.Hanee	-	SLTS-I,Zahira College, Gampola
Mr. W.G. Pathirana	-	SLTS-I, Rahula College, Matara
Mrs. C.V.S.Devotta	-	SLTS-I,Dammissara College, Natthandiya

Language Editing - Dr. Chandra Amarasekara
- Mr.M.A.P. Munasinghe

Cover and Typesetting - Mrs. R. R. K. Pathirana - Technical Assitant- NIE

Supporting Staff - Mrs.Padma Weerawardana -N.I.E
- Mr.Mangala Welipitiya - N.I.E
- Mr.Ranjith Dayawansa - N.I.E

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Guidelines to use the Teachers' Guide

In the G.C.E (A/L) classes new education reforms introduced from the year 2017 in accordance with the new education reforms implemented in the interim classes in the year 2015. According to the reforms, Teachers' Guide for Biology for grade 12 has been prepared.

The grade 12 Teachers' Guide has been organized under the titles competencies and competency levels, content, learning outcomes and number of periods. The proposed lesson sequence is given for the leaning teaching process. Further it is expected that this teachers' Guide will help to the teachers to prepare their lessons and lessons plans for the purpose of class room learning teaching process. Also it is expected that this Guide will help the teachers to take the responsibility to explain the subject matters more confidently. This teachers' Guide is divided into three parts each for a term.

In preparing lesson sequence, attention given to the sequential order of concepts, students ability of learning and teachers' ability of teaching. Therefore sequential order of subject matters in the syllabus and in the teachers Guide may differ. It is advised to the teachers to follow the sequence as in the teachers' Guide.

To attain the learning outcomes mentioned in the teachers' Guide, teachers should consider the subject matters with extra attention. Further it is expected to refer extra curricular materials and reference materials to improve their quality of teaching.

Total number of periods to teach this Biology syllabus is 600. Teachers can be flexible to change the number of periods according to their necessity. Teachers can use school based assessment to assess the students.

The teacher has the freedom to make necessary amendments to the specimen lesson plan given in the new teachers' manual which includes many new features, depending on the classroom and the abilities of the students.

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Competency 1.0 : **Conducts investigations from a biological prospective**

Competency Level 1.1.1 : **Elaborates on the nature, scope and importance of biology with reference to challenges faced by mankind**

Number of Periods : **02**

Learning Outcomes:

- states the importance of learning biology
- states the issues and challenges pertaining to biology

Suggested Teaching- Learning Process

- Provide/quote suitable sources to gather information regarding nature, scope and the importance of biology.
- Instruct the students to gather information on issues pertaining to biology from different sources.
- Advise students (groups) to categorize the information in accordance with the given areas.

  1. Biological diversity
  2. Human body and its functions
  3. Plant life
  4. Natural resources and management
  5. Sustainable food production
  6. Diseases, and their causes
  7. Addressing legal and ethical issues

- Assign students to construct a concept map on the importance of studying biology

Assessment and Evaluation

- Assess student's concept map based on the following criteria:
  - Accuracy of the subject matter
  - Relevant examples
  - Inter links in the concept map
  - Time management

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Competency Level 1.1.2 : Reviews the nature and the organizational patterns of the living world

Number of Periods : 03

Learning Outcomes:

- briefly discusses diversity of organisms in size, shape, form and habitat using appropriate examples
- discusses how organisms differ from each other using appropriate examples
- states characteristic of organisms
- constructs the hierarchical level of organization with suitable examples
- emphasizes the cell as the basic structural and functional unit of life
- appreciates all kinds of organisms and their interactions

Suggested Teaching- Learning Process

- Use power point presentations or diagrams or specimens and other sources to highlight the diversity of organisms.
- Explain the following characteristics of organisms with examples.
  - Order and Organization
  - Metabolism
  - Growth and Development
  - Irritability and Co-ordination
  - Adaptation
  - Reproduction
  - Heredity and Evolution
  - Provide pictures with hierarchical levels of organization in organisms to students and guide them to arrange those in correct order to make aflow chart from molecules to biosphere.
  - Advise students to denote the basic structural and functional unit of life on that flow chart.

Assessment and Evaluation

- Assess the flow chart of the students using the following criteria.
  - Accuracy and relevance of information
  - Active participation
  - Time management

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Competency 2.1.0 : **Investigates the chemical basis of life**

Competency Level 2.1.1 : **Inquires into the elemental composition of organisms**

Number of Periods : **02**

Learning Outcomes:

- lists out the most abundant elements present in living matter.

Suggested Teaching- Learning Process

- Ask student groups to list elements present in living matter and mention that about 20-25% of natural elements are known to be essential for life.
- Discuss that C,H,O,N are the four most abundant elements in human (96%) and that P, S, Ca, K and a few others constitute 4% in living matter.

Assessment and Evaluation

- Assess students on the most abundant elements and other essentials in humans using questioning techniques for assessment

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Competency Level 2.1.2 : Investigates the physical and chemical properties of water important for life.

Number of Periods : 04

Learning Outcomes:

- presents as small groups the importance of water for life
- appreciates the unique properties of water for existence of life.

Suggested Teaching- Learning Process

- Discuss water molecule as a small, dipolar and angular molecule and due to the polarity nature hydrogen bonds are formed.
- Give examples for the importance of water for life.
- Conduct a discussion to relate chemical and physical properties of water to the importance of water for life.
- Assign students to write an article on the importance of water for life to be displayed as a wall paper.

Assessment and Evaluation

- Assess the article using the following criteria.
  - Analysis of necessary information
  - Examples
  - References
  - Suitability as a wall paper

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Competency Level 2.1.3 : Examines the chemical nature and functions of the main organic compounds of organisms

Number of Periods : 08

Learning Outcomes:

- classifies the organic compounds found in living organisms into four main types
- describes the basic chemical nature of carbohydrates
- classifies the carbohydrates based on number of monomers and their reducing nature
- briefly describes the formation of glycosidic bond in carbohydrates(no need to explain through chemical structures)
- briefly discusses the major functions of carbohydrate (energy source, storage contribution to structure and transport)
- classifies lipids as fat, oil, phospholipids and steroids
- briefly describes the basic chemical nature of lipids based on their elemental composition, molecular nature and hydrophobic nature
- briefly discusses types of lipids
- briefly discusses the functions of lipids (storage, structure, hormones)
- briefly describes the basic chemical nature of proteins based on their elemental composition monomers and chemical structure
- briefly describes the four levels of protein structures
- briefly describes denaturation as a property of protein
- states the functions of proteins as catalysts contribution to structure, storage, transport, hormones, contraction and defensive function
- differentiates between nucleoside, nucleotide and polynucleotide using suitable models
- discusses the structure and functions of DNA and RNA
- differentiates DNA and RNA
- explains the role of DNA and RNA as hereditary material
- states functions of ADP, ATP,NAD^+,FAD and $NADP^+$
- conducts laboratory tests to identify the reducing sugars, non reducing sugars, starch, proteins and lipids
- appreciates that proteins, carbohydrates , lipids and nucleic acids form the chemical basis of life
- appreciates the unique properties of DNA which are important to act as the hereditary material of all organisms

Suggested Teaching- Learning Process

- Assign for Student groups to classify the organic compounds found in living organisms into four main types such as carbohydrates, proteins, lipids and nucleic acids.
- Use diagrams to explain the basic chemical nature of carbohydrates.

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- Let students classify the carbohydrates based on the number of monomers and the monosaccharides based on the number of carbon atoms.
- Lead a discussion on the functions of carbohydrates stating relevant examples.
- Lead a discussion on the basic chemical nature, different types and functions of lipids.
- Use diagrams/charts/ pictures/ electronic materials to explain
    - four levels of protein structures;
    - properties and functions of proteins.
- Use models to explain the basic chemical nature of nucleic acids.
- Introduce the terms nucleoside, nucleotide and polynucleotide.
- Use models/ diagrams/ videoclips to introduce the structure of DNA and RNA.
- Guide students to tabulate the differences between DNA and RNA.
- State the functions of other nucleotides such as ADP, ATP, NAD^+, $NADP^+$ and FAD.
- Guide students to carryout experiments to identify reducing sugars, non reducing sugars, starch, proteins and lipids.

Assessment and Evaluation

- Assess each group of students during their activity (carrying out experiments)
    - Proper handling of equipments and materials
    - Correct way of taking observation
    - Correct recording
    - Team work

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Competency 2.2.0 : **Examines the cells as the basic functioning unit of life**

Competency Level 2.2.1 : **Elaborates on the contribution of the microscopes to the expansion of knowledge on cells and cellular organization**

Number of Periods : **06**

Learning Outcomes:

- explores the importance of microscope in biology
- defines magnification and resolution
- compares significant features of the electron microscope and light microscope
- states main features of transmission and scanning electron microscopes
- identifies cellular and sub cellular components using light microscope and electron micrographs.
- uses the light microscope properly to observe specimens
- values the contribution of the microscope in biological studies

Suggested Teaching- Learning Process

- Lead students to gather information on the importance of the microscope and conduct a discussion on that.
- Introduce magnification and resolution power of the microscope.
- Ask students to identify and map parts and their functions of the light microscope.
- Introduce the electron microscope using diagrams/ charts/ pictures/ videos.
- Explain the main features of TEM and SEM.
- Guide student groups to tabulate the comparison of light and electron microscopes and present it.
- Demonstrate the proper handling of a light microscope and the use of the microscope to observe specimens.
- Provide the opportunity for students to observe and draw onion epidermal cells/ *Roheo* epidermal cells and cells from the lining of the buccal cavity under light microscope.

Assessment and Evaluation

- Assess student's practical work based on the following criteria.
- Proper handling of microscope
- Correct observation and correct identification
- Correct recording
- Accurate labeling in drawings

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Competency Level 2.2.2 : Describes the historical background of the cell and analyzes the structure and functions of the sub cellular units

Number of Periods : 16

Learning Outcomes:

- describes the contribution of scientists towards cell theory
- explains the cell theory
- explains the differences between eukaryotic and prokaryotic cells
- compares the structural differences between plant and animal cells
- briefly describes the structure and function of the plasma membrane
- describes the nature of the cytoplasm
- describes the structures and main functions of organelles and sub cellular components of cells
- describes extra cellular components
- uses electron micrographs to identify cellular organelles and sub cellular components of a cell
- uses electron micrographs to differentiate eukaryotic and prokaryotic cellular organization
- appreciates division of labour and compartmentalization within a cell

Suggested Teaching- Learning Process

- Guide students to collect information from different sources on the historical background of the cell and let them present it.
- Lead a discussion to introduce the cell theory.
- Conduct a discussion on the organization of cells as prokaryotic and eukaryotic using relevant diagrams.
- Provide students with diagrams/ charts/ videos/ presentations of prokaryotic and eukaryotic cells and ask them to compare and tabulate the differences between eukaryotic and prokaryotic cells.
- Provide the opportunity for students to observe the diagrams of plant and animal cells and ask them to compare the differences.
- Explain the structure of the plasma membrane using models/ diagrams/ charts/ video clips.
- Guide students to list down the functions relating the structure of the plasma membrane.
- Explain the nature of cytoplasm.
- Provide microscopic slides/ electron micrograph and diagrams for students to observe and identify the organelles and sub cellular components.

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- Guide students to plot the necessary information of structure and functions of each organelle and subcellular component on cell diagrams.
- Use diagrams/ charts/ video clips to describe the extra cellular components.

Assessment and Evaluation

- Assess the prepared cell diagrams using the following criteria.
  - Correctness of information
  - Correctness of scale
  - Inclusion of a necessary information

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Competency 2.3.0 : Investigates the importance of cell cycle and cell division

Competency Level 2.3.1: Describes the cell cycle and the process of cell division

Number of Periods : 09

Learning Outcomes :

- states what cell cycle is
- states the phases and main events of cell cycle
- describes the basic structure of eukaryotic chromosome
- discusses the main events that occur in each phase of mitosis and meiosis
- describes the stages in mitosis and meiosis with reference to chromosomal behavior
- explains how meiosis contribute for variations among organisms
- describes the significance of synaptonemal complex and kinetochore
- compares and contrasts mitosis and meiosis
- states the significances of mitosis and meiosis
- uses prepared slides to identify different stages of mitosis and meiosis under light microscope
- appreciates that rapid and uncontrolled mitotic cell division results in formation of galls, tumors and cancers

Suggested Teaching- Learning Process

- Use print /electronic presentation to show the phases of cell cycle and conduct a discussion on that.
- Discuss the structure of a chromosome using diagrams.
- Conduct a discussion to explain the phases and main events of a cell cycle.
- Use slides of onion root tip to identify different stages of mitosis.
- Use relevant resources such as video clips and electronic sources to explain behavior of chromosomes and other parts of a cell during mitosis.
- Explain the process of mitosis and its significance.
- Use slides of pollen to identify the different stages of meiosis.
- Use relevant resources and explain the behavior of chromosomes and other parts of the cell during meiosis.
- Explain the significance of the synaptomeal complex and kinetochore.
- Discuss the significance of meiosis.
- Explain the formation of galls, tumours and cancers as a result of rapid and uncontrolled cell division with suitable examples.

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- Let students compare and tabulate the differences between mitosis and meiosis.

Assessment and Evaluation

- Ask the students to identify the different phases of cell division by providing them unlabelled diagrams/ micrographs and assess them using following criteria.
    - Correct identification
    - Correct labeling

- Assess the students' comparison of mitosis and meiosis using the following criteria.
    - Accuracy
    - Adequacy of information
    - Correct identification

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Competency2.4.0 : Investigates energy relationships in metabolic processes of organisms

Competency Level 2.4.1 : Analyses the energy relationship in metabolic processes

Number of Periods : 02

Learning outcomes:

- describes metabolism as sum of anabolic and catabolic reactions
- highlights the need of energy for living systems
- lists the cellular processes involving energy
- relates energy requirements of organisms in relation to body size, activity and environment
- describes catabolic and anabolic reactions with examples
- discusses the structure and the importance of ATP as a universal energy currency unit
- states the role of electron carriers (NAD^+, $NADP^+$ and FAD)
- appreciates the role of ATP in universal energy transaction

Suggested Teaching- Learning Process

- Conduct a brain storming session to highlight need of energy for living systems.
- Ask students to list down the cellular processes involving energy.
- Conduct a discussion to relate energy requirements of organisms in relation to body size, activity and environment.
- Use relevant reactions to highlight anabolic (e.g. $6CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6O_2$in photosynthesis) and catabolic reactions (e.g. $C_6H_{12}O_6 + O_2 \rightarrow 6CO_2 + 6\ H_2O$).
- Make an elaboration to highlight the structure and important characters of ATP.
- Discuss the significance of the role of ATP as an universal energy currency.
- Discuss the role of following electron carriers.
  - NAD^+
  - $NADP^+$
  - FAD

Assessment and Evaluation

- Assess students by oral questioning techniques during the teaching -learning process. Use following criteria.
  - Accuracy
  - Relevance

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Competency Level2.4.2: Investigates the role of enzymes in regulating metabolic reactions

Number of Periods : 10

Learning outcomes:

- constructs appropriate definition for the term 'enzymes'
- explains the general characteristics of enzymes and states their role
- describes a mechanism for enzyme activity using suitable diagrams
- describes the importance of co-factors for enzymatic activities
- explains how pH, temperature, substrate concentration, and inhibitors (competitive and non competitive) affect the rate of enzyme activity
- appreciates the regulation mechanisms found in cells
- organizes and conducts suitable experiment to demonstrate enzyme activity and how temperature affects the rate of enzyme activity using starch amylase reaction
- appreciates the role of enzymes in metabolic reactions

Suggested Teaching- Learning Process

- Guide students to construct an appropriate definition for enzymes.
- Guide students to list down characteristics of enzymes and lead a discussion on that.
- Explain the role of enzymes in the organisms and their general characteristics.
- Use relevant models to explain the mechanism of enzyme reaction (Induced fit mechanism).
- Conduct discussions to identify and make students understand cofactors with examples
  (inorganic ions, co-enzymes).
- Discuss factors affecting enzymatic reactions. pH, temperature, substrate concentration and inhibitors (competitive and non competitive).
- Use video clips/ diagrams to discuss the regulation mechanism of enzymatic activity in cells.
- Conduct laboratory experiments to demonstrate the role of enzyme reactions using starch-amylase system.

Assessment and Evaluation

- Assess student's performance on the laboratory experiments.
  - Handling of equipment
  - Correct recording
  - Making conclusions
  - Time management

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Competency Level 2.4.3: Examines photosynthesis as an energy fixing mechanism

Number of Periods : 11

Learning Outcomes :

- constructs an appropriate definition for photosynthesis
- describes the role of pigments involved in photosynthesis
- briefly describes the action and absorption spectrums of each pigment
- describes the light dependent reaction of photosynthesis
- describes the role of photo-systems in light dependent reaction
- describes the Calvin cycle of photosynthesis
- describes the C_4 pathway of photosynthesis
- discusses the negative impact of photorespiration in C_3plants
- explains that the C_4 pathway has evolved to minimize photorespiration
- differentiates the leaf structures of C_3 and C_4 plants
- provides examples for C_3 and C_4 plants
- briefly discusses the effect of carbon dioxide, light, temperature, as limiting factors of photosynthesis
- discusses the effect of limiting factors in efficiency of photosynthesis
- discusses the global and biological importance of photosynthesis
- accepts the effect of global warming on photosynthesis
- appreciates the universal role of photosynthesis
- designs and carries out experiments to determine the rate of photosynthesis by measuring the amount of oxygen released (for different CO_2 concentration and light intense)
- discusses special adaptations of C_3 and C_4 leaves for photosynthesis

Suggested Teaching- Learning Process

- Recall and guide students to construct an appropriate definition for photosynthesis.
- Recall and discuss importance of photosynthesis.
- Explain the role of pigments in photosynthesis.
- Explain photosystem I , photosystem II and light harvesting complex.
- Discuss action spectrum and absorption spectrum of photosynthetic pigments of higher plants.
- Explain light dependent reaction and Calvin cycle of photosynthesis with the following steps.

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- Light dependent reaction
  - Capturing energy from sunlight
  - Splitting of water molecules by enzymatic catalysis
  - Synthesis of NADPH and ATP
- Calvin Cycle
  - Carboxylation- role of RUBP carboxylase
  - Reduction of PGA and synthesis of carbohydrates
  - Regeneration of RUBP
- Guide student groups to illustrate steps in photosynthesis diagrammatically.
- Discuss structural and functional adaptations of the dicot leaf for efficient photosynthesis.
- Explain the process of photorespiration in C_3 plants.
- Discuss the impact of photorespiration on photosynthesis.
- Explain C4 pathway of photosynthesis and discuss the significance of the C4 pathway.
- Provide photographs of (electronic and printed) or prepared slides of T.S. of C_4 plant leaf and C_3 mesophytic dicot plant leaf and guide students to explain anatomical features of the above plant leaves.
- Introduce Blackman's principle to students and discuss the limiting factors of photosynthesis as
  - Carbon dioxide
  - Light
  - Temperature
- Explain Blackman's principle of limiting factors.
- Guide students to carry out experiments to determine the rate of photosynthesis by the amount of oxygen released using Audus apparatus at different CO_2 concentrations and light intensities.

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Assessment and Evaluation

- Assess student performances on the practical activities using following criteria.
  - Time management
  - Correct set up
  - Proper handling of equipment
  - Co-operation

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Competency Level 2.4.4:Examines cellular respiration as a process of obtaining energy

Number of Periods : 12

Learning outcomes:

- constructs an appropriate definition for cellular respiration
- states cellular respiration as the process of supplying energy for all cellular activities
- describes the location, major events and end products of aerobic respiration
- discusses how proteins and fats are used up in aerobic respiration
- briefly describes the location and end products of ethanol fermentation and lactic acid fermentation
- differentiates aerobic and anaerobic respiration
- states what is respiratory quotient
- lists out the significance of cellular respiration
- relates the substrate with respiratory quotient
- determines the rate of respiration and respiratory quotient using germinating seeds
- appreciates the significance of respiration in providing continuous energy for living organisms

Suggested Teaching- Learning Process

- Construct an appropriate definition for the term cellular respiration with a classroom discussion.
- Explain the process of cellular respiration using relevant sources.
- Conduct a discussion to explain the importance of cellular respiration.
- Explain the main steps of aerobic respiration.
- Instruct the students to make a flow chart relevant to major steps of aerobic respiration.
- Discuss the location, major steps and end products of anaerobic respiration
  - Ethanol fermentation
  - Lactic acid fermentation
- Instruct the students to make a flow chart relevant to anaerobic respiration.
- Ask students to differentiate anaerobic and aerobic respirations.
- Explain different types of respiratory substrates.
- Assign students to calculate the respiratory quotient.
- Guide students to determine experimentally the rate of respiration and respiratory quotient using germinating seeds.
- Discuss the respiratory quotient of different respiratory substrates.

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Assessment and Evaluation

- Assess student performances on the practical activity using following criteria.
- Correct set up
- Proper handling of equipments
- Time management
- Asses students when calculating the respiratory quotient.

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Competency 3.1.0 : **Explores evolution of life**

Competency Level 3.1.0 : **Uses the theories on origin of life and natural selection to analyze the process of evolution of life**

Number of Periods : **07**

Learning Outcomes:

- describes the nature on the earth before life
- states the main incidences of evolution of biological diversity since the biochemical evolution
- names geological eons and eras of evolution
- briefly describes the theory of Lamark
- briefly describes Darwin – Wallace theory of natural selection
- briefly states the theory of Neo-Darwinism
- accepts the importance of evolution for sustaining life in accordance with the changing environment

Suggested Teaching-Learning Process

- Describe the conditions of the earth before life , using pictures/ charts/ power point presentations.
- State the major geological eons as Haedan, Archaen, Proterozoic and Phanerozoic.
- Mention eras of Phanerozoic as Paleozoic, Mesozoic and Cenozoic.
- Explain the biochemical evolution.
- Relate the evolution of biodiversity with eons and eras considering origin of protocell, origin of photosynthetic organisms, origin of eukaryotes and diversification of eukaryotes.
- Conduct a discussion on the following with the aid of suitable charts / pictures/ power point presentations.
  1. Lamarck theory
  2. Theory of natural selection/ Darwin Wallace theory
  3. Theory of Neo- Darwinism

Assessment and Evaluation

- Assess students during class discussions using the following criteria.
  - Active participation
  - Knowledge
  - Accuracy of information

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Competency 3.2.0 : Explore the diversity of organisms.

Competency Level 3.2.1 : Constructs hierarchy of taxa on scientific basis

Number of Periods : 11

Learning Outcomes:

- distinguishes between natural and artificial classification methodologies
- states advantages of classification of organisms
- briefly describes historical methods of classification
- identifies taxonomic levels used in classification of organisms
- states biological definition of species
- classifies a given set of organisms using a dichotomous key
- names organisms according to the binomial nomenclature
- classifies organisms into three domains based on their specific characteristics
- names four kingdoms of domain eukarya

Suggested Teaching-Learning Process

- Conduct a brain storming session on diversity of organisms taking students to a field or providing facilities using modern technology (print or electronic).
- Let students prepare a set of criteria to classify organisms based on their observations.
- Lead a discussion on the attempts made to classify organisms in the past and the present status of taxonomic levels and classification of organisms.
- Recall the binomial nomenclature and rules and ask them to name the organisms according to binomial nomenclature.
- State the hierarchy of taxa from domain to species.
- Construct a biological definition for a species.
- Guide students to construct a dichotomous key using a given list of organisms.
- State the specific characteristics of the three domains.
- Provide students with diagrams/ electronic materials/ pictures of organisms belonging to kingdoms of domain Eukarya and let students list down their characteristic features. Conduct a discussion to highlight the above characteristic features.

Assessment and Evaluation

- Asses the student performance on the preparation of a dichotomous key using following criteria.
  - Identification of relevant characters
  - Time management
  - Correct identification of organisms

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Competency Level 3.2.2 : Explores the diversity of organisms within the domain bacteria

Number of Periods : 05

Learning Outcomes:

- lists out the major characteristic features of bacteria and cyanobacteria
- distinguishes bacteria and cyanobacteria under light microscope as well as electron micrographs
- appreciates the diversity of bacteria and cyanobacteria in the ecosystems

Suggested Teaching-Learning Process

- Use pictures/ diagrams/ videos/ prepared slides to describe the major characteristics of bacteria and cyanobacteria.
- Conduct a discussion using diagrams, charts which show morphological features of bacteria and cyanobacteria and ask them to distinguish them.
  Let students present the above.

Assessment and Evaluation

- Assign groups to present on bacteria and cyano bacteria and assess students using following criteria
  - Creativity
  - Accuracy of information
  - Use of visual aids
  - Presentation skills

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Competency Level 3.2.3 : Explores the diversity of organisms within the kingdom Protista

Number of Periods : 06

Learning Outcomes:

- states key characteristics of kingdom Protista with the given examples
- describes habitat, cell form, locomotory structures, nutrition type, unique features of *Euglena, Paramecium* and *Amoeba*
- describes habitat, cell form, cell wall material, pigments, stored food and external appearance of *Ulva, Gelidium, Sargassum* and diatoms
- appreciates the diversity of Protista in the ecosystems

Suggested Teaching-Learning Process

- Lead a brain storming discussion using living specimens (as far as possible) pictures and digital materials of Protists on their diversity.
- Provide students with diagrams of *Euglena*, *Paramecium*, *Amoeba*, *Ulva*, *Gelidium*, *Sargassum* and Diatoms and ask them to state key characteristics of kingdom Protista.

Assessment and Evaluation

- Assess students during class discussion using the following criteria.
  - Active participation
  - Correct information

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Competency Level 3.2.4 : Explores the diversity of organisms within the kingdom Plantae

Number of Periods : 08

Learning Outcomes:

- represents the evolutionary relationships among major groups of plants using an appropriate diagram
- describes morphological features of typical organisms of Phylum Bryophyta, Phylum Lycophyta, Phylum Pterophyta, Phylum Cycadophyta, Phylum Gnetophyta , Phylum Coniferophyta and Phylum Anthophyta by observation
- classifies flowering plants as Monocots and Dicots based on their morphological features
- appreciates the importance of members of kingdom Plantae in ecosystems

Suggested Teaching-Learning Process

- Assign students to collect plant specimens and pictures representing different environments.
- Provide opportunities for the students to make observations on what they have collected.
- Guide students to identify and list out the characteristic features of the plant phyla with the guidelines provided
  - Non vascular- Hepatophyta, Bryophyta, Anthocerophyta
  - Vascular seedless- Lycophyta, Pterophyta
  - Vascular seeded- Cycadophyta, Gnetophyta, Coniferophyta, Anthophyta
- Provide opportunities for the students to relate the characteristic features of the phyla to overcome the problems in the land habitat.
- Ask students to prepare a booklet on characteristic features of non vascular, vascular seedless plants and vascular seeded plants.

Assessment and Evaluation

- Assess student booklet using the following criteria.
  - Adaquacy of information
  - Completeness of information
  - Format for booklet
  - Readability

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Competency Level 3.2.5 : Explores the diversity of organism within the kingdom Fungi

Number of Periods : 06

Learning Outcomes:

- elaborates the characteristic features of kingdom Fungi
- classifies organisms in kingdom Fungi into phyla
- identifies key characteristic features of typical organisms of the given phyla of kingdom Fungi
- recognizes the diversity of fungi in eco-systems

Suggested Teaching-Learning Process

- Conduct a discussion to highlight the characteristic features of the kingdom Fungi on the basis of vegetative and reproductive structures of fungi using pictures, charts and collected specimens.
- Discuss the characteristic features of given phyla.
  - Phylum Chytridiomycota- *Allomyces*
  - Zygomycota- *Mucor*
  - Ascomycota- *Aspergillus*
  - Basidiomcota- *Agaricus*

Assessment and Evaluation

- Conduct a written test on the kingdom Fungi.

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Competency Level 3.2.6 : Explores the diversity of organisms within the kingdom Animalia

Number of Periods : 09

Learning Outcomes:

- elaborates the general characteristic features of kingdom Animalia
- explains the evolutionary relationships among major phyla
- classifies organisms in kingdom Animalia into phyla
- tabulates the characteristic features of the given phyla of kingdom Animalia
- identifies organisms belonging to major phyla of invertebrates based on their characteristics
- appreciates the diversity of invertebrates
- recognizes the contribution of different invertebrate phyla to total number of identified species
- recognizes the diversity of kingdom Animalia in the ecosystem

Suggested Teaching-Learning Process

- Demonstrate the characteristic features of the kingdom Animalia using diagrams/ charts/ power point presentations.
- Using the phylogenetic tree briefly explain the evolutionary relationships among major phyla.
- Ask students to group animals into different phyla by providing lists of characteristics and specimens/ pictures of typical animals of each phylum.
  - Cnidaria- *Hydra*
  - Platyhelminthes- *Planaria*
  - Nematoda- *Ascaris*
  - Annelida- earth worm
  - Arthropola - cockroach
  - Mollusca- garden snail
  - Echinodermata- star fish

Assessment and Evaluation

- Assess students when engaged in group activities to identify characteristics of different invertebrate phyla and typical animals using the following criteria.
  - Active participation
  - Responding with the correct observation
  - Accuracy of grouping animals

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Competency Level 3.2.7 : Uses the characteristic features to study organisms belonging to phylum Chordata

Number of periods : 08

Learning Outcomes:

- states the major characteristic features of phylum chordata
- identifies organisms belonging to major classes of phylum Chordata based on their specific characteristics
- tabulates the characteristic features of typical organisms of the given classes of phylum Chordata
- appreciates the diversity of major classes of phylum Chordata

Suggested Teaching-Learning Process

- Engage students to survey and report the diversity of chordates using literature or proper observation.
- Assign students to observe the general characteristics of classes of phylum Chordata using diagrams of following organisms
  - Chondrichthyes- shark
  - Osteichtheyes- yellow finned tuna
  - Amphibia- frog
  - Reptilia- lizard
  - Aves- crow
  - Mammalia- rat
- Ask student groups to present and lead a discussion to highlight key characteristics achieved by organisms in the process of evolution using pictures/charts.

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Assessment and Evaluation

- Assess the student presentations using the following criteria.
  - Presentation skills
  - Accuracy of information
  - Time management

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Competency 4.1.0 : Explores structure, growth and development of plants

Competency Level 4.1.1 : Examines different types of tissues and relates the structure of plant tissues to their functions

Number of Periods : 08

Learning Outcomes:

- lists down the characteristic features of meristematic cells
- names three types of meristems according to their location
- explains the role of each type of meristem
- identifies the regions in developing apical meristem (root and shoot tips); zone of cell division, the zone of elongation and the zone of differentiation by using a diagram
- names three types of basic tissues which arise from apical meristem; the protoderm, ground meristem and the procambium
- lists and compare the structural differences of the root and the shoot tip
- states the three types of tissue systems which arise from apical meristem and root tip (dermal, ground and vascular)
- names the structures of the three major tissue systems
- states the gross structure and the functions of epidermis and guard cells
- briefly describes the structures of simple ground tissues of plants; parenchyma, sclerenchyma and collenchyma
- states the functions of parenchyma, sclerenchyma and collenchyma tissues
- briefly describes the structure and functions of xylem tissue
- briefly describes the structure and functions of the phloem tissue
- identifies the special features of the cell types found in dermal, ground and vascular tissue systems by using a microscope
- accepts that the plant tissues and their differentiations are evolved to perform their respective functions efficiently

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Suggested Teaching-Learning Process

- Using microscopic slides and drawings introduce meristems and list the characteristic freatures of meristematic cells.
- Explain the three different types of meristems such as apical meristems, lateral meristems and Intercalary meristems based on their location and functions.
- Use diagrams to describe how differentiation of tissues takes place at shoot apex and root apex.
- Compare the shoot apex and the root apex.

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- Using microscopic slides and drawings, describe the three different types of tissue systems such as dermal tissues, ground tissues and vascular tissues in plants elaborating special features of cell types, location, and functions of each tissue system.
- Explain the structural and functional relationship of tissue systems.
- Guide students to identify special characters of cell types of each tissue using the light microscope.

Assessment and Evaluation

- Assess the student's identification of special characteristics of cell types of each tissue using following criteria.
    - Accuracy of identification
    - Stating correct characters
    - Correct recording

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Competency Level 4.1.2 : **Examines the changes taking place in the growth and development process of a plant**

Number of Periods : 10

Learning Outcomes:

- states basic differences between primary and secondary growth of plants
- briefly describes the histological structures of primary dicotyledonous root and monocotyledonous root
- briefly describes the differences between histological structure of primary dicotyledonous stem and monocotyledonous stem
- briefly describes the process of secondary growth of dicotyledonous stem using appropriate line diagrams
- states how the secondary growth of a dicotyledonous root differ from the secondary growth of a dicotyledonous stem
- briefly explains wood and growth rings formation as a result of secondary growth
- names the tissues included in bark and wood
- lists out the differences between sap wood and heart wood
- mentions the differences between soft wood and hard wood
- identifies the primary stems and primary roots of monocots and dicots using microscopic and macroscopic transverse sections dicotyledonous wood (Practical work)
- appreciates the importance of secondary growth for the existence of perennial plants

Suggested Teaching-Learning Process

- Use specimens/ microscopic slides/ diagrams to illustrate the histological structure of primary stems and roots of monocotyledonous and dicotyledonous plants.
- Assign students to draw labelled line diagrams of the
  - primary structure of monocot and dicot stems and roots
  - secondary structure of dicot stem and root
- Introduce the secondary growth of plants and distinguish between primary and secondary growth.
- Describe the major events that take place during the secondary growth in dicotyledonous stems and roots using appropriate line diagrams.
- Guide students to identify the distribution of tissues in secondary stems and roots of dicotyledonous plants using transverse sections.
- Introduce and differentiate the following terms inrelation to the secondary xylem tissue using cross sections and longitudinal sections of plants/ diagrams or photographs.
  - heart wood
  - sap wood
  - hard wood
  - soft wood

Assessment and Evaluation

- Assess students' diagrams of roots and stems based on following criteria
  - Neatness of the diagram
  - Correct labelling
  - Correct proportion of the parts

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Competency 4.2.0 : Examines resource acquisition and transport in vascular plants.

Competency Level4.2.1 : Investigates the shoot architecture and light capture

Number of Periods : 01

Learning Outcomes :

- states various adaptations seen in plants to maximize capturing of light
- carries out experiments to observe cross section of mesophytic dicot leaf with special reference to adaptations for photosynthesis

Suggested Teaching-Learning Process

- Illustrate anatomical features of the dicot leaf using diagrams.
- Explain the adaptations found in dicot leaves to maximize capturing of light.
- Let students observe cross section of a mesophytic dicot leaf and let them identify the adaptations for photosynthesis.
- Explain how the length of stem, their branching pattern, leaf size and its structure and arrangement of leaves on the stem help capture maximum amount of sunlight to increase the efficiency of photosynthesis.
- Guide students to prepare a poster to demonstrate light capturing techniques in plants.

Assessment and Evaluation

- Assess posters using the following criteria
  - Attractiveness
  - Number of examples
  - Diversified techniques of light capturing

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Competency Level4.2.2 : Investigates the process of gaseous exchange in plants

Number of Periods : 04

Learning Outcomes :

- briefly describes the histological structure of typical dicot leaf
- states the major structural differences between a typical monocot leaf and a typical dicot leaf
- names the main gaseous exchange structures as stomata and lenti cells
- identifies the features of leaf for efficient gaseous exchange
- relates the structure of stomata to its function
- briefly explains mechanism of opening and closing of stomata using K^+ influx
- briefly explains the factors affecting the opening and closing of stomata (light, CO_2 concentration in sub-stomatal cavity, drought, high temperature, wind, production of ABA)
- identifies the structure of stomata and lenticels through microscope (Practical work)

Suggested Teaching-Learning Process

- Describe the major structural features of monocot and dicot leaves using diagrams/ microscopic specimens and micrographs.
- State leaves of plants as the main surface for gaseous exchange.
- Discuss how gases can exchange through stomata, lenticels and the cuticle.
- Guide students to observe epidermal peels of mesophytic dicot and grass leaves under the microscope.
- Guide students to prepare a slide with dicot epidermal peel and draw a fully labeled diagram of stomata by observing it under the high power of a light microscope
- Guide students to observe stomata under high power and to compare the surface view of a dicot and grass leaf.
- Discuss the shapes, patterns of thickening of cell walls and the presence of chloroplasts in the guard cells in relation to their function.
- Explain the mechanism of the opening and closing of stomata using K^+influx hypothesis.
- Discuss how different factors relate to the functioning of stomata
- Explain the role of ABA in stomatal closure under water stress conditions

Assessment and Evaluation

- Assess student's drawings for
  - Accuracy
  - Correct proportion
  - Correct labeling
  - Neatness

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Competency Level 4.2.3 : Investigates the concepts of acquisition of water and minerals

Number of Periods : 10

Learning Outcomes:

- states the need of water and mineral transportation in plants
- names diffusion, osmosis and imbibition as the three basic methods of water mineral transportation
- briefly explains the concept of water potential
- presents the water potential equation by explaining the concepts of solute potential and pressure potential
- explains how the water potential components of a vacuolated cell differ when placed in hypertonic, hypotonic and isotonic solutions
- explains the difference between the water absorption and mineral absorption from the soil solution into the root hair
- briefly explains the radial transportation process which takes place by the three pathways; apoplast, symplast and transmembrane route
- presents the cohesive, adhesive and tension theory to explain the upward movement of water plants
- discusses the principles of the experiment which determines the water potential
- conducts experiments to determine the water potential of potato tubers and a petioles of *Alocasia* (Practical work)
- conducts experiment to determine the water potential of *Tradescantia* (*Rhoeo*) epidermal peels

Suggested Teaching-Learning Process

- Discuss the need for transport of materials in the plant body.
- Explain apoplast, symplast, transmembrane routes as the pathways of movement of water and mineral nutrients through and between the cells of the plant body.
- Explain the concepts and principles such as water potential, solute potential pressure potential of solutions as underlying transport of water and minerals in plants using diagrams/ models/ videos etc.
- Explain the process of upward movement of water and minerals in plants using – cohesion- adhesion -tension theory.
- Recall the root anatomy of plants.
- Use suitable diagrams to explain absorption and transport of water and minerals in relation to the root anatomy.
- Explain absorption and radial transport of water and minerals in a plant root using suitable diagrams/ videos etc.
- Conduct simple experiments to determine the solute potential of cells using *Rhoeo,* potato tubers and petioles of *Alocasia.*
- Discuss the contribution of roots in the mineral acquisition of plants.

Assessment and Evaluation

- Assess the students giving problems on water potential.
- Assess the diagrams drawn by students to show the pathways of radial transport of water.

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Competency Level 4.2.4 : Investigates the process involved in the transport of materials in phloem

Number of Periods : 05

Learning Outcomes :

- states the materials transported through phloem
- describes the mechanism of phloem translocation
- relates the structure of the phloem tissue to its function
- appreciates the process of phloem translocation

Suggested Teaching-Learning Process

- Recall previous knowledge of the phloem tissue.
- Ask students to list the substances transported through the phloem.
- Relate the structure of the phloem tissue to its function.
- Explain important features of phloem translocation.
- Use suitable diagrams/ video clips to explain the pressure -flow hypothesis of pholem transport with the following points.
  - Source to sink (with examples)
  - Phloem loading
  - Phloem unloading
  - Mass flow

Assessment and Evaluation

- Assess students by an oral test using following criteria.
  - Accuracy
  - Adequacy of knowledge

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Competency Level 4.2.5 : Investigates the processes of water loss in plants

Number of Periods : 04

Learning Outcomes:

- names the routes of transpiration
- lists the factors affecting rate of transpiration and briefly describe how those factors effect transpiration
- describes guttation
- states how root pressure develops in plants and affects guttation
- compares the basic features of transpiration and guttation
- designs and conducts experiments to determine the rates of transpiration from leaves and shoots under different environmental conditions
- appreciates the significance of transpiration to plants

Suggested Teaching-Learning Process

- Name the main methods of loss of water from the plants.
- Define the term transpiration.
- Guide students to determine the rate of transpiration using the potometer.
- Assist student groups to compare the rate of transpiration under different environmental conditions.
- Discuss the route of transpiration.
- Explain that the rate of transpiration is regulated to a large extent by stomata.
- Discuss how external factors and internal factors affect the rate of transpiration.
- Define guttation and explain how root pressure is involved in guttation.

Assessment and Evaluation

- Assess student performance in experimentation using the following criteria.
  - Making hypothesis
  - Designing of experiments
  - Handling of equipment
  - Data collection
  - Making conclusions

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Competency level 4.3.0: Explores the diversity of nutritional processes in plants

Competency Level4.3.1: Investigates the modes of nutrition of plants

Number of Periods : 05

Learning Outcomes:

- explains the importance of nutrition for organisms
- lists down the modes of nutrition of plants
- briefly describes the modes of nutrition, photoautotrophic, mutualism, parasitism, and commensalism with suitable examples of plant
- briefly describes the carnivorous nutrition with examples

Suggested Teaching-Learning Process

- Discuss the importance of nutrition for plant life.
- Discuss the autotrophic nutrition and photoautotrophic nutrition.
- Describe the other modes of nutrition in plants with suitable examples.
- Ask students to prepare presentations based on modes of nutrition in plants.

Assessment and Evaluation

- Assess presentations using the following criteria.
  - Accuracy of information
  - Presentation skills
  - Time management
  - Creativity

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Competency Level4.3.2: Investigates nutritional requirement for the optimal growth of plants

Number of Periods : 04

Learning outcome:

- defines the terms of essential elements, micro elements and macro elements
- names the macro and micro elements related to plants
- states the modes of taking into plant bodies, sources, functions and their deficiency symptoms
- appreciates the importance of elements related to plant life

Suggested Teaching-Learning Process

- Guide students to define the following terms with examples.
  - essential elements
  - macronutrients
  - micronutrients
- Instruct the students to gather information from a variety of sources regarding mineral nutrients of plants and functions of each.
- Show some photographs/specimens of affected plant leaf and conduct a discussion with the students regarding major nutritional deficiency symptoms of macro and micronutrients.
- Instruct the students groups to prepare a table containing plant nutrients and their sources, forms of absorption, functions and deficiency symptoms.

Assessment and Evaluation

- Assess the students table using the following criteria.
  - Accuracy of information
  - Adequacy of information
  - Cooperation in group activity
  - Time management

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Competency 4. 4.0 : Inquires into the reproductive process in plants

Competency Level4.4.1: Uses the trends in life cycles, to relate the adaptations of plants for a terrestrial life

Number of Periods : 10

Learning Outcomes :

- states the special features of sexual reproduction of terrestrial plants
- explains the terms haploid generation, diploid generation, sphorophyte and gametophyte
- briefly explains alternation of generation
- states the basic features of life cycles of *Pogonatum, Nephrolepis, Selaginella, Cycas, and* Anthophyta
- accepts that in the evolution of land plants, gametophytic generation gradually reduced and the sporophytic generation became dominant as an adaptation to land habit

Suggested Teaching-Learning Process

- Introduce haploid and diploid generations in a life cycle.
- Introduce the gametophyte and sporophyte in relation to plant life cycle.
- Introduce the alternation of generations in relation to plant life cycle.
- Briefly explain the basic features of the common life cycle of terrestrial plants.
- Briefly describe the basic features of the following life cycles using diagrams and appropriate teaching aids.
  1. Life cycle of *Pogonatum* and the terrestrial adaptations.
  2. Life cycle of *Nephrolepis* and the terrestrial adaptations.
  3. Life cycle of *Selaginella* and the terrestrial adaptations.
  4. Life cycle of *Cycas* and the terrestrial adaptations.
  5. Life cycle of Angiosperms and terrestrial adaptations.
- Explain how the gametophyte generation has gradually reduced and the Sporophyte generation became dominant as an adaptation in the evolution of land plants.
- Let student groups prepare a presentation on plant life cycles and let them present it.

Assessment and Evaluation:

- Use the following criteria to assess student group presentations.
  - Attractiveness
  - Clarity
  - Accuracy of information
  - Adequacy of information

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Competency Level4.4.2 : Examines structures and functions associated with sexual reproduction in flowering plants

Number of Periods : 07

Learning Outcomes:

- briefly explains the structure and functions of the important parts of the flower as the reproductive organ of anthophyta (parts of androceium and gynoecium)
- defines pollination, self-pollination, and cross pollination
- writes down the importances/ advantages of cross pollination
- briefly explains the fertilization process
- states the important features of embryo, seed, and fruit development
- states the differences between parthenogenesis and parthenocarpy with examples
- state what is seed dormancy
- states the importance of seed dormancy
- states the main physiological differences taking place at the beginning of seed germination
- appreciates the diversification of plants for the existence of the all forms life on land

Suggested Teaching-Learning Process

- Assign each student to bring different types of flowers including *Hibiscus rosasinensis.*
- Conduct an open discussion on the flower *Hibiscus rosasinensis* as the typical flower.
- Let them study the parts of a flower using the flower of *Hibiscus rosasinensis.*
- Describe how pollen is produced and released by stamens.
- Use suitable diagrams/ video clips/ charts to describe the structure of typical ovary, structure of an ovule and the development of the female gametophyte.
- Define pollination, self pollination and cross pollination.
- State the mechanisms that prevent self-pollination.
- Discuss the significance of cross pollination.
- Guide students to identify adaptations for cross-pollination.
- Explain how pollen germinates on stigma, and how fertilization, seed development, fruit development take place, using pictures/diagrams/ video clip etc.
- Ask students to collect samples of seeds and fruits and help them to identify parts of them.
- Discuss differences between parthenocarpy and parthenogenesis with examples.
- Explain physiological changes of seed germination.
- Explain seed dormancy, significance of dormancy and common causes of seed dormancy.

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Assessment and Evaluation

- Assess student group work based on identification of ;
    - parts of a flower
    - parts of a fruit
- Use the following criteria to assess student performance on identification of parts
    - Accuracy
    - Team work
    - Time management

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Competency Level 4.5.0: Explores plant responses to internal and external signals.

Competency Level4.5.1: Investigates responses of plants to different stimuli

Number of Periods : 06

Learning Outcomes :

- defines photo-morphogenesis of plants as a response to light
- states the two main types of photoreceptors as blue photoreceptors and phytochrome
- states the effect of light on seed germination, detection of plant spacing, flowering, shoot elongation and directional growth (phototrophic movements)
- briefly explains how plants respond to positive and negative geotrophism using statolith hypothesis
- writes down the differences between thigmotrophism, thigmonastic movements as the response to mechanical responses
- compares the responses of plants to various stimuli with suitable examples
- appreciates the importance of plant movements for their survival

Suggested Teaching-Learning Process

- Conduct a discussion regarding plant responses to different stimuli.
- Explain photomorphogenesis.
- Conduct a brain storming session to recall action spectrum of light.
- Explain the influence of light for plant life other than photosynthesis including
  - Light in seed germination
  - Detection of plant spacing
  - Flowering
  - Shoot elongation
  - Directional growth (phototropism)
- Use statolith hypothesis using video clips/ charts/ diagrams to explain plant responses to gravity.
- Explain plant response to mechanical stimuli including thigmotrophism and thigmonastic responses.
- Describe the reversible and irreversible responses in plants with examples.
- Ask students to make charts illustrating responses of plants to different stimuli.

Assessment and Evaluation

- Assess students' illustrations using following criteria.
  - Accuracy of information
  - Using proper diagrams/ photographs
  - Attractiveness

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Competency Level 4.5.2: **Investigates the role of plant growth substances/regulators/hormones in response to different stimuli**

Time perids: 03

Learning Outcomes :

- states the general features of plant growth substances
- names the five major growth substances
- states the role of auxins, cytokinin, gibberellins, abscisic acid and ethylene
- states the applications of the above growth substances in agriculture

Suggested Teaching-Learning Process

- Explain the general characteristics of plant growth substances/ regulators.
- Discuss the functions of following plant growth substances.
  - Auxins
  - Cytokinin
  - Gibberellin
  - Abscisic acid
  - Ethylene
  - Jasmonic acid
- Give examples to the agricultural uses of plant growth substances.
- Let students prepare a report on plant growth substances, their natural role and uses in modern agriculture.

Assessment and Evaluation

- Assess reports using the following criteria.
  - Adequacy of information
  - Accuracy of information
  - Number of references given
  - Format of the report

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Competency Level4.5.3 :Investigates response of plants to some biotic and abiotic stresses

Number of Periods : 03

Learning Outcomes :

- states the instances for biotic stresses faced by plants
- states the instances for abiotic stresses faced by plants
- states the mechanisms against selected abiotic stresses
- states the secondary metabolites found in plants responsible for plant defense
- appreciates the fact that secondary metabolites have a medicinal and economical value

Suggested Teaching-Learning Process

- Introduce biotic stress and abiotic stress faced by plants with relevant examples.
- Explain the selected résistance mechanisms against abiotic(drought, cold, flood and salinity) stress using diagrams/ charts/ videos etc.
- Explain the selected resistance mechanisms against biotic stress(pests, pathogens and herbivore attack) using diagrams/ charts/ videos etc.
- Introduce the major groups of secondary metabolites such as cyanogenic glucoside, terpenoid , alkaloid and phenolics and their role in defences.

Assessment and Evaluation

- Assess the students by an oral test using relevant criteria.

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Competency 5.1.0 : **Explores structure and growth of animals**

Competency Level 5.1.1 : **Relates the structure of animal tissues to their functions**

Number of Periods : **10**

Learning Outcomes:

- states the four major types of tissues as epithelial tissues, connective tissues, muscle tissues and nervous tissues
- lists the structural features of epithelial tissues
- states the structure and basic functions of each tissue types and differentiates them according to the number of cell layers and the shape of the cell
- lists the major features of connective tissues
- classifies the connective tissues as loose, dense, adipose, blood, cartilage and bone
- briefly explains the structure of each connective tissue and states the locations of each
- writes down the major structural and functional features of muscle tissues
- classifies the muscle tissues as smooth, skeletal and cardiac muscles.
- compares the major structural and physiological features which contribute to form major muscle types.
- states the locations of each muscle tissue within the human body.
- states the basic features of the nervous tissue.
- names the neurons and neuroglia as different cells from each other in nervous tissue.
- states the major difference of the cells; neurons and neuroglia.
- briefly explains the gross structure of the motor neurone by using a diagram.
- writes down the major functions of the neuroglea.

Suggested Teaching-Learning Process

- Name the major types of animal tissues as epithelial, connective , muscle and nervous.
- Discuss the structural features , functions and locations of simple epithelial tissue (squamous, cuboidal, columnar and pseudostratified and stratified using diagrams/ videos/ charts/ micrographs/ prepared slides.)
- Discuss the basic structural features, functions and locations of areolar, fibrous and adipose connective tissues, blood, cartilage and bone using diagrams/ videos/ charts/ micrographs/ prepared slides.
- Discuss the basic structural features , functions and locations of skeletal, cardiac and smooth muscle using diagrams/ videos/ charts/ micrographs/ prepared slides.

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- Discuss the basic structural features, functions and locations of neurons and neuroglia.
- Guide students to identify the animal tissues under light microscope/ diagrams.

Assessment and Evaluation

- Assess student performances by giving a spot test to identify tissues using their characteristics when microscopic diagrams are given.

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Competency 5.2.0 : Explores nutrition in animals.

Competency Level 5.2.1 : Explores heterotrophic nutrition in animals

Number of Periods : 05

Learning Outcome

- briefly describes heterotrophic nutrition
- states the stages in holozoic nutrition
- states the feeding mechanisms of animals using suitable examples
- describes symbiosis with examples
- appreciates the diversity in heterotrophic nutrition found in animals

Suggested Teaching-Learning Process

- Explain heterotrophic nutrition.
- Use suitable examples to explain main stages in holozoic nutrition ingestion, digestion, absorption, assimilation and elimination.
- Name and explain feeding mechanisms of animals with relevant examples (filter feeders- whale, substrate feeders- leaf miner caterpillar, fluid feeders- mosquito and bulk feeders-man).
- Discuss symbiosis and explain the forms of symbiosis with examples.
  - Mutualism (human and intestinal bacteria producing vitamin K)
  - Parasitism (man and *Plasmodium*)
  - Commensalism (cow and crane)
- Ask students to prepare a report on different feeding relationships of animals.

Assessment and Evaluation

- Use the following criteria to assess reports.
  - Accuracy of information
  - Sufficiency of information
  - Relevance of information
  - Sources of information
  - Format of the report

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Competency Level 5.2.2 : Relates the structure of the hum and digestive system to its functions

Number of Periods : 15

Learning Outcomes:

- Identifies the major organs of the human digestive system
- relates structure of each organ in the digestive system to its function
- describes the contribution of associated glands in the process of digestion
- explains the process of digestion
- describes the absorption
- lists the processing in large intestine
- briefly describes the causes of disorders related to the alimentary canal and states necessary precautions to avoid them
- briefly describes the regulation of digestion in human
- states the balanced diet
- lists outs the components of food and their function
- states the significance of essential amino acids and fatty acids
- tabulates sources and deficiency symptoms of vitamins and minerals
- briefly discusses major causes and symptoms of malnutrition and obesity giving suitable examples
- briefly describes basal metabolic rate and its variation with size
- briefly describes energy budget of animals with suitable examples
- states the reasons for food related disorders and states how to avoid them by practicing proper food habits
- avoids food related disorders by practicing proper food habits
- appreciates the role of dietary fibres and antioxidants for healthy life in avoiding disorders in the alimentary canal

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Suggested Teaching-Learning Process

- Let the students draw and label a diagram of the human digestive system.
- Relate and tabulate the structures of the human alimentary canal with specific functions (mouth, pharynx, oesophagus, stomach, small intestine, large intestine, rectum).
- Discuss location and functions of salivary glands.
- State the components and functions of saliva (structure of the salivary gland is not expected).
- Discuss the gross morphological structure, location, functions of liver and the histological structure of the liver lobule.

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- Describe the gross morphological structure, location and functions and histological structure of the pancreas.
- Let students list food items, along with their components and conduct a discussion to explain the balanced diet, components of food and their functions.
- Guide students to create a poster on the importance of balanced diet and let them exhibit it.
- Guide students to explore the importance of essential amino acids, essential fatty acids and antioxidants in food.
- Discuss the basal metabolic rate and energy budget.
- Explain the causes and means to avoid obesity, malnutrition, food allergies, gastritis and constipation.

Assessment and Evaluation

- Assess students' poster using following criteria
  - Accuracy of information
  - Relevance
  - Attractiveness

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Competency 5.3.0 : investigates circulation and gas exchange of animals.

Competency Level5.3.1 : Investigates the organization of circulatory systems in animals

Number of Periods : 03

Learning Outcomes:

- states the need of a circulatory system for animals
- lists the substances that are transported in the animal body
- names the major components of a blood circulatory system; heart as the pumping organ, blood vessels and blood as the circulatory fluid
- names the types of various circulatory systems in the animal kingdom
- compares the basic features of the open and closed circulatory systems
- names the animal phyla related to the open and closed circulatory systems
- compares the basic features of single and double circulation to describe the organization of vertebrate circulatory systems
- states the importance of double circulation
- appreciates the importance of circulatory systems for the functioning of complex multicellular organisms

Suggested Teaching-Learning Process

- Conduct a discussion on the need for transport in the body.
- List down the substances the are transported in the body.
- Let students tabulate the comparison of open and closed circulatory systems with examples and diagrams.
- Let students to tabulate the comparison of single circulation and double circulation with examples and diagrams.

Assessment and Evaluation

- Assess students' comparison based on the following criteria.
  - Accuracy of information
  - Descriptive diagram
  - Correct examples

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Competency Level5.3.2 : Relates the structure of the human circulatory y system to its functions

Number of Periods : 11

Learning Outcomes:

- briefly explains the basic plan of the human blood circulatory system by using a flow chart
- presents a sketch to express basic organization of human lymphatic system
- names the major parts of the lymphatic system
- describes the structure and functions of the human heart by using a suitable diagram
- describes the three major steps of the human cardiac cycle; ventricular systole, auricular systole and complete cardiac diastole
- states what is stroke volume
- briefly explains what is E.C.G.
- identifies the peaks of an E.C.G. of a healthy person and name them.
- states that the functions of the heart can be discovered by the aid of an E.C.G.
- briefly describes the blood pressure, diastolic pressure and systolic pressure.
- states what are hypotension and hyper tension and name the factors which effects on hypertension and hypotension.
- states the harmful effects of hypertension and hypotension regarding the human body.
- briefly describes the coronary circulation related to the human heart.
- briefly describes the effects of coronary arterial blockages and thickening leading to heart attacks and strokes
- states the major functions of the lymphatic system
- identifies the organization of human circulatory system by using relevant specimens, diagrams and models

Suggested Teaching-Learning Process

- Let students use diagrams (print or electronic media) of the circulatory systems of some common vertebrates and mammals and guide them to construct basic plans for the circulatory systems.
- Guide students to compare the above basic plan with the basic plan of the human circulatory system.

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- Describe the basic plan of the human circulatory system and lymphatic system.
- Relate the ,structure of the heart with the functions using relevant materials such as diagrams/ electronic media etc.
- Explain cardicac cycle and stroke volume.
- Explain the peaks of the cardiac cycle in an electrocardiogram.
- Explain systolic and diastolic pressure.
- Discuss hypertension and hypotension as conditions leading to cardiovascular disorders.
- Explain coronary circulation and consequences of blockage of coronary arteries.
- Let students do a one minute talk on the following topics.
    - Cardiovascular diseases
    - Structure of heart
    - Basic plan of circulatory system of a mammal
    - Blood pressure

Assessment and Evaluation

- Assess student speeches using the following criteria.
    - Accuracy of information
    - Speech plan
    - Talking to the audience
    - Using expressions
    - Time management

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Competency Level5.3.3 : Inquires in to the role of blood.

Number of Periods : 08

Learning Outcomes:

- names the respiratory pigments and states their roles in human and other animals
- briefly describes the transport of respiratory gases and other substances within the human body
- states the composition and major functions of human blood
- briefly describes blood clotting process by using a flow chart
- briefly describes the A, B, O grouping of blood, based on agglutinogen and agglutinin
- briefly explains the significance of blood grouping in blood transfusion
- States what "Rh" factor is
- Appreciates the importance of "Rh" factor in pregnancy and blood transfusion

Suggested Teaching-Learning Process

- Describe what respiratory pigment is.
- Explain the role of respiratory pigments in the animal kingdom.
- Give examples of the respiratory pigments in animals (Haemocyanin, Hemoglobin).
- Briefly explain the composition and role of blood.
- Explain the transport of respiratory gases and other substances.
- Guide student groups to prepare flow charts on composition and role of blood.
- Guide student groups to construct illustrations to explain the principles of ABO blood grouping based on agglutinogen and agglutinin.
- Explain the basis of Rh blood grouping based on antigen and antibodies.
- Explain the significance of blood grouping in blood transfusion.
- Explain the importance of Rh grouping in pregnancy

Assessment and Evaluation

- Assess student performance on the chart using following criteria
  - Accuracy
  - Relevance of information
  - Attractiveness

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Competency Level5.3.4 : Explores the diversity of the respiratory structures in the animal kingdom

Number of Periods : 02

Learning Outcomes:

- states the need of respiratory structures in animals
- describes the characteristics of respiratory surfaces
- states different respiratory structures of animals with suitable examples
- describes how the complexity of respiratory structures of different animal groups has evolved over the time
- appreciates the diverse respiratory structures found in animals

Suggested Teaching-Learning Process

- Discuss the need for respiratory surfaces in animals.
- Describe the characteristics of respiratory surfaces.
- Use diagrams/ photographs/ illustrations to introduce the different respiratory structures of animals such as body covering, external gills, internal gills, trachea, and book lungs.
  (Detailed structures are not necessary. The students should be able to identify the respiratory structures)
- Let students conduct a discussion to relate the complexity of respiratory structure over time and dependence on the habitat.

Assessment and Evaluation

- Assess student discussions using following criteria.
  - Accuracy of information
  - Relevance of information
  - Sufficiency of information
  - Active participation

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Competency Level 5.3.5 : Relates the structures of the human respiratory system to its functions

Number of Periods : 08

Learning Outcomes:

- describes the gross structure of the human respiratory system
- relates the structure with the function of each part of the respiratory system
- describes the mechanism of ventilation of lungs
- explains the processes of exchange of gases between blood and air, blood and tissue
- describes the homeostatic control of breathing in man
- briefly explains the causes of major disorders of the human respiratory system and suggest necessary preventive measures to avoid or minimize the impacts of those disorders
- explains respiratory cycle, lung capacity and lung volume
- states the changes in lung capacity, tidal volume during a strenuous exercise
- measures effects of exercise on respiratory rate and pulse rate

Suggested Teaching-Learning Process

- Lead a discussion using prepared specimens, models, charts, animation or web resources to highlight the relationship between the structure and functions of the human respiratory system.
- Explain the mechanism of lung ventilation by using animations/diagrams.
- Get students to prepare models to explain the function of ribs and related structures in ventilation of lungs.
- Use diagrams to explain the mechanism of gaseous exchange through alveolar epithelium, capillary epithelium and cell membrane.
- Explain homeostatic control of breathing in man.
- Assign students to prepare a report to explain the impact of smoking, occupational hazards due to the exposure to silica and asbestos particles.
- Explain the respiratory cycle.
- Describe the terms related to lung volumes by using the volume vs. time graph.
- Facilitate students to observe effects of exercise on the respiratory rate and pulse rate.

Assessment and Evaluation

- Assess student activities on the effect of exercise on the respiratory rate and pulse rate using the following criteria.
  - Recording
  - Correct observation
  - Accurate calculation

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Competency 5.4.0 : Explores immunity

Competency Level5.4.1 : Explores types of Immunity

Number of Periods : 08

Learning Outcomes:

- briefly explains what is immunity
- names the two types of immunity
- defines the term innate immunity
- discusses the three external defenses/barrier found in human body for innate immunity such as skin mucus membranes and secretions
- discusses how phagocytic cells, antimicrobial proteins, inflammatory response and natural killer cells act as internal defenses
- defines the term adaptive immunity
- names the two types of responses in adaptive immunity
- states what is humoral immunity response in adaptive immunity
- states what is cell mediated immune response in adaptive immunity
- describes the role of T lymphocytes and B lymphocytes in proving immunity
- differentiates between active immunity and passive immunity with examples
- briefly describes the term allergies
- briefly describes the differences between the terms anti immune diseases and immune deficiency diseases
- states possible causes for allergies, anti-immune diseases and immune deficiency diseases
- states the typical allergy symptoms
- states the rheumatized arthritis, type of diabetes mellitus and multiple sclerosis as anti-immune diseases
- appreciates the importance of immune system for survival of human beings

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Suggested Teaching-Learning Process

- Use some events and examples to introduce the term immunity.
- Guide students to collect examples for innate immunity.
- Conduct a discussion to categorize defense into external and internal defenses.
- External defenses- skin, mucous membrane, secretions
- Internal defenses- phagocytosis, antimicrobial proteins, inflammatory response, natural killer cells
- Use examples to discuss adaptive immunity.
- Lead a discussion on different types of acquired immunity.
- Introduce antigens, antibodies and lymphocytes.

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- Lead a discussion introducing naturally acquired immunity and artificially acquired immunity considering humoral immunity responses and cell mediated immunity responses.
- Explain naturally and artificially acquired immunities including active and passive with examples.
- Discuss allergies.
- Discuss auto immune diseases with examples.
- Discuss immune- deficiency diseases.
- Instruct students to complete an assignment on allergies, immune deficiency diseases and precautions.

Assessment and Evaluation

- Use the following criteria to assess student performances in completing the assignment.
    - Handing over in time
    - Completeness
    - Accuracy of information
    - Adequacy of information
    - Use of references

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Competency 5.5.0 : Explores osmo regulation and excretion

Competency Level5.5.1 : Examines the relationship between metabolism and excretory substances

Number of Periods : 04

Learning Outcomes:

- states what is the osmo regulation
- states what is excretion
- relates the importance and need of osmo regulation and excretion for the survival of animal beings
- describes the relationship between metabolic substrates and excretory products
- names the nitrogenous excretory products
- describes the relationship between the nitrogenous excretory products and living environment
- states examples of organisms which secrete different types of nitrogenous excretory products

Suggested Teaching-Learning Process

- Discuss the need and importance of osmoregulation and excretion.
- Introduce excretory products.
- Explain the relationship between metabolism of substrate and metabolic products.
- Introduce nitrogenous excretory products.
- Guide students to make a presentation to relate excretory products and habitat with examples.

Assessment and Evaluation

- Assess student performance on the presentation using following criteria.
  - Presentation skills
  - Accuracy of information
  - Relatedness
  - Time management

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Competency Level 5.5.2 : **Investigate the diversity of excretory structures of organisms**

Number of Periods : 04

Learning Outcomes:

- lists the different types of excretory structures found in animals with examples
- identifies and names the different excretory structures using diagrams or charts (practical work)

Suggested Teaching-Learning Process

- Provide students with diagrams of different excretory structures of the animal kingdom and have a discussion and ask them to identify body surface, contractile vacuole, flame cells, nephridia, Malphigiantubule , green glands or antennal glands, sweat glands and salt glands(details of fine structure of excretory structures are not necessary).
- Let students construct their own notes on diversity of excretory structures of organisms with relevant examples.

Assessment and Evaluation

- Assess the students on their answers based on an oral test.

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Competency Level5.5.3 : **Investigates the gross structure and function of the human urinary system.**

Number of Periods : 09

Learning Outcomes:

- lists the parts of the human urinary system
- states the main function of different parts of the human urinary system
- describes the location of the kidney and the blood supply associated with it
- describes the gross structure of the kidney
- explains the structure of a nephron with associated blood capillaries
- states the three steps involved in urine formation
- describes the process of urine formation
- constructs a flow chart on the role of ADH and Aldosterone on the functioning of the kidney
- states the role of kidney as the main homeostasis organ
- states bladder stones, kidney stones and CKDu as disorders related to human urinary system
- states the causative factors and preventive measures of bladder and kidney stones
- explains kidney failure and reasons for kidney failure and dialysis
- explains what CKDu is and discusses hypothized reasons for its occurrence
- appreciates the importance of maintaining wellbeing of the urinary system

Suggested Teaching-Learning Process

- Lead a discussion using specimens, models etc. to highlight the following and instruct them to make their own notes with relevant diagrams.
  - Major parts of the human urinary system.
  - Microscopic structure of the nephron considering it as the structural and functional unit of the kidney.
  - Relating the structural adaptations to the function of the nephron.
  - Process of urine formation- ultrafiltration, selective absorption.
- Explain the role of ADH and aldosterone in the process of urine formation.
- Discuss the functions of the kidney as a homeostatic organ including osmoregulation, control of blood volume, blood pH regulation, secretion of erythropoietin and rennin, control of blood pressure.

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- Guide students to prepare brochures on the disorders associated to kidney (bladder and kidney stones, chronic kidney disease) and their preventive measures.
- Explain what CKDu is and discuss hypothized reasons for its occurrence.

Assessment and Evaluation

- Assess the students on the brochures using following criteria.
    - Correctness of information
    - Sufficiency of information
    - Relevance of information
    - Presentation format

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