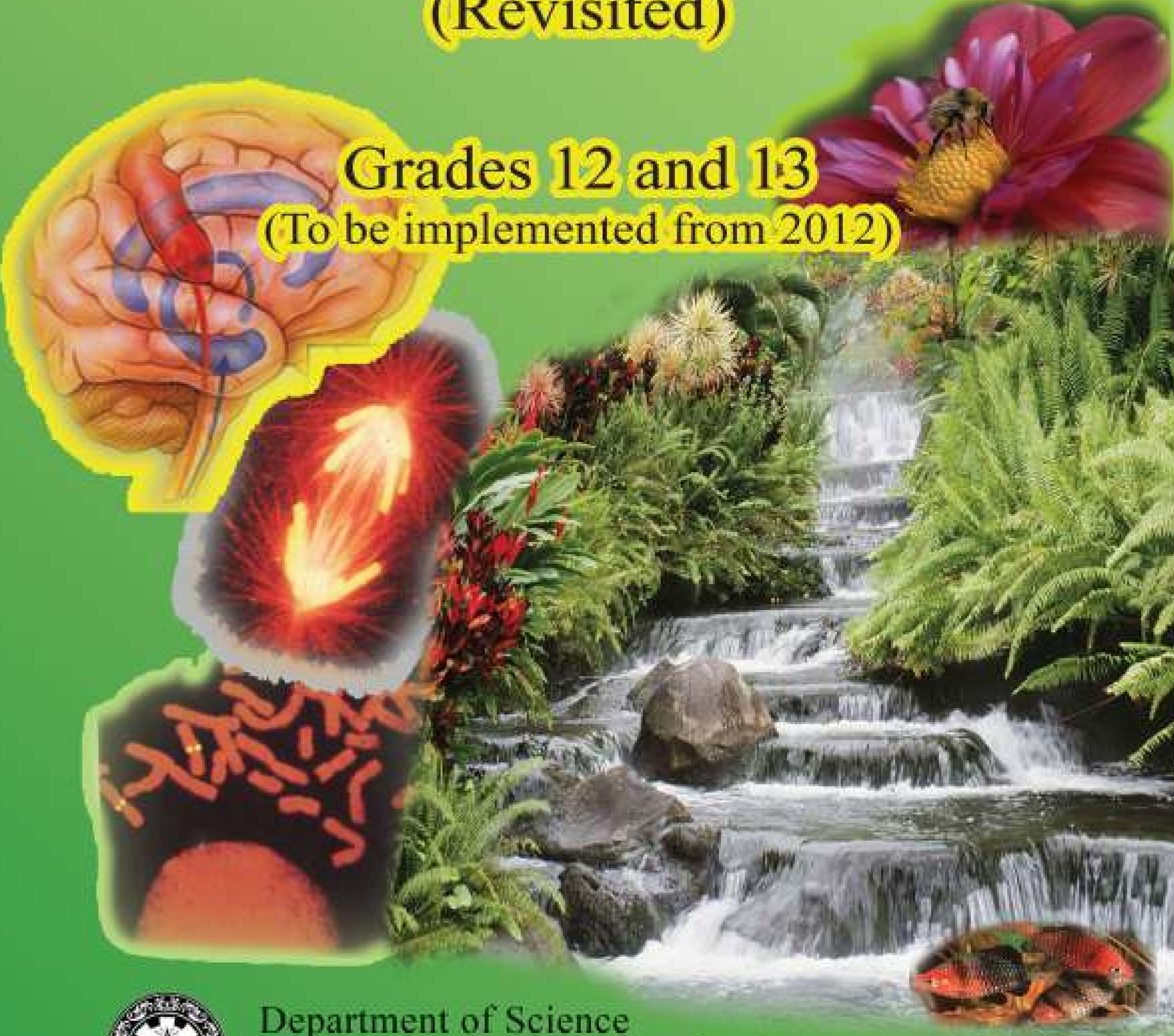
G.C.E. (Advanced Level)

BIOLOGY

Teacher's Instructional Manual
(Revisited)

Grades 12 and 13
(To be implemented from 2012)



Department of Science
Faculty of Science and Technology
National Institute of Education

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Grades 12 & 13 – 2012

First Print -2013

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Director General's Message

The new G.C.E. Advanced Level Biology Syllabus was introduced to the school system in 2009 and subsequently the Teacher's Instructional Manuals were published in the same year for Grade 12 and in 2010 for Grade 13.

As per the requests of the schools and universities, the G.C.E. Advanced Level Biology syllabus was revised in 2012 with a follow-up. This new book has been prepared by revising the two instructional manuals conforming to the syllabus.

This book comprehensively presents the details as regard the competencies and competency levels expected to be achieved by the students. We believe that this information is of utmost importance to teachers when designing learning teaching events in Biology.

Three aspects need to be taken into consideration by teachers when using this book. They are, the coherence of the Teacher's Instructional Manual and the syllabus, its building up founded on the vision of the syllabus and the expected competencies and its preparation taking into consideration the expected achievement level of grades 12-13 students. Thus the use of this book meaningfully is an indispensable task and a responsibility on the part of teacher.

With a view to bringing the three aforesaid matters to your attention, the National Institute of Education is in the process of giving the necessary training to all the teachers teaching G.C.E. Advanced Level classes. Participation of the relevant teachers in these training sessions is extremely important because it is a great underpinning to understand the learning teaching principles and processes set out here. Especially the school-based assessment is expected to be applied to develop the student competencies. We all involved in the process of education and evaluation should discern that these interventions are essential to realize the task of promoting the students' skills without limiting merely to the transmission of subject matter.

I wish to extend my special thank to all the staff of the National Institute of Education including the officers of the academic sections and all the external scholars who shouldered the arduous task of compiling this manual.

Prof. W.M. Abeyrathna Bandara
Director General
National Institute of Education

Foreword

This Teacher's Instructional Manual is useful to organize the learning and teaching process for the students of grades 12 from 2012 . It is compulsory to cover the competency levels and the content during the given time period. When planning the school based assessment tools, it is important to consider the learning outcomes given under each competency level. It is advised to encourage the students to use websites and additional resources relevant to the subject matter to get a clear understanding of the subject.

In this modern era where the technology is developed to facilitate education, the teacher has a responsibility to organize the teaching learning environment to get the best use of the technology to make learning a pleasurable and a meaningful activity to the student.

I would like to thank the subject specialists of the National Institute of Education and external resource persons who contributed their time and expertise in performing this Teacher's Instructional Manual.

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Unit 1 – Introduction to Biology

Competency 1.1.0 : **Conducts investigations from a biological perspective.**

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

Number of Periods : **01**

Learning Outcomes :

The student should be able to:

- describe on the nature, scope and importance of biology
- discuss the issues and challenges faced by mankind with reference to biology

Suggested learning- teaching process:

- Provide / quote suitable sources to gather information
- Instruct the students to gather information on issues pertaining to biology from different sources.
- Advice students to do presentations in groups to expand their knowledge on issues pertaining to biology.
- Make an elaboration according to an appropriate sequence

Guidelines :

- **Understanding biological diversity :**
  There has been life on earth for over 3.5 billion years. Students should understand that there are around 30 million species of animals and plants in the world. There is a dynamic relationship between the world of life and the inanimate world.
- **Understanding the human body and its functions:**
  Students should be able to appreciate the organization of the human body, how systems within the body are interconnected and the way structure is related to function.
- **Management of natural resources and environment:**
  Make aware students that natural resources are limited and with the current increase in growth of human population there is a threat of depletion of natural resources. Destruction of Ozone layer in the atmosphere, acid rain, global warming caused by increasing concentrations of CO_2 in the atmosphere, pollution of rivers and underground water supplies leading to a dearth in drinking water in the future etc, are some of the results.
- **Sustainable food production:**
  With the current rate of population growth, three people are added to the world's population each second. The current human population of 6 billion is expected to double in less than 40 years. Therefore, for the survival of mankind, sustainable food production is necessary. Production of high yielding varieties of plants and animals, development of disease resistant varieties, improved methods of post harvest technology needs to be emphasized.
- **Understanding of causes and effects of diseases:**
  Scientists are currently working on cures for diseases such as cancer, AIDS, malaria and TB. AIDS is a serious and growing health problem worldwide. Malaria can kill over 3 million people per year in underdeveloped countries. Cancers which is the leading cause of death in some countries are not fully understood yet.
  In addition, new diseases arise from time to time. Scientists are working on prevention, remedial measures and cures for diseases.

Competency 1.1.0 : **Conducts investigations from a biological perspective**
Competency Level 1.1.2 : **Reviews the nature and the organizational patterns of the living world**
Number of Periods : **04**
Learning Outcomes :
The student should be able to:
- discuss the wide range in shapes, sizes and forms and distribution of living organisms.
- elaborate characteristics of organisms
- construct the hierarchical levels of organization with suitable examples
- justify the cell as the basic structural and functional unit of life

Suggested learning- teaching process:
- Use PowerPoint presentations, diagrams, specimens and other sources to highlight the nature of organisms
- With the aid of suitable diagrams or examples make the students identify characteristics of organisms
- Let the students build up the hierarchical levels of organization of life using suitable examples. (Group activities are preferred)
- Highlight the importance of cell as the basic structural and functional unit of life
- Make an elaboration according to an appropriate sequence

Guidelines :
- Living organisms show a wide range of variation in size, shape, form and distribution.
- Size – Bacteria – 0.25 μ – 2 μ to Giant Sequoia (Giant Red Wood)– 100m
- Shape – Organisms are diverse in shape
- Form – acellular , unicellular, multicellular
- Distribution – Terrestrial, aquatic, arboreal, aerial (give examples)

Characteristics of living organisms

(1) Order and organization
From molecular level to biosphere there is an order and organization in organisms to perform their biological activities efficiently

(2) Metabolism
The sum of all chemical activities taking place in an organism is its metabolism. It includes catabolic reactions and anabolic reactions.

(3) Growth and development
All organisms begin their life as a single cell. During growth an irreversible increase in dry mass occurs, which is characterized only by the living. Irreversible changes that occur during the life span of an organism is development.Growth and development are two consequent processes that happen in the life span of organisms.

(4) Irritability and coordination
Irritability is the ability to respond to stimuli from both internal and external environment. Movement of organisms occur as a result of irritability and coordination. In animals this happens as a result of coordinated efforts of nervous, hormonal, muscular and skeletal systems

(5) Adaptation

Adaptation is a peculiarity of structure, physiology or behavior that promotes the likelihood of an organism's survival and reproduction in a particular environment e.g., sunken stomata in xerophytes, viviparity in some mangroves,
production of more sweat in a hot climate, camouflage, splayed-out foot of camel prevents the foot sinking into soft sand

(6) Reproduction

Ability to produce a new offspring for continuous existence of species

(7) Heredity & Evolution

Organisms have genes that pass from one generation to the next and control specific physiological, morphological and behavioral characters of organisms.
Ability of organisms to change over time as a result of genetic modification of species is evolution

- Many non living entities may have one or more of these characteristics but not all of them e.g., crystals grow, waves move but only living organisms display all these characteristics simultaneously or at some point during their life cycle.

- **Hierarchical levels of organization**:
 Organisms are organized from molecules to biosphere level. At every level, structure and functions are different and are precisely coordinated.
- The cell is considered as the basic structural and functional unit in the hierarchical levels of organization.

Competency 1.1.0 : **Conducts investigations from a biological perspective**
Competency Level 1.1.3 : **Uses the scientific method in solving biological problems**
Number of Periods : **02**
Learning Outcomes :

The student should be able to:

- analyze a simple experiment to identify the steps of scientific method.
- apply the scientific method as a means of solving problems.

Suggested learning -teaching process:

Present the following problem to the class (As an engagement)

- A student who started to write in his book with a pen noticed that the lines could not be seen.
- Discuss the students' responses and analyze the problem and develop hypotheses.
- Following instructions are for the students to engage in the exploration.
  - Pay attention to the observation assigned to your group.
    - A branch with leaves in a tree had been covered with polythene. Water droplets could be observed after some time.
    - A patch of grass had been covered with a coconut shell and kept for several days. The grass patch had turned yellow.
    - A container of coconut water kept open for some time gave a sour taste.
  - Identify the problems in the above observations.
  - Present hypotheses for the above observations.
  - Plan experiments to test the hypotheses presented by your group.
  - List out the possible observations from the experiments you have proposed.
- After considering the observations explain how you can select the most suitable hypothesis.
- Prepare the students for a presentation of their findings.
- Make an elaboration according to an appropriate sequence.

Guidelines:

- **Scientific method**

  Students must be made aware that there is a standard sequence of steps normally followed by scientists or biologists all over the world in investigating particular events or problems. This may be a problem in biology or any other event that happens in the daily life. This organized pattern of investigation is called the scientific method.
- The scientific method consists of the following steps
  - Identification of the problem which then forms the basis of systematic observations.
  - Posing questions and formulating of hypothesis based on them
  - Testing hypothesis by conducting experiments with controls , where necessary
  - Making predictions and testing them by further experiments
  - Confirming hypothesis supported by evidence/ observations
  - Formulating a theory which may be modified in the light of new knowledge
- Explain the scientific method using relevant examples

Unit 2 – Chemical & cellular basis of life

Competency 2.1.0 : Investigates the chemical basis of life.
Competency Level 2.1.1 : Inquires into the elemental composition of living bodies.
Number of Periods : 02

Learning Outcomes :
The student should be able to:
- list the elements present in organisms.
- distinguish between macro and trace elements.
- State functions of macro and trace elements.

Suggested learning-teaching process
- Provide students with relevant literature (print and electronic) on elemental composition of plants and animals.
- Advice them to make charts/graphs /tables showing relative abundance of different elements in organisms.
- Allow students to prepare tables/charts on the functions of each element.
- Prepare the students for a presentation.
- Elaborate on the chemical basis of life as per given in the content of the syllabus.

Guidelines:
- **Elemental composition of living matter**
- Among the 92 naturally occurring elements, about 20 elements constitute the living matter.
- Carbon, Hydrogen, Oxygen, Nitrogen, Phosphorus and Sulphur are the six most abundant elements.

- Elements
  Exact composition of elements in organisms can vary. However some elements are named as essential elements. They are separated in to macro elements and trace elements depending on their abundance in living matter.

- **Macro elements**

Found 0.01% or more in the dry weight of an organism. C, H, O, N, P, S, Ca, K, Mg are found as macro elements in all organisms. In some organisms e.g. Human Na,Fe and Cl are also found as macro molecules.

- **Trace elements**

Found less than 0.01% in dry weight Cl, Si, V, Cr, Co, B, Mn, Zn, Cu, Mo,I,Fe,Al etc.

- Functions of macro elements and trace elements

Competency 2.1.0 : Investigates the chemical basis of life.
Competency Level 2.1.2 : Investigates the physical and chemical properties of water important for life.
Number of Periods : 02

Learning Outcomes :
The student should be able to:
- explain the importance of water for life.
- describe physical and chemical properties of water which are important for life.
- relate the physical and chemical properties of water to its functions performed in living systems.

Suggested learning-teaching process
- Provide students with relevant literature (print and electronic) on physical and chemical properties of water and their relation to its functions performed in living systems.
- Advice them to write an essay on 'Water as the essential ingredient for Life'.
- Discuss the essential points that should be included in the essay.
- Prepare the students for a presentation.
- Make an elaboration according to an appropriate sequence.

Guidelines :
- Importance of water for life.
  - The most abundant inorganic compound in living matter is water.
  - The main functions of water in organisms.
    1. Component of protoplasm
    2. Solvent
    3. Reactant
    4. Maintaining turgidity

- Other functions

Property	Role	Example
Liquid at room temperature	Medium of protoplasm	Major component in protoplasm is H_2O
Polarity	Powerful solvent	Most of the materials of a cell are dissolved in protoplasm & cell sap Metabolic reactions take place in an aqueous medium in a cell
Chemical property	Reactant in some biochemical processes	Photosynthesis $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ Hydrolysis – Starch + $H_2O \rightarrow$ Maltose
High adhesive and cohesive forces.	Maintenance of turgor in cells	Cell enlargement mechanical support in herbaceous plants, turgor movements, Movement of guard cells Blooming of flowers

Property	Role	Example
High surface tension	Provides habitats for some aquatic insects	Water skaters
High adhesive and cohesive forces	Transport and absorption of materials in organisms	Translocation and ascent of sap, absorption of water and minerals from soil solution.
High specific heat capacity	Water resists to change its temperature when a considerable amount of heat is absorbed or lost	Maintain the body temperature of poikilotherms within a narrow range
High latent heat of vaporization	Cooling the body surfaces	Sweating, transpiration
High latent heat of fusion	A lot of heat should be dissipated for water bodies to freeze	Water will not freeze easily within the cells and in water bodies.
Anomalous expansion of volume on freezing	Water bodies will not freeze solid. Ice forms on top and liquid water remains at the bottom	Aquatic organisms are capable of surviving during winter.
Transparency	Allowing penetration of light	Allows to grow aquatic plants and algae in a considerable depth in water bodies.

Competency 2.1.0 : **Investigates the chemical basis of life.**
Competency Level 2.1.3 : **Examines the chemical nature and functions of main organic compounds of organisms.**
Number of Periods : **08**

Learning Outcomes :
The student should be able to :
- describe the basic chemical nature of four main types of organic compounds found in organisms
- elaborate on the functions of four major types of organic compounds.
- conduct laboratory tests to identify the reducing sugars, non reducing sugars, starch, proteins and lipids.

Suggested learning-teaching process
- Demonstrate the laboratory tests for reducing and non-reducing sugars, starch, proteins and lipids.
- Provide the following unnamed solutions (such as starch, sucrose, glucose, egg white, coconut oil etc.) to the students
- Instruct them to identify the compounds and make a report on the procedures followed
- Provide students with relevant literature (print and electronic)
- Instruct students to present a report on carbohydrates, proteins, lipids and nucleic acids and their functions in organisms.
- Elaborate the subject content given for the relevant competency level.

Guidelines:
- Describe the basic chemical nature and functions of the four main types of organic compounds found in organisms
- The major organic compounds found in organisms are
  - Carbohydrates
  - Lipids
  - Proteins
  - Nucleic acids
- Explain that carbohydrates, proteins, lipids and nucleic acids are found in living matter, and are considered as major biological molecules.
- State that large molecules (molecular weight 10^4 - 10^{10}) such as proteins, nucleic acids and some carbohydrates are considered as macromolecules.

- **Carbohydrates**
  - Most abundant organic matter on earth
  - The substances that we know as sugars and flour in day-to-day life are examples
  - Major elemental composition is C,H,O
  - General formula $C_x(H_2O)_y$ - Hydrates of carbon contains the same proportions of H:O (2:1) found in water
  - Monosaccharides, disaccharides and polysaccharides are the three main classes of carbohydrates

- Monosaccharides
  - Explain the basic chemical nature and biological functions.
- Name monosaccharides according to the number of C atoms as; Triose (3C) e.g. Glyceraldehyde, Tetrose (4C) e.g. Erythrose - rare in nature, Pentose (5C) e.g. Ribose, Ribulose, Hexose(6C) e.g. glucose, fructose, galactose.
- All Monosaccharides are reducing sugars
- Disaccharides
  - Explain what glycosidic bonds are and how two monosaccharides form disaccharides.

    E.g., $2C_6H_{12}O_6 \longrightarrow C_{12}H_{22}O_{11} + H_2O$
  - Maltose, Lactose are reducing sugars, Sucrose is not a reducing sugar.
- Polysaccharides
  - Explain how polymeric structure is formed. Straight chains and branched chain structure. Basic structure and functions of starch, glycogen and cellulose. Amylase activity on starch. Inulin as an example of another polysaccharide and hemicellulose, pectin and chitin as important polysaccharide derivatives.

- Functions of Carbohydrates

  Explain the importance and functions of monosaccharides, disaccharides and polysaccharides in cellular function.

  Demonstrate some simple laboratory tests to identify starch, reducing and non reducing sugars and to observe hydrolysis of starch by amylase.
- **Lipids**

  Brief description of following points
  - Heterogeneous group of compounds which are insoluble in water.
  - Major elemental composition is C,H,O sometimes P and/or N. Less oxygen than carbohydrates
  - The structure of fatty acids - saturated and unsaturated with examples.
  - Distinguish oils and fats. Triglyceride structure of oils and fats.
  - Give examples of other types of lipids e.g., waxes, phospholipids, steroids and terpenes.
  - Explain major functions of lipids.
  - Laboratory tests to identify fats and oils.
- **Proteins**
  - State proteins are polymers of amino acids with high molecular weights. They contain C, H,O, N and sometimes S
  - State amino acids as monomer units of proteins. Although there are several amino acids in the body only around 20 different amino acids are involved in making proteins. Explain what are peptide bonds, how they are formed and Polypeptide structure.
  - Complex structure of proteins can be described in 4 stages.
    - Primary - linear sequence of amino acids.
    - Secondary - helical or pleated sheet structure
    - Tertiary - bending, folding of polypeptide chains produce globular shape. Different types of bonds stabilizing tertiary structure.

- Quaternary- aggregation of 2 or more polypeptides to form a complex globular structure.
- Denaturation of proteins, effect of denaturation on activity of protein.
  Role of proteins in cells and organisms. Explain different types of functions (structural, catalyst, transport, storage, contractile, protective, hormonal, toxic)
  Laboratory tests for proteins. Biuret test.

- **Nucleic acids**
  Brief description of the following points
  - Polymers of high molecular weight, contains C, H, O, N and P.
  - Two types - DNA and RNA.
  - Nucleotides as building units. Constituents of nucleotides.
  - Types of N-bases. Purines and pyrimidines. Difference of sugars and bases of nucleotides of DNA and RNA.
  - Polynucleotide structure. Explain fully the double helical structure of DNA.
  - Self replication of DNA
  - Denaturation of DNA. Renaturation of DNA.
  - Differences between RNA and DNA. Three different types of RNA (mRNA, t-RNA and r-RNA).
  - Functions of DNA and RNA
  - Nucleotides other than those found in nucleic acids (ATP,NAD,NADP) and their functions.
  - Practical:
    - Simple laboratory tests for identification of reducing and non-reducing sugars, starch, proteins, fats and oils

Competency 2.2.0 : **Examines how cells and tissues contribute to the functioning of organisms.**

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

Number of Periods : **04**

Learning Outcomes :

The student should be able to :

- use the light microscope properly.
- compare significant features of the electron microscope and light microscope
- explain the cell theory
- use electron micrographs to identify eukaryotic and prokaryotic cellular organizations.

Suggested Learning-teaching Process :

- Provide the opportunity for the students to observe and draw onion epidermal cells and buccal cavity cells from the lining of mouth under microscope.
- Engage students to observe electron micrographs from relevant sources (print and electronic) and identify eukaryotic and prokaryotic cellular organizations.
- Advice students to make a presentation covering following points.
  - Cell theory, relative advantages and disadvantages of light and electron microscopes, handling and taking care of laboratory microscopes, comparison of prokaryotic and eukaryotic cellular organizations.
  - Make an elaboration to cover the specified subject content

Guidelines:

- Proper use of microscope with care.
- Magnification and resolution of light and electron microscopes
- Comparison of light and electron microscopes
- Eukaryotic and prokaryotic cellular organizations.

- **Light microscope**.
  - Distinguish between simple and compound microscopes.
  - Explain the basic features and components of compound microscope, eye piece and objective piece and their magnification powers. Magnification and resolution powers (resolution refers to the minimum distance between two points which can be distinguished).
- **Electron microscope**,
  - Magnification and resolution powers.
  - Transmission and scanning type.
- Demonstrate the proper handling of light microscope.
- Demonstrate the use of microscope to observe specimens.

- **Cell theory.**
- All organisms are composed of cells, some of a single cell some of many cells.
- Recall the hierarchy of life, the levels of organization mentioned earlier. The basic unit which can be called “living” is the cell, which may form a single celled

organism (e.g., *Chlamydomonas*, Yeast) or a multicellular plant or animal. The cell is the basic structural and functional unit of life.

- The level of organization of matter represented by a cell shows all the characteristics of life. Any stage below level of a cell cannot be considered living, whether it is a single celled organism or multicellular plant or an animal.
- Robert Hooke (1663), while trying to understand why, cork which is a solid substance can float, examined thin slices using a microscope and found that they are made up of 'pores' and coined the term 'cells' to describe the pores.
- Anton Van Leeuwenhook (1650), a contemporary of Robert Hooke was the first to describe and record living single celled organisms, *Euglena* & bacteria
- Matthias Schleiden (1831), a botanist, studying plant tissues concluded that all plants are made up of cells.
- Theodore Schwann a zoologist and Shleiden (1839),concluded that animal tissues are also made up of cells.
- Virchow (1855) showed that all cells arise from pre existing cells by cell division,
- Schleiden ,Schwann and Virchow presented the 'Cell Theory' which included the following.
  1. All organisms are composed of one or more cells.
  2. The basic structural and functional unit of organisms is the cell.
  3. All cells arise from pre-existing cells.
- Organization of cells
- Two kinds of cellular organization - Prokaryotic and Eukaryotic
- The differences between prokaryotic cells and eukaryotic cells.
- Bacteria and Archaebacteria have prokaryotic cells. All the other organisms have eukaryotic cells.
- Prokaryotic cells, in comparison to eukaryotic cells, are small in size, have no organized nucleus, no membrane bound organelles, have 70 s ribosomes, flagella are simple without microtubules and not bound by membrane, have no endoplasmic reticulum and cytoskeleton, Peptidoglycan present in cell wall of bacteria and polysaccharides and proteins present in Archaebacteria
- Features of different cellular organizations illustrated by diagrams, electron micrographs or electronic sources.

- Practicals:
  - Parts and functions of microscope and using microscope to observe specimens
  - Use of electron micrographs to understand the structure of cellular components

Competency 2.2.0	**:**	**Examines how cells and tissues contribute to the functioning of organisms.**
Competency Level 2.2.2	**:**	**Analyses the structure and functions of the sub cellular units.**
Number of Periods	**:**	**07**

Learning Outcomes :

The student should be able to:

- compare the structural differences between plant and animal cells.
- use electron micrographs to identify cellular organelle and components.
- describe the structure and function of organelle and sub cellular components of cells.

Suggested learning- teaching process:

- Show two diagrams of plant and animal cells to the class.
- Ask students to come up with the similarities and differences of these cells
- Engage students in following group activity.
  - Out of the three sets of organelle given below, pay attention to the set assigned to your group.
    - Mitochondria , chloroplasts, Golgi bodies, micro tubules, lysosomes
    - Plasma membrane, micro bodies, vacuoles, cell junctions, cytoskeleton
    - Cell wall, rough endoplasmic reticulum and smooth endoplasmic reticulum, nucleus, ribosomes, flagella and cillia
- Use microscopic slides, electron micrographs and diagrams provided to your group to observe and identify the structures assigned to your group.
- Use the given sources to find the functions of the structures assigned.
- Differentiate the organelles and sub cellular components as found in plant and animal cells.
- Be prepared to make an innovative whole class team presentation.
- Make an elaboration covering all the relevant points

Guidelines

- Use the electron micrographs of plant cells and animal cells.
- Structures and functions of organelles and sub cellular components.

  - **Cell wall**
    - Outer envelope of plant cell. Animal cells do not have cell walls.
    - Made up of cellulose and pectin. Hemicellulose, lignin, suberin may also be present.
    - May have primary and secondary walls. Explain the chemical components of middle lamella, primary cell wall and secondary cell wall.
    - Cell wall has pits through which cytoplasm of adjoining cells join through plasmodesmata.
    - Functions of cell wall.

- **Plasma membrane**
  - Outer limit of protoplasm.
  - Illustrate the structure of the fluid mosaic model of the plasma membrane, consisting of a bilayer of lipids, integral proteins and peripheral proteins. Movable lipids give the fluidity whereas the arrangement of protein molecules gives the mosaic structure.
  - Other membranes in the cell also have the same structure.
  - Explain the functions of plasma membrane
    - Dynamic boundary of cell.
    - Permits the entry of water, ions and certain organic molecules.
    - Regulates the exit of waste materials.
    - Maintains an osmotic balance within the cell.
    - Receives information through receptors and transmit signals to co-ordinate activities between cells/ identification of cells.
  - **Nucleus**
    - Stores genetic information of the cell.
    - Most cells possess one nucleus, some have several nuclei. (e.g., fungi)
    - Explain the structure of nucleus, consisting of double membrane envelope, nuclear sap, chromatin, nuclear pores, and nucleolus.
    - Explain the functions of nucleus.
      - Control cellular activities.
      - Synthesizes DNA to produce new nuclei for cell divisions.
      - Synthesizes ribosomes and RNA required for protein synthesis.
  - **Ribosomes**
    - Consists of a large and a small sub unit composed of r- RNA and protein.
    - Synthesizes proteins coded by m-RNA with the help of t-RNA.
  - **Endoplasmic reticulum**
    - Network of internal membranes forming flattened or tubular sacs separating cytosol from ER lumen. Continuous with the outer membrane of nuclear envelope
    - Two types of ER; Rough ER and Smooth ER
      - **Rough ER**
        - Rough ER consists of flattened sacs, and ribosomes bound to surface
        - Proteins synthesized by ribosomes move into lumen of ER.
        - Synthesize membrane phospholipids and membrane glycolipids
        - Transport enzymes and other proteins within cell. Produce transmission vesicles for transport
      - **Smooth ER**
        - Network of tubular sacs without ribosomes
        - Presence of membrane bound enzymes
        - Synthesize lipids, steroids and carbohydrates
        - Transport within cell. Produce transmission vesicles for transport.
        - Detoxification
        - Stores Ca^{2+} ions

- **Golgi complex**
  - Stacks of flattened vesicles or Golgi bodies
  - Inner and outer surfaces can be identified
  - Illustrate the structure of Golgi complex
  - Functions of Golgi complex
  - Proteins and lipids manufactured in endoplasmic reticulum (ER) are transported through channels of ER or vesicles into Golgi complexes
  - Lipids and proteins combine with polysaccharides to form glycolipids and glycoproteins respectively within the cisternae of Golgi complex
  - When necessary ,vesicles containing glycoproteins or glycolipids are budded off from cisternae and move into other locations of the cell
  - Produce lysosomes
- **Lysosomes**
  - Membrane bounded vesicles contributing to digestive activity
  - Contain hydrolytic enzymes which catalyze breakdown of carbohydrates, proteins, lipids and nucleic acids.
  - Digest food particles received by phagocytosis
  - Digest worn out organelles
  - Transport residue material out of cell by exocytosis
  - Autolysis causing cell death
- **Microbodies (Peroxisome & glyoxysome)**
  - Membrane bound vesicles with oxidizing enzymes.
  - Two common types of microbodies
    - Glyoxisomes – present in plant cells
    - Peroxysomes – present in plant and animal cells.
  - Enzymes in glyoxisome converts fat into carbohydrate
  - Enzymes in peroxysome catalyze the break-down of H_2O_2
  - Function of peroxysome
    - Detoxification of peroxides
    - Photorespiration in plants
- **Mitochondria**
  - Organelle bound by two membranes. Inner membrane bearing cristae.
  - Illustrate the ultra structure of mitochondria with two membranes, cristae, matrix with ribosomes and DNA.
  - Explain the function of mitochondria
  - Matrix carries enzymes for reactions of Krebs cycle. Cristae carry out electron transport chain and oxidative phosphorylation system.
  - Synthesize ATP by oxidizing reduced coenzymes using oxygen.
- **Chloroplasts**
  - Double membrane bound organelle found only in plant cells
  - Explain the gross structure of chloroplast using an electron micrograph including outer membrane, inner membrane, thylakoids, grana and stroma with ribosomes DNA and starch granules.
  - Thylakoids contain photosynthetic pigments.
  - Function of chloroplast - photosynthesis

- **Cytoskeleton**
  - Supporting structure of cytoplasm made of microtubules and protein filaments. Dynamic structure, breaking and reforming as needed.
  - Explain structure of three types of components.
    - Microtubules, Actin filaments, Intermediate filaments
  - Functions of cytoskeleton
    - Gives strength to cytoplasm
    - Support organelle of cell
    - Movement of cytoplasm, cytoplasmic streaming, moves organelle and chromosomes when necessary.
- **Cilia and Flagella**
  - Made of microtubules, with a 9+2 structure. Covered by plasma membrane. Bound to a basal body.
  - Illustrate the structure with electron micrographs.
  - Functions of flagella and cilia includes locomotion and transport of material on cell surface.
- **Centriole**
  - A pair of cylindrical structures made of microtubules found in animal cells. Produce aster and spindle in cell divisions.
- **Vacuoles**
  - A large structure, bound by tonoplast, filled with liquid found in plant cells.
  - Stores water and other materials such as sugars, ions and pigments
  - Maintains water balance of cell
  - Gives turgidity and support to cell.
  - Produce colours in some plants with sap pigments
  - Stores soluble substances needed for cellular activities.
- **Cell junctions**
  - Structures at which cytoplasm of adjoining cells are joined.
  - Plasmodesmata in plant cells.
  - Three types in animal cells
    - Tight junctions – connect the plasma membranes of adjacent cells tightly e.g., in epithelial cells of gut preventing leakages through intercellular space.
    - Anchor junctions – mechanically attach the cytoskeletons of adjoining cells for strong binding eg. skin epithelium
    - Gap junctions (Communication junctions) – allow signal and material exchange between adjacent cells through direct connections. e.g., heart muscles

Competency 2.2.0 : Examines how cells and tissues contribute to the functioning of organisms.

Competency Level 2.2.3 : Relates the structure of plant tissues to their functions.

Number of Periods : 05

Learning Outcomes :

The student should be able to :

- describe the concept of 'tissue'.
- list main types of plant tissues.
- compile a list of characters of main types of plant tissues
- relate the structural features of plant tissues to their function.
- use characters of plant tissues to identify them under microscope.
- compare the different types of plant tissues.

Suggested Learning- teaching process:

- Use charts, drawings and power-point presentation to show tissues as seen in the plant body.
- Request the students to identify and make notes on the location, main features, and expected functions of each type of plant tissue.
- Provide opportunities for the students to observe plant tissues under microscope.
- Prepare them for creative presentations on their findings.
- Make an elaboration to highlight the important points to be considered.

Guidelines:

- In multicellular organisms, the cells are organized into tissues, organs & organ systems.
- Tissue is a group of physically linked cells with common origin specialized for a particular function or functions.
- Types of plant tissues, their structure & function
- Plant tissues can be classified into two groups
  - Simple tissues – mainly one type of cells
  - Complex tissues – more than one type of cells
- Simple plant tissues are divided into three groups
  1. Parenchyma 2. Collenchyma 3. Sclerenchyma
- The structure, function and distribution of simple plant tissues.
- Modified parenchyma cells and their distribution and function
- Complex plant tissues are divided into two groups.
  1. Xylem 2. Phloem
- Structure, function and distribution of complex plant tissues.
- Practical:
- Microscopic observation and identification of different types of plant tissues

Competency 2.2.0 : **Examines how cells and tissues contribute to the functioning of organisms.**

Competency Level 2.2.4 : **Relates the structure of animal tissues to their functions.**

Number of Periods : **05**

Learning Outcomes :

The student should be able to :

- list main types of animal tissues
- relate the structural features of animal tissues to their function
- compile a list of characters of main types of animal tissues
- use characters of animal tissues to identify the main types under microscope.
- compare the different types of animal tissues.

Suggested learning- teaching process:

- Use relevant sources (prepared slides, pictures, PowerPoint presentations, diagrams etc.) to show the structure of tissues.
- Allow students to identify the parts.
- Ask the students to collect information to relate the functions with the structure.
- Encourage students to make a presentation on their findings.
- Make an elaboration to highlight important points.

Guidelines:

- Main types of animal tissues and their characters.
- Structure-function relationship of tissues.
- Microscopic observations and identifying types of tissues.
- Types of animal tissues, their structures and functions.
  - Basically animal tissues are grouped into four categories
    1. Epithelial tissue
    2. Connective tissue
    3. Muscle tissue
    4. Nervous tissue
  - **Epithelial tissue**
  - Explain the characteristics of epithelial tissue
  - There are two general classes of epithelium
    1. Simple
    2. Stratified
  - Explain that these classes are further subdivided into three based upon the shape of the cells
    1. squamous
    2. cuboidal
    3. columnar
  - Explain the structure, function and distribution of squamous, cuboidal and columnar epithelium
  - Explain the characteristics and the structure of stratified epithelium and distribution of different types of stratified epithelium

- **Connective tissues**
  - Explain the characteristics of connective tissues
  - Divided into two major classes
    1. Connective tissue proper
    2. Special connective tissue
  - Connective tissue proper is divided into two
    1. Loose connective tissue
    2. Dense connective tissue
  - Explain the structure, function and distribution of loose connective tissue and dense connective tissue.
- Special connective tissues are classified into three
  1. Cartilage
  2. Bone
  3. Blood
- Explain the structure, function and distribution of cartilage, bone and blood.
- **Muscle Tissue**
  - Explain the characteristic features of muscle tissue
  - There are three kinds of muscles
    1. Smooth muscle
    2. Skeletal muscle
    3. Cardiac muscle
  - Explain the structure, function and distribution of smooth muscle, skeletal muscle and cardiac muscle
- **Nervous tissue**
  - Explain the characteristic features of nervous tissue
  - There are three types of neurons
    1. Sensory neurons
    2. Motor neurons
    3. Inter neurons
  - Explain the structure and function of a neuron by using motor neurons.
- Practical :
- Microscopic observration and identification of different types of animal tissues

Competency 2.3.0 : Investigates the importance of cell division
Competency Level 2.3.1 : Analyses the process of cell division
Number of Periods : 06

Learning Outcomes :
The student should be able to :
- elaborate on the phases of cell cycle.
- discuss the main events that occur in each phase.
- describe the four stages in mitosis with reference to chromosomal behavior
- state the importance of mitosis and meiosis
- use prepared slides to identify different stages of mitosis and meiosis under microscope.

Suggested learning- teaching process:
- Use various sources (print and electronic)to show the stages of cell cycle
- Allow students to observe onion root and shoot tip slides under microscope to identify different stages of mitosis
- Provide literature or relevant computer assisted learning resources to study the behavior of chromosomes during mitosis and meiosis
- Encourage students to make a presentation on their findings
- Make an elaboration to highlight important points

Guidelines :
- **Cell cycle**
  - The events that takes place in the cell from beginning of one cell division to the beginning of the next.
  - Net result – one cell gives rise to two cells
- **Eukaryotic cell cycle**
  - Explain the phases – G_1, S, G_2, M (mitosis)and C(cytokinesis) of cell cycle and events that take place in each stage. G_1+S+ G_2 together forms interphase.

- **Mitosis**
  - DNA synthesis takes place in S phase of cell cycle. Chromosomes are divided into two chromatids bound together at centromere.
  - Mitosis has four phases, prophase, metaphase, anaphase and telophase
  - Explain the behavior of chromosomes in each of the above phases during mitosis.
  - Animal cells have centrioles which forms aster and spindle at mitosis.
  - Plant cells do not have centrioles but forms spindle.
  - Spindle fibers attach to kinetochores at the two sides of centromere before separation into poles.
  - In cytokinesis animal cells form a cleavage furrow and plant cells form a cell plate.
  - Explain the significance of mitosis

- **Meiosis**
  - Explain that meiosis involves two consecutive nuclear divisions. First one is a reduction division and the second is exactly like mitosis.
  - Meiosis is divided into 8 stages, meiosis I and meiosis II both having 4 phases- prophase, metaphase, anaphase and telophase. Prophase I is the longest and eventful phase.
  - Explain events occurring in all 8 phases.
  - Explain what are homologous chromosomes and how they pair in prophase I.
  - Explain formation of synaptonemal complex and exchange of segments of chromatids.
  - Explain significance of meiosis.

  - Practical :
    - Identification of different stages of mitosis and meiosis using microscopic slides

Competency 2.4.0 : **Investigates energy relationships in metabolic processes of organisms**
Competency Level 2.4.1 : **Analyses the energy relationships in metabolic processes**
Number of Periods : **01**

Learning Outcomes :
The student should be able to:
- highlight the need of energy for living systems
- explain catabolic and anabolic reactions with examples
- discuss the structure and the importance of ATP as an energy currency unit
- list the cellular processes involving energy

Suggested learning- teaching process:
- Provide students with relevant sources (print and electronic) on energy relations in cells
- Facilitate students to extract important points and make a summary
- Encourage students to make a presentation on their findings
- Make an elaboration to highlight important points

Guidelines:
- Explain the need of energy for living systems. Constant supply of energy is required to maintain all life functions in different forms (mechanical, chemical, transport and illumination).
- Metabolism – sum of all chemical reactions carried out by a cell. Explain anabolic and catabolic processes with suitable examples
- Emphasize the need of energy for living systems, endogonic(energy absorbing) reactions and exogonic(energy liberating) reactions.
  Cells use energy of catabolic reactions to carry out anabolic reactions.
- ATP acts as a carrier of energy between reactions.
  Discuss the structure of ATP with examples on how it acts as an energy carrier.
  Hydrolysis reaction of ATP to ADP releases 30.6 kJ mol^{-1}
  ATP is mobile, can release energy quickly and reform quickly.

Competency 2.4.0 : Investigates energy relationships in metabolic processes of organisms
Competency Level 2.4.2 : Investigates the role of enzymes in regulating metabolic reactions
Number of Periods : 06

Learning Outcomes :
The student should be able to :
- explain the general characteristics of enzymes and their role
- describe major features of enzymes
- describe the importance of co-factors for enzymatic activities
- describe the mechanism of enzyme activity by using suitable diagrams
- explain how pH, temperature, substrate concentration, enzyme concentration and inhibitors affect the rate of enzyme activity
- conduct laboratory experiments to show how temperature affects the rate of enzyme reaction using starch – amylase system

Suggested learning- teaching process:
- Conduct simple experiments to demonstrate the role of enzymes.
- Provide the students with relevant sources (print and electronic) on enzymes together with material and equipment needed to determine the factors affecting enzyme activity
- Advice the students to present their findings.
- Make an elaboration highlighting the relevant points to cover the content

Guidelines :
- Explain the general characteristics of enzymes, protein structure, specificity
- Describe that the enzymes are capable of reducing activation energy of a particular reaction.
- Explain the mechanisms of an enzyme reaction with the aid of diagrams
  1. Lock and key mechanism
  2. Induced fit mechanism
- Explain that some enzymes require non protein components called cofactors for their efficient activity
- There are three types of cofactors
  1. Co-enzymes
  2. Prosthetic groups
  3. Inorganic ions
- Explain the functions of three types of co factors with examples
- Explain above three types of cofactors with suitable examples.
- Explain how activators and inhibitors affect enzyme activity. Ex: Heavy metals Ag^+,Hg^+,Cd^+
- Explain the factors affecting the rate of enzymatic reactions
  - pH, temperature, substrate concentration, enzyme concentration, inhibitors.
- Practical:
  - Conduct laboratory experiments to demonstrate enzyme activity and to determine the rate of enzymatic reactions (starch – Amylase)

Competency 2.4.0 : Investigates energy relationships in metabolic processes of organisms

Competency Level 2.4.3 : Examines photosynthesis as an energy fixing mechanism

Number of Periods : 08

Learning Outcomes :

The student should be able to :

- discuss the importance of the process of photosynthesis
- describe the light reaction of photosynthesis
- describe the dark reaction of photosynthesis
- describe the C4 pathway of photosynthesis
- conduct experiments to determine the factors affecting photosynthesis
- describe the principle of limiting factors
- carryout experiments to determine the rate of photosynthesis by amount of oxygen released.

Suggested learning- teaching process:

- Provide students with relevant sources (print and electronic) on photosynthesis
- Facilitate students to extract important points and make a summary
- Encourage students to make a presentation on their findings
- Make an elaboration to highlight important points

Guidelines

- Global and biological importance of photosynthesis
- Define the process of photosynthesis in terms of reactions and the end products with reference to the carbon and energy fixing mechanism.
- Chloroplasts as the site of photosynthesis, its fine structure, thylakoids, grana and stroma.
- Pigments associated with absorption of light energy. Absorption spectrum of a pigment. Compare with action spectrum of photosynthesis.
- Mechanism of photosynthesis highlighting following points
  - Light reactions
  - Dark reactions
    - **Light reaction**
      - Explain with following details which takes place in thylakoid membranes.
      - Photosystems I and II. Antenna complex, excitation of pigment molecules, resonance transfer of energy between pigment molecules. Reaction center molecules, electron transport, photolysis of water, noncyclic and cyclic photophosphorylation, synthesis of NADPH and ATP.
    - **Dark reaction**
      - Explain with following details which takes place in stroma.
      - Calvin cycle of reactions has three stages.
      - Carboxylation -CO_2 fixation- RuBP as CO_2 acceptor. RuBP carboxylase enzyme. Formation of PGA.
      - Reduction of PGA, with the use of ATP and NADPH produced in light reaction. Formation of PGAL. Part of PGAL formed is used in synthesis of organic food.

- Regeneration of RuBP. Part of PGAL formed is used to produce RuBP, using ATP which happens through RuMP.
- **Photorespiration** ,Combining of RuBP with oxygen to produce 1 PGA (C3) and Phospho Glycolic Acid (C2).Thereby reducing the efficiency of photosynthesis

- Explain the C4 mechanism of CO_2 fixation. It takes place in two stages in two different types of cells. Mesophyll cells and bundle sheath cells. PEP as a more efficient CO_2 acceptor, formation of oxaloacetate, malate, its transport through plasmodesmata, release of CO_2 in bundle sheath cells. Formation of pyruvate and return to mesophyll cells. Calvin cycle in bundle sheath cells in a higher concentration of CO_2.
- Explain the significance of C4 photosynthesis.
- Distinguish between C3 photosynthesis and C4 photosynthesis.
- Explain the factors affecting the rate of photosynthesis and the principle of limiting factors.
- Effect of CO_2 concentration, light, water and temperature on the rate of photosynthesis.
- Practical:
- Experiments to determine the rate of photosynthesis by amount of O_2 released
- Microscopic observation of cross section of a leaf with special reference to adaptations for photosynthesis

Competency 2.4.0 : **Investigates energy relationships in metabolic processes of organisms**

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

Number of Periods : **08**

Learning Outcomes :

The student should be able to:

- highlight cellular respiration as the process of supplying energy for all cellular activities.
- describe the location, major events and end products of aerobic respiration.
- describe the location, major events and end products of anaerobic respiration
- list out the significance of cellular respiration.

Suggested learning- teaching process:

- Provide students with relevant sources (print and electronic) on respiration
- Facilitate students to extract important points and make a summary
- Encourage students to make a presentation on their findings
- Make an elaboration to highlight important points.

Guidelines :

- Importance of cellular respiration
- Aerobic respiration and anaerobic respiration
- **Steps of aerobic respiration of glucose**
- Glycolysis- Break down of glucose to two molecules of pyruvate. Takes place in cytoplasm. Explain what substrate phosphorylation is and how NADH and ATP are formed in the process.
- Conversion of pyruvate to acetyl co-enzyme A in matrix of a mitochondrion with release of CO_2.
- Krebs Cycle- oxidation of acetyl co-enzyme A to CO_2 in a cycle of reactions taking place in mitochondrial matrix.
- Explain how reduced coenzymes NADH, $FADH_2$ and ATP are formed in glycolysis, pyruvate oxidation and in Krebs cycle.
- Electron transport chain, oxidative phosphorylation–oxidation of reduced coenzymes in inner membrane of mitochondria.
- Calculate energy generating efficiency of aerobic oxidation of glucose.
- Anaerobic respiration
    - Explain ethanol fermentation and lactic acid fermentation and their significance.
    - Energy generating efficiency of anaerobic respiration.
- Use of substrates other than glucose in respiration-lipids and proteins.
- Significance of krebs cycle as a center for metabolic intermediates, for the synthesis of amino acids
- Respiratory quotient – Explain what is respiratory quotient and how it can be calculated.

Practical:

- Determination of the rate of respiration using germinating seeds.

Unit 3 – Diversity of organisms

Competency 3.1.0 : **Explores the diversity of organisms**
Competency Level 3.1.1 : **Constructs hierarchy of taxa on scientific basis**
Number of Periods : **08**
Learning Outcomes :
The student should be able to :

- explain the importance of classifying organisms.
- identify organisms through classification and nomenclature.
- name organisms according to the binomial nomenclature.
- explain the methods of natural & artificial classification
- explain systems of classification.
- identify taxonomic levels used in classification of organisms.
- explain characteristics specific to viruses
- use specific characteristics of organisms to classify them into three domains and kingdoms

Suggested learning- teaching process:

- Conduct a brainstorming session on the 'benefits of a systematic classification for the study of organisms.'
- Provide sources (print or electronic) on diverse organisms to the students and ask them to prepare a set of criteria to classify them.
- Lead a discussion on the attempts made to classify organisms in the past and the present status of classification of organisms.
- Advise students to prepare charts and tables depicting the modern biological classification.
- Make an elaboration according to an appropriate sequence.

Guidelines :

- **Identification of organisms, classification and nomenclature.**
  - **Need for classification and nomenclature**
    From the dawn of human civilization people must have begun to identify plants and animals and named them, because their survival was dependent on the use of plants and animals.
    Species were identified separately by their specific characters.
    Major groups of plants and animals (like grasses, fishes, snakes, birds)were also identified separately.
    The names used were however varied depending on the language of the people and the place.
    Biological study of organisms needs a unified system of classification and nomenclature.
    Aristotle was the first person who classified organisms systematically.
  - **Binomial nomenclature**
    With the advance of science and knowledge of biology, different scientists, botanists and zoologists used different methods of naming and classification of organisms. Most often a polynomial system was used, until 18th century.
    Carolous Linnaeus (1707-1778) proposed a binomial system of nomenclature of species, which was accepted world wide.
    The name of an organism has two parts
    First is the generic name and the second is specific epithet
    Generic name is usually a noun and specific epithet an adjective describing a particular feature. Example: *Homo sapiens*- *Homo* means man, *sapiens* means intelligent

Related species have the same generic name with different specific epithets. Ex; *Dipterocarpus zeylanicus* and *Dipterocarpus grandiflorus*

Dipterocarpus zeylanicus means fruit with two wings, and endemic to Sri Lanka.

Dipterocarpus grandiflorus means fruit with two wings and having large flowers.

- **International codes of Binomial nomenclature**

  Biologists have adopted sets of rules or codes of nomenclature. These codes are slightly different for plants, animals, bacteria and viruses. Some of the important rules for naming plants, fungi,bacteria and animals are as follows.
  - Two species of organisms cannot have the same name.
  - Each species has a generic name and a specific epithet, both together forming the species name or scientific name.
  - Name should be made up of Latinized words written in the Roman script.
  - It should be underlined when hand written and italicized when printed.
  - The first letter of the generic name must be capitalized and specific epithet must be in simple letter.

  In scientific work name of the author who gave the name is indicated by a capital letter, an abbreviation or full word at the end of the name, which is not Latinized. Example *Cocos nucifera* L., (L for Linnaeus).

  A third word can be used to represent a subspecies or a variety, example *Panthera pardus kotiya* (Sri Lankan leopard).

- **Methods of natural & artificial classification**

  Arrangement of organisms into groups on the basis of the common characteristics is called classification. Taxonomy is the scientific study on classification. This includes placing groups of organisms in a hierarchical order.

  Two methods of classification

  (1) Artificial classification - grouping is based on a few pre selected unifying characters.
  - The characters are selected first according to convenience and organisms are grouped based on the selected criteria.
  - Natural relationships are ignored.
  - Only system used before 18^{th} century.
  - Easy to use, easy to expand by adding more groups.

    Examples. Plants can be classified as cereals, ornamental plants, medicinal plants, poisonous plants etc. Animals can be classified as two legged, four legged, six legged, eight legged etc. Linnaeus classified plants according to number of stamens.

  (2) Natural classification - grouping based on evolutionary relationships.
  - Represent true (natural) relationships, based on phylogeny.
  - Systems developed after study of evolution.
  - Based on many characters.

    Characters used can be morphological, anatomical, cytological or molecular biological.

    Most recently DNA and RNA base sequences (molecular) are being used

    Examples- Plants can be classified into Bryophyta, Lycophyta, Pterophyta, Cycadophyta, Coniferophyta and Anthophyta etc. Arthropods can be classified into Crustacea, Insecta, Chilopoda, Diplopoda and Arachnida.

- Discuss the advantages and disadvantages of the two systems of classification
- **Use of keys**
  - Used to group organisms and identify
  - Common key is the dichotomous key

- Do not show the evolutionary relationships
- Provide students keys to practice

Example 1: Silverfish, Butterfly, House fly, Beetle

1. Possess wings …………………………………………………. (2)
   Do not possess wings ……………………………………….. Silverfish
2. Possess two pairs of wings ………………………………… …….. (3)
   Do not possess two pairs of wings……………………………………………Housefly
3. Possess a proboscis ……..…………………………………..Butterfly
   Do not possess a proboscis …………………………............ Beetle

Example 2: Snake, Earthworm, Frog, Sea anemone, Butterfly

1. Radially symmetrical body …………………………………..Sea anemone
   Not having radially symmetrical body …………………………..(2)
2. Possess legs……………………………………………………(3)
   Do not possess legs ……………………………………………...(4)
3. Wings present…………………………………....................Butterfly
   Wings absent ……………………………….....................Frog
4. Body covered by scales …………………………………………Snake
   Body is not covered by scales.…………………………………Earthworm

- **Systems of classification**

The early classification systems were all artificial systems. Mostly based on human uses.
Aristotle was the first to classify organisms scientifically. He divided organisms into plants and animals. Animals were further classified according to criteria such as mode of locomotion, reproduction and presence or absence of red blood cells. Aristotle's pupil Theophrastus classified plants according to habit. e.g. Trees, Shrubs and herbs, and according to lifespan e.g. annuals, biennials and perennials.
Up to the time of Linnaeus scientists used many different methods.
Carolus Linnaeus(1753), Swedish botanist, introduced binomial nomenclature and classified about 6000 plants into a hierarchical order of taxa.; Species, genus, order, and class. His classification of flowering plants was based on the number of stamens and styles of flower. He identified two kingdoms of organisms; plants and animals.
With the discovery of microorganisms the scientists understood that there were organisms which could not be assigned into either plants or animals. To get over this difficulty Ernest Haeckel (1866) introduced a third kingdom: Protista. He also introduced the taxon Phylum and classified many organisms.
With the discovery of electron microscope biologists identified prokaryotic and eukaryotic cellular organization . Robert H Whittaker (1969) introduced five kingdom system of biological classification; Monera, Protista, Fungi, Plantae and Animalia. His classification was based on nature of cellular organization, unicellular or multicellular nature and mode of nutrition.
With the acceptance of Darwin's theory on evolution and unitary origin of life, taxonomists began to use natural systems. With recent advancement of molecular biology and the use of molecular methods in studying evolutionary relationships it became apparent that in the very early evolution, organisms had separated into three stocks which are now called Domains. Carl Woese (1977) classified organisms into three Domains Archaea, Bacteria and Eukarya at a higher level over Kingdoms .

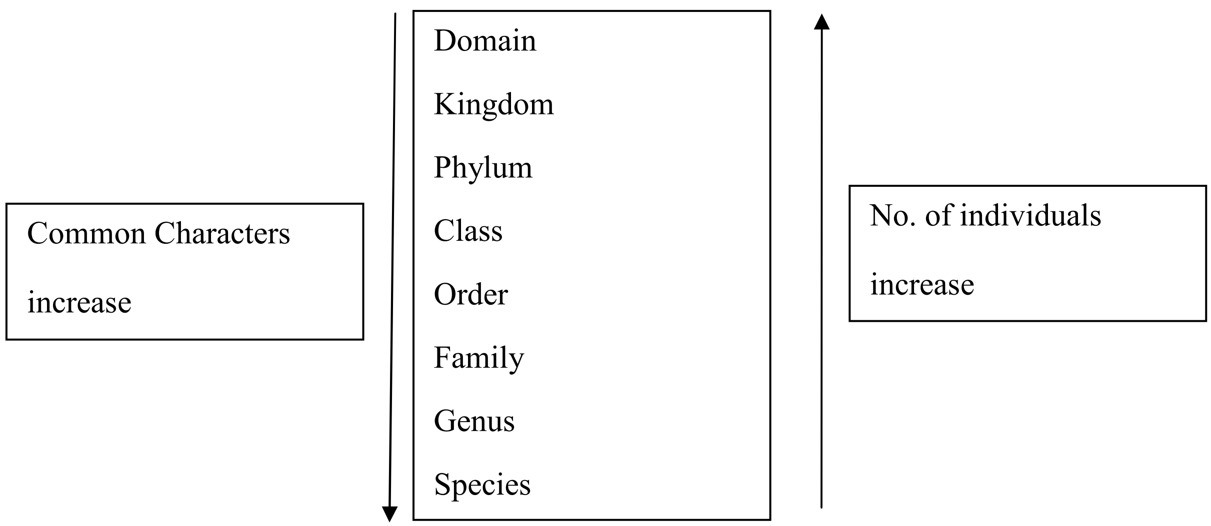
- **Hierarchy of Taxa from Domains to Species.**

  In taxonomy each level of taxonomical hierarchy is called a taxon (plural-taxa) and each taxon has a rank and a name.

  E.g.: Class: Reptilia

  Under the hierarchical system there are levels of taxa. Each Domain is divided into kingdoms. Kingdom is divided into phyla (singular phylum), phylum into classes .etc. Many of these categories may also be subdivided.

  E.g.: Sub-family, Subspecies etc.



From domain to species, the number of shared characters among the members in the taxa increases. From species to domain, the number of individuals in the taxon increases.

- **Present system of classification and its basis**

  With the rapid advance of molecular biology new information on the evolutionary relationships of organisms are being collected rapidly. The sequence of bases of DNA of important genes, DNA of mitochondria, the base sequence of ribosomal RNA, the sequence of amino acids in common proteins, molecular structure of cellular components are used as important taxonomic criteria in modern systematics. As a result classification systems are changing rapidly.

  We adopt here the three domain classification suggested by Woese for convenience. It is very clear however that the kingdom Protista is not a natural group. It is an artificial group including organisms which have different evolutionary origins. Viruses do not have cellular organization, therefore do not belong to any of the kingdoms. It is also an artificial group considered separately.

- **Domain**

  Domain – Bacteria
  Domain - Archaea
  Domain - Eukarya
  Kingdom - Protista
  Kingdom - Fungi
  Kingdom - Plantae
  Kingdom - Animalia

- **Domain : Bacteria**
  - Cellular organization prokaryotic
  - Cell wall component peptidoglycan.
  - Lipids in cell membrane are not branched.
  - Sensitive to antibiotics.
  - Protein synthesis begins with formyl methionine.
  - One kind of RNA polymerase enzyme.
  - Lives in many habitats.
  - Eg: Cyanobacteria, Purple bacteria, Green sulphur bacteria

- **Domain : Archaea**
  - Cellular organization prokaryotic
  - Cell wall component lacks peptidoglycan, contains proteins and polysaccharides.
  - Lipids in cell membrane have branched and chained structure.
  - Not sensitive to antibiotics like streptomycin and chloramphenicol(like eukaryotes)
  - Protein synthesis begins with methionine (like in eukaryotes)
  - Several kinds of RNA polymerase enzymes (like in eukaryotes)
  - Lives in extreme environmental conditions such as volcanic pits, hot springs, salt marshes, deep-sea etc.
  - Eg: *Methanococcus, Thermococcus*
    Methanobacterium, Halobacterium

- **Domain Eukarya**
  - Cellular organization eukaryotic
  - Cell wall component lacks peptidoglycan, contains polysaccharides.
  - Lipids in cell membrane are not branched.
  - Not sensitive to antibiotics.
  - Protein synthesis begins with methionine.
  - Several kinds of RNA polymerase enzymes.
  - Lives in many different environmental conditions.
  - E.g. protists, fungi, plants and animals.

- **Viruses** - Discuss the common characteristics of viruses

- **Tables given in this unit are for the teacher's reference only**
- Kingdoms of Domain Eukarya

- **Main characteristics of each kingdom**

Kingdom Protista	Kingdom Fungi	Kingdom Plantae	Kingdom Animalia
Unicellular or multicellular or colonial form	Unicellular or not truly multicellular which form hyphae	Multicellular	Multicellular
Photoautotrophic or heterotrophic	Heterotrophic	Photoautotrophic	Heterotrophic
If cell wall is present it is made up of cellulose	Cell wall is made up of chitin	Cell wall is mainly composed of cellulose	Cell wall absent
Diverse types of storage food	Storage food is glycogen	Main storage food is starch	Main storage food is glycogen
Flagella ,cilia or pseudopodia may be present	A few are flagellated	Locomotory organs absent but cilia or flagella may be found in gametes	Special locomotory structures present such as cilia, flagella and contractile fibrils

Competency 3.1.0 : Explores the diversity of organisms
Competency Level 3.1.2 : Explores the diversity of organisms within Domain Bacteria
Number of Periods : 02
Learning Outcomes :

The student should be able to :

- elaborate the characteristic features of domain Bacteria.
- differentiate between Bacteria and Cyanobacteria.
- Observe and identify Bacteria and Cyanobacteria through microscope

Suggested learning- teaching process:

- Provide students with literature (print or electronic) on Bacteria and Cyanobacteria.
- Advise them to extract characteristic features and make attractive presentations.
- Provide opportunities for the students to observe Bacteria and Cyanobacteria under light microscope.
- Prepare the students for a presentation on the subject content.
- Make an elaboration according to an appropriate sequence.

Guidelines :

- **Domain : Bacteria**
  - **Characteristic features of Bacteria**
    - Prokaryotic organisms
    - Photoautotrophic, Chemoautotrophic or heterotrophic
    - Motile or nonmotile
    - Unicellular or colony forming
    - Cell division is by transverse binary fission
    - Plasma membrane is a fluid mosaic structure
    - The cell walls are composed of Peptidoglycan
    - Ribosomal proteins & RNA Polymerase are different from those of eukaryotes.
    - Examples : Coccus, Bacillus
  - **Characteristic features of Cyanobacteria**
    - Prokaryotic organisms
    - Photosynthetic
    - Most are unicellular. But some are linked to form filaments sheathed in mucous.
    - Photosynthetic pigments are chlorophyll a , phycocyanin .Blue-green in colour.
    - Some have the ability of fixing atmospheric nitrogen
    - Examples : *Lyngbya, Anabaena*, *Nostoc*
  - Practical:
  - Observation of the characteristic features of typical Bacteria and Cyanobacteria

Competency 3.1.0 : **Explores the diversity of organisms**
Competency Level 3.1.3 : **Explores the diversity of organisms within the kingdom Protista**
Number of Periods : **04**
Learning Outcomes :

The student should be able to :

- elaborate the characteristic features of kingdom Protista.
- classify organisms in kingdom Protista into phyla using characteristic features.
- identify organisms belonging to kingdom Protista.

Suggested learning- teaching process:

- Provide students with literature (print or electronic) on kingdom Protista
- Advise them to extract characteristic features
- Provide opportunities for the students to make observations using microscope and live/preserved specimens of Protists to identify characteristics.
- Prepare the students for a presentation
- Make an elaboration according to an appropriate sequence.

Guidelines :

- Phyla of kingdom Protista
- Discuss the main characteristics of each phylum

Ciliophora	**Rhizopoda**	**Chrysophyta**	**Phaeophyta**	**Rhodophyta**	**Chlorophyta**
Unicellular	Unicellular	Unicellular	Multicellular	Multicellular	Uni or multicellular
Heterotrophic	Heterotrophic	Photo autotrophic Chlorophyll-a,c, carotene, fucoxanthin are the photosynthetic pigments	Photo autotrophic Chlorophyll-a,c, carotene fucoxanthin	Photoautotrophic Chlorophyll-a,d, phy cocyanin, phycoerythrin, carotene	Photoautotrophic Chlorophyll-a,b, carotene, xanthophyll
Cilia as the locomotory structures	Pseudopodia	Reproductive cells have single flagellum	Reproductive cells have flagella	No flagella	Vegetative cells and reproductive cells posses flagella
No cell wall	No cell wall	Made up of cellulose, pectin, mainly silica	Cellulose, alginic acid	Cellulose, agar	Cellulose, pectin
		Storage - Chrysolaminarin	Laminarin & manitol	Floridian starch	Starch
Paramecium	*Amoeba*	Diatoms	*Sargassam*	*Gelidium*	*Chlamydomonas*

- Practical
  - Observation of the characteristic features of typical organisms of above phyla.

Competency 3.1.0 : **Explores the diversity of organisms**
Competency Level 3.1.4 : **Explores the diversity of organisms within the kingdom Fungi**
Number of Periods : **04**
Learning Outcomes :

The student should be able to :

- identify fungi growing in different habitats.
- observe and identify the vegetative and reproductive structures of fungi.
- classify organisms in kingdom Fungi on the basis of vegetative and reproductive structures.

Suggested learning- teaching process:

- Provide students with literature (print or electronic) on kingdom Fungi.
- Advise them to extract characteristic features
- Provide opportunities for the students to make observations on microscopic and live/preserved specimens of Fungi and identify characteristics.
- Prepare the students for a presentation
- Make an elaboration according to an appropriate sequence.

Guidelines :

- Discuss the main characteristics of main phyla of kingdom Fungi

Phylum - Chytridiomycota	**Phylum – Zygomycota**	**Phylum – Ascomycota**	**Phylum – Basidiomycota**
Aquatic, flagellated fungi, dichotomously branched hyphae	Branched, coenocytic and aseptate mycelium	Branched, multinucleated and septate mycelium	Branched, monokaryotic or dikaryotic and septate mycelium
Asexual reproduction by flagellated zoospores.	Asexual reproduction by spores within sporangium	Asexual reproduction by conidia	Asexual reproduction by various spores
Sexual reproduction by motile male and female gametes	zygosporangium is produced in sexual reproduction	Sexual reproduction by ascospores	Sexual reproduction by basidiospores
Allomyces	*Mucor*	*Aspergillus*	*Agaricus*

- Practical:
    - Observation of the characteristic features of typical organisms of the above phyla.

Competency 3.1.0 : **Explores the diversity of organisms**

Competency Level 3.1.5 : **Explores the diversity of organisms within the kingdom Plantae**

Number of Periods : **06**

Learning Outcomes :

The student should be able to :

- classify organisms in to kingdom Plantae using characteristic features.
- describe and compare the adaptations of each phyla in Plant kingdom for their successful terrestrial life.
- classify flowering plants into Monocots and Dicots using characteristics features.

Suggested learning- teaching process:

- Provide students with literature (print or electronic) on Kingdom Plantae
- Provide opportunities for the students to make observations on microscopic and live/preserved specimens and identify characteristics.
- Prepare students for a presentation.
- Make an elaboration according to an appropriate sequence

Guidelines :

- Discuss the main characteristics of the phyla of kingdom Plantae

<table>
<tr><th>Bryophyta</th><th>Lycophyta</th><th>Pterophyta</th><th>Cycadophyta</th><th>Coniferophyta</th><th>Anthophyta</th></tr>
<tr><td>Especially common in moist terrestrial places</td><td>Common in moist terrestrial places</td><td colspan="4">Terrestrial Life adaptations are found</td></tr>
<tr><td>No vascular tissue</td><td colspan="5">Vascular tissues are present</td></tr>
<tr><td>Gametophytes are dominant & photosynthetic</td><td>Sporophytes are dominant & gametophytes partially depend on sporophytes</td><td>Sporophytes are dominant both are photosynthetic</td><td colspan="3">Sporophytes are dominant and photosynthetic Gametophytes depend on Sporophytes</td></tr>
<tr><td>Homosporous</td><td>Homosporous or heterosporous</td><td>homosporous</td><td colspan="3">Heterosporous</td></tr>
<tr><td colspan="3">External water is necessary for fertilization</td><td colspan="3">For fertilization external water is not essential</td></tr>
<tr><td colspan="3">Seed less plants</td><td colspan="3">Seed bearing plants</td></tr>
<tr><td colspan="3"></td><td colspan="2">Naked seed plants</td><td>seeds in fruits</td></tr>
<tr><td colspan="5">← Do not bear flowers →</td><td>Bear flowers as sexual reproducing unit</td></tr>
<tr><td>Marchantia, Mosses- Pogonatum</td><td>Sellaginella Lycopodium</td><td>Nephrolepis (Ferns)</td><td>Cycas</td><td>Pinus</td><td>flowering plant</td></tr>
</table>

- Discuss the main characteristic features of classes of phylum Anthophyta

Class – Monocotyledoneae	Class – Dicotyledoneae
The embryos have only one cotyledone	Embryos have two cotyledons
Fibrous root system	Tap root system
Parallel veins in leaves	Reticulate veins in leaves
Flower parts are trimerous	Flowers are pentamerous or tetramerous
Perianth present in flowers (No distinct calyx & corolla)	Distinct calyx and corolla present in flowers
Vascular bundles in the stem do not have cambia and are scattered E.g.: grasses, coconut, paddy	Vascular bundles in the stem have cambia and arranged in a ring E.g.: Rose, shoe flower

- Practical:
  - Observation of characteristic features of typical organisms of the above phyla and classes.

Competency 3.1.0 : **Explores the diversity of organisms**
Competency Level 3.1.6 : **Explores the diversity of organisms within the kingdom Animalia**
Number of Periods : **05**
Learning Outcomes :
The student should be able to:
- elaborate the characteristic features of kingdom Animalia.
- uses characteristic features of each phylum as appropriate criteria to classify organisms belonging to kingdom Animalia
- identify typical organisms belonging to phyla in kingdom Animalia.

Suggested learning- teaching process:
- Provide students with literature (print or electronic) on invertebrate phyla of kingdom Animalia.
- Provide opportunities for the students to make observations on live/preserved specimens to identify characteristics.
- Advise them to synthesize characteristic features
- Prepare the students for a presentation.
- make an elaboration to highlight important points.

Guidelines :
- Discuss the main characteristics, of the Invertebrate phyla of kingdom Animalia.

Coelenterata (Cnidaria)	**Platyhelminthes**	**Nematoda**	**Annelida**	**Mollusca**	**Arthropoda**	**Echinodermata**
Marine or freshwater	Free-living forms inhabit water or moist soil, parasites inside the host body	Found in soil, water and as parasites.	Found in marine, freshwater or on/in soil	Mostly marine or freshwater, Some terrestrial	Terrestrial or aquatic	Exclusively marine
Radial symmetry	Bilateral symmetry					Adults: penta radial symmetry Larvae :bilateral symmetry
Diploblastic,	Triploblastic					
Mesoglea present between two germ layers	No body cavity	Pseudocoel-om present	Well developed coelom	Haemocoel (Coelom reduced)	Haemocoel (Coelom greatly reduced)	Large coelom .A part is developed as water vascular system with associated tube feet

Coelenterata (Cnidaria)	**Platyhelminthes**	**Nematoda**	**Annelida**	**Mollusca**	**Arthropoda**	**Echinoderma ta**
Two types of body form - tube like polyp, umbrella like medusa No segmentation	Dorsoventrally flattened body. No segmentation	Slender, cylindrical tapered end body. No segmentation	Cylindri- -cal worm like body internal and external segmentation	A little trace of segmen- tation Different types of body forms	Externally segmented body. Each segment typically bears a pair of jointed appendages.	Cylindrical or star or flower like form. No segmentation
Cephalization absent	Shows some degree of cephalization	Shows some degree of cephalizatio n	Shows cephalization	Clear cephalization. Body is divided into head, muscular foot, visceral mass	Distinct cephalization, parts of body; generally divided into head, thorax & abdomen	No cephalization Body is arranged in oral aboral axis
Nematocysts present in cell layer. No cuticle	Epidermis soft and ciliated or covered by cuticle and with external suckers or hooks or both	Tough cuticle is present	Definite cuticle and chetae of chitin	Body covering is soft and it forms a mantle	Exoskeleton of chitin secreted by epidermis	Body covered by delicate epidermis often with spines
Corals posses limy or horny Exoskeleton.	No skeleton	Hydrostatic skeleton of pseudocoelo mic fluid	Hydrostatic skeleton of coelomic fluid	Many have Exoskeleton, In some endoskeleton	exoskeleton	endoskeleton
		Lacks cilia at any stage			Lacks cilia at any stage	

Coelenterata (Cnidaria)	Platyhelminthes	Nematoda	Annelida	Mollusca	Arthropoda	Echinodermata
Gastro vascular cavity	Incomplete alimentary canal. Only mouth no anus	Complete Alimentary canal having mouth & anus				Complete alimentary tract in some. Some lack anus
				Radulla present in some	Mouth parts present	
No circulatory system			Closed circulatory system with lateral hearts	Open circulatory system with dorsal heart		Reduced circulatory system
No respiratory organs			Some have external gills	Gills or ctenidia in the mantle cavity for respiration. Land forms respire through mantle	Gills or book lungs or trachea as respiratory structures	Gills or papillae or tube feet or cloacal respiratory tree as respiratory structure
No excretory system	Simple excretory system with flame cells & ducts	Simple excretory system with longitudinal canals	Excretory structures: nephridia		Green gland or malphigian tubules	No excretory system
Nerve net	A pair of anterior ganglia or a nerve ring with longitudinal nerve cords (1-3)	Nerve ring with longitudinal nerve cords	One pair of cerebral ganglia & double, solid, mid ventral nerve cord	Nerve ring with pairs of ganglia & 2 pairs of nerve cords	Paired dorsal cerebral ganglia & double ventral solid nerve cord	Nervous system with nerve rings and radial nerves
Some with eyespots and/or statocysts as sensory structures	Free living forms have eyespots & chemoreceptors	Mainly papillae	Simple eyes. tentacles and palps in some	Sensory Organs Tentacles, Some have eyes,eyespots and statocysts	Antennae, statocysts sensory hairs simple and compound eyes	Most do not have sensory organs. Some have tactile tube feet eye spots & sen sitive tentacles
Simple gonads without ducts	Gonads, gonadal ducts, accessory organs present	Gonads with ducts	Gonads and ducts	Gonads & ducts	Gonads & ducts	Large gonads with ducts
Asexual reproduction by budding or regeneration	Asexual reproduction in some forms by fragmentation	No asexual reproduction or regeneration	In some by budding or regeneration		In some regeneration	In some regeneration
Unisexual/ bisexual	Usually bisexual	Unisexual	Unisexual or bisexual	Usually unisexual	Unisexual By parthen ogenesis in some insects and crustaceans	Unisexual
External fertilization	Internal fertilization	Internal fertilization	External or internal fertilization	External or internal	Mostly internal	External fertilization
Planula larva	Many larval Stages in parasites. Free living forms have no larval stages	Larval Stage in some	Trochophore larva	Trochophore or veliger larva	One or more larval stages	Bipinnaria or dipleurula larva

- Discuss characteristic features of Phylum Chordata
  - A rod like dorsal notochord present in adults or at least during some developmental stages
  - A single, dorsal hollow nerve cord
  - Pharyngeal gill slits are present at some developmental stage
  - Post-anal tail is present in adults or at least during some developmental stage
  - Closed circulatory system with a ventral heart
  - Coelom well developed
  - Skeleton if present, is an endoskeleton formed by mesoderm
  - Sexes usually separate, oviparous, ovoviviparous or viviparous
- Practical
  - Observation of characteristic features of typical organisms of the above phyla

Competency 3.1.0 : **Explores the diversity of organisms.**
Competency Level 3.1.7 : **Uses the external features of organisms to identify their classes.**
Number of Periods : **06**
Learning Outcomes :

The student should be able to :

- use external features to classify organisms in phylum Coelenterata, Platyhelminthes, Annelida, Mollusca, Arthropoda and Echinodermata into major classes.
- identify organisms belonging to major classes of phylum Coelenterata, Platyhelminthes, Annelida, Mollusca, Arthropoda and Echinodermata.
- explores the diversity of classes within the Invertebrate Phyla.

Suggested learning -teaching process:

- Provide students with literature (print or electronic) on selected classes of Invertebrate phyla of kingdom Animalia.
- Provide opportunities for the students to make observations on live/preserved specimens to identify characteristics.
- Advise them to synthesize characteristic features and make presentations.
- Make an elaboration to highlight the important points.

Guidelines :

- **Classes of Phylum Coelenterata (Cnidaria)**

Hydrozoa	Scyphozoa	Anthozoa
Dominant stage- polyp which is solitary or colonial, medusa is small & free swimming	Dominant stage-medusa which is umbrella shaped & free swimming, polyp stage is minute or lacking	Polyp stage only ,which is solitary or colonial , No medusa stage
A circle of tentacles around mouth	Four oral arms around mouth , Tentacles on the edge	Many tentacles around mouth in many circles
E.g., *Hydra, Obelia*	E.g., *Aurelia* (jelly fish)	E.g.,Sea anemone, Corals

Classes of Phylum : Platyhelminthes

Turbellaria	Trematoda	Cestoda
Free living	Endoparasitic or ectoparasitic	Endoparasitic
Leaf like body. Eye spots present	Leaf like body, No eyespots in adults	Slender, elongated,flat body divided into scolex and proglottids, no eye spots
Ventral mouth with protrudable pharynx, No suckers	Ventral sucker or suckers on ventral side and oral sucker surrounds mouth	Suckers and hooks on scolex. No mouth
Ciliated epithelium with mucus glands	Cuticle with spines	Cuticle with microvilli
E.g., *Planaria,Bipalium*	E.g., *Fasciola* (liver fluke)	E.g., *Taenia* (tape worm)

Classes of Phylum : Annelida

Polychaeta	Oligochaeta	Hirudinea
Distinct head with eyes and tentacles	No distinct head	No distinct head, having anterior and posterior suckers
Presence of parapodia	No parapodia	No parapodia
Numerous setae	Fewer number of setae	No setae
No clitellum	Clitellium present	No clitellum
E.g.,*Nereis*	E.g.,Earth worm	E.g.,Leech

Classes of Phylum : Mollusca

Polyplacophora	Bivalvia	Gastropoda	Cephalopoda
Dorsal shell formed by 8 over - lapping plates	Shell of two lateral valves	Univalved shell usually coiled,In some shells are reduced or absent	Shell external, internal or none
Radula present	No radula	Radula present	Radula present
Large, flat foot	Hatchet shaped foot	Largely developed foot	Foot is modified into arms, tentacles and siphon
Head is present, without eyes or Tentacles. In some eye spots present	No head No eyes No tentacles	Head is present with tentacles and eyes Eyes on one pair of tentacles	Head is present with conspicuous eyes and 8-10 arms
E.g.,*Chiton*	E.g.,Mussels, Oyster	E.g.,Snail, Slug	E.g.,Squid, Octopus

Classes of phylum : Arthropoda

Crustacea	Insecta	Chilopoda	Diplopoda	Arachnida
Body is divided into cephalothorax and abdomen	Head, thorax and abdomen distinct	Head followed by numerous segments of body	Head, short thorax abdomen	(prosoma) cephalo - thorax and abdomen (opisthosoma)(except in ticks)
One pair of appendages per somite	3 pairs of legs on thorax one/two pairs of wings.Some without wings	One pair of legs per somite of the body. Poison claws present	Two pairs of legs per somite in the abdomen	4 pairs of legs on cephalothorax (prosoma)
Two pairs of antennae	One pair of antennae	One pair of long antenna	One pair of short antenna	No antennae
E.g.,prawn, crab	E.g., cockroach (any insect)	E.g., Centipede	E.g.,Millipede	E.g.,Scorpion, Spider, Tick, Mite

Classes of phylum : Echinodermata

Asteroidea	Ophiuroidea	Echinoidea	Holothuroidea	Crinoidea
Consists of a central disc and five tapering arms,each with a longitudinal central groove (ambulacral groove)	Small rounded disc with five distinct arms which are long,slender fragile & jointed,closed ambulacaral groove	No arms: Rounded or flat body	Elongated cylindrical slender body	Body is a small cup shaped calyx of limy (calcified)plates to which five flexible arms (each with a longitudinal ambulacral groove) are attached. Some have stalks
On the upper surface there are many blunt calcareous spines and pedicellaria,Many gills present	No pedicellaria Spines in lateral side of arm	Movable spines and pedicellaria. Ten gills around mouth	No spines or pedicellaria	Bearing many slender lateral pinnules. No spines
Mouth is in the lower(oral) surface & anus is in the upper(aboral) surface	Mouth is centered & no anus	Mouth oral (ventral surface) & anus aboral(dorsal surface)	Mouth anterior. Anus posterior	Mouth and anus on oral (upper) surface
Tube feet with suckers are present in the oral surface	Tube feet with no suckers in two rows	Slender tube feet with suckers	Tube feet usually present with suckers	Tentacle like tube feet
E.g., Star fish	E.g., Brittle star	E.g., Sea urchin, Sand dollar	E.g., Sea cucumber	E.g., Sea lily

- Observation of characteristic features (external) of typical organisms of the above classes.

Competency 3.1.0 : Explores the diversity of organisms.
Competency Level 3.1.8 : Uses the characteristic features to study organisms belonging to phylum Chordata
Number of Periods : 05
Learning Outcomes :

The student should be able to :
- classify organisms in phylum Chordata into classes using characteristic features.
- identify organisms belonging to classes of phylum Chordata.

Suggested learning - teaching process
- Provide students with literature (print or electronic) on selected classes of phylum Chordata.
- Provide opportunities for the students to make observations on live/preserved specimens to identify characteristics.
- Advise them to synthesize characteristic features and make presentations.
- Make an elaboration to highlight important points.

Guidelines :
- Characteristic features to identify major classes of Chordata.

Classes of Phylum : Chordata

Chondrichthyes	Osteichthyes	Amphibia	Reptilia	Aves	Mammalia
Spindle shaped body divided into head , trunk and tail.	Spindle shaped body divided into head ,trunk and tail.	Body comprises head and trunk Some have a tail	Head, neck, trunk and tail,	Stream lined body divided into head, neck, trunk, tail	Body with head, neck, trunk & tail. Differ in forms
Skin with placoid scales	Skin with cycloid or ctenoid scales	Soft skin with glands	Skin dry with horny scales or horny plates,No skin glands	Skin bears feathers ;legs have scales	Skin bears hairs and glands
Paired pectoral & pelvic fins		Paired pentadactyl limbs		Paired pentadactyl limbs; front pair form wings	Paired pentadactyl limbs
Heterocercal caudal fin	Homocercal caudal fin	Some adults have tail . All larval forms have tails	Post anal tail covered with scales	Short tail bears long tail feathers	Tails are of diverse forms.Some have tails only in embryo
Ventral mouth with enamel capped teeth	Usually terminal mouth with teeth which are bony	Ventral mouth. If teeth are present they are fastened to the surface of bones	Wide mouth margined with teeth, in some teeth in sockets	Mouth is extended as beak;. no teeth	Ventral mouth with teeth in sockets

Chondrichthyes	Osteichthyes	Amphibia	Reptilia	Aves	Mammalia
Inner ear only; no middle or external ear	Inner ear only;no middle or external ear	Inner and middle ear only; no external ear	Inner ,middle and external ear	Inner ,middle and external ear	External, middle and inner ear. Pinna present
Cartilaginous skeleton.	Bony skeleton	Largely bony skeleton	Completely ossified skeleton	Skeleton light, strong, fully ossified with air cavities	Skeleton largely of bony with cartilage articulating over surfaces
Eyes usually well developed without lids,lateral line present	Eyes usually well developed without lids. lateral line present	Eyes often with movable lids. Nictitating membrane present. Lateral line in larvae	Large lateral eyes with eye lids and nictitating membrane	Large and lateral eyes with eye lids and nictitating membrane	Eyes with movable lids some have nictitating membrane. In some it is vestigial
Two chambered heart	Two chambered heart	Three chambered heart	Three chambered heart	Four chambered heart	Four chambered heart
Respiration by gills ,several gill openings No operculum	Respiration by gills, pair of gill openings. Gills covered by operculum	Respiration by gills, lungs, skin or Buccal cavity lining	Respiration by lungs		
Excretion by kidney, major nitrogenous waste is urea	Excretion by kidney, major nitrogenous waste is urea - for marine forms, NH_3 for fresh water forms	Excretion by kidney, major nitrogenous waste is urea for adults, NH_3 for larval forms	Excretion by kidney, major nitrogenous waste is uric acid		Excretion by kidney, major nitrogenous waste is urea
Poikilothermic				Homoeothermic	
Ten pairs of cranial nerves			Twelve pairs of cranial nerves		

Chondrichthyes	**Osteichthyes**	**Amphibia**	**Reptilia**	**Aves**	**Mammalia**
No larval stage; oviparous or ovoviviparous;	Larval stage may be present; usually oviparous;	Larval stage usually present. Oviparous	No larval stage. Oviparous or ovoviviparous ; yolky eggs in shells	No larval stage. Yolky eggs in calcareous shells; oviparous.	No larval stage. Embryo develop within mother. Viviparous , some are oviparous . young feed on milk produced by the mammary glands of mother
Internal fertilization	External fertilization	External or internal fertilization	Internal fertilization	Internal fertilization	Internal fertilization
E.g.: shark, skate	E.g.: mullet, Tuna, Carangids,Tilapia	E.g.: toad, frog, salamander, *Ichthyophis*	E.g.: lizard, Cobra, crocodile, turtle ,tortoise	E.g.: parrot, crow,Ostrich (Any bird)	E.g.: rat, man, whale, sea lion, platypus, bat (Any animal that feeds on mother's milk)

- Practical
    - Observe the characteristic features (external) of typical organisms of the above classes.

Unit 4 - Nutrition

Competency 4.1.0 : Explores the diversity of nutritional processes.

Competency Level 4.1.1 : Investigates the modes of nutrition in organisms

Number of Periods : 06

Learning Outcomes :

The student should be able to:

- explain nutrition as an essential life process
- differentiate between photoautotrophic & chemoautotrophic nutrition.
- explain the process of heterotrophic nutrition.
- describe modes of heterotrophic process.
- describe the nutrition of insectivorous plants as a special mode

Suggested learning- teaching process:

- Show a video/ picture of an insectivorous plant and get the students to name a few examples.
- Provide sources (print and electronic) on nutrition
- Make them understand insectivorous plants as a special mode of nutrition.
- Let the students study the resource materials and extract the following points on each mode of nutrition
  - Concept
  - Need
  - Process
  - Benefits
  - Examples
- Instruct the students to present their findings.
- Make an elaboration according to an appropriate sequence

Guidelines :

- **Nutrition and its need**
  - Nutrition is the process of acquiring energy and carbon
  - Organisms need energy for synthesis of substances for growth and repair. Ex: Protein synthesis, active transport of substances into and out of cells against concentration gradient (Sodium-Potassium pump), electrical transmission of nerve impulses, mechanical contraction of muscle and beating of cilia and flagella
- **Different modes of nutritional patterns in the living world:**
  - Living organisms can be grouped on the basis of their source of energy or source of carbon
  - Organisms which have an inorganic source of carbon such as carbon dioxide are described as autotrophic
  - Organisms having an organic source of carbon are described as heterotrophic
  - Organisms using light energy are described as phototrophic
  - Organisms using chemical energy are described as chemotrophic

- Autotrophs synthesize their own organic requirements from simple inorganic materials
- **Autotrophic nutrition** - is of two types:
  - **Photoautotrophic** – Energy source is sunlight and carbon source is carbondioxide.eg: cyanobacteria, ,green plants
  - **Chemoautotrophic**- energy source is chemical substances and carbon source is Carbondioxide eg; nitrifying bacteria like *Nitrobacter, Nitrosomonas*
- **Heterotrophic nutrition -** organisms feed on an organic source of carbon. All animals and fungi and majority of bacteria are heterotrophic
  - **Modes of heterotrophic nutrition**
  - There are three types:
    1. Saprotrophic
    2. Holozoic
    3. Symbiotic
    - **Saprotrophic nutrition**
      Organisms which feed on dead or decaying organic matter are called saprotrophs. eg: Many fungi and bacteria. Saprotrophs secrete enzymes on to the dead organic matter and digest. Soluble end products of this extracellular digestion are then absorbed and assimilated by the saprotrophs
    - **Holozoic nutrition**
      Most animals are holozoic. They ingest food into their alimentary canal. This mode of nutrition consists of five main steps ;
      Ingestion, digestion, absorption, assimilation and ejection.
    - **Symbiosis**
      Two different species of organisms living together. It is divided into three groups.
      - Mutualism
      - Parasitism
      - Commensalism
        - **Mutualism**
          It is a close association between two living organisms of different species, which is beneficial to both partners. e.g., Legume root nodules and *Rhizobium*
        - **Parasitism**
          It is a close association between two living organisms of different species, which is beneficial to one (parasite) and harmful to the other (host)
          e.g., *Plasmodium*, *Necator americanus, Cuscuta, Loranthus*
        - **Commensalism**
          It is a close association between two living organisms of different species which is beneficial to one and does not affect the other. e.g., Sea anemone and hermit crab, epiphytes (orchids)

- **Insectivorous plants**

  This is a special type of nutrition. These plants capture insects passively or actively and obtain specially their nitrogen requirements by digesting them.

  e.g., *Nepenthes, Drosera, Utricularia*

Competency 4.1.0 : Explores the diversity of nutritional processes

Competency Level 4.1.2 : Analyses the nutritional requirements for the optimum growth of plants

Number of Periods : 01

Learning Outcomes :

The student should be able to:

- state the macro & trace elements required for plants.
- explain forms of absorption
- describe functions & deficiency symptoms

Suggested learning- teaching process:

- Engage the students referring the competency level 2.1.1 (examines the elemental composition of living bodies)
- Give the following groups of elements to the students.
- C, N, Mg, Cl, Zn, Mo
- O, K, P, Fe, B
- H, Ca, S, Mn, Cu
- Instruct the students to gather information from a variety of sources regarding the following topics, and conduct a presentation to the class.
- Divide the elements into macro and trace elements required for plants, forms of absorption, functions and deficiency symptoms.
- Make an elaboration to cover the specified content

Guidelines :

- **Macro and trace elements required for plants**
- Plants require a number of inorganic nutrients
- Some elements are considered essential elements due to the fact that:
  - They are components of structural material of plant
  - They cannot complete the life cycle without these nutrients
- Some of these are macro elements, which the plants need in relatively large amounts- e.g., C , H , O ,N , K , Ca , Mg , P , S
- Trace elements are required in low amounts e.g., Cl , Fe , B , Mn , Zn , Cu ,Mo,

Functions and deficiency symptoms

  - See appendix

- **Forms of absorption**
  - See appendix

Competency 4.1.0 : Explores the diversity of nutritional processes
Competency Level 4.1.3 : Relates the structure of the human digestive system to its functions
Number of Periods : 07
Learning Outcomes :

The student should be able to:

- explain the structure & functions of the human digestive system.
- describe the components of food & their function.
- state the sources & deficiency symptoms.
- explain food related disorders in the alimentary canal.

Suggested learning - teaching process:

- Let the students study the models/ diagrams and other sources.
- Make them study the basic histological structure of the human alimentary canal and relate the major variations in different regions to their functions (to be done together with practical activity)
- Instruct them to find the following
  - Structure and functions of human digestive system
  - Associated glands

- Ask the students to find out the components of food and their functions, sources and deficiency symptoms
- Make students find information on the common disorders of human alimentary canal.
- Encourage the students to present their findings to the whole class
- Make an elaboration to cover the specified content.

Guidelines :

- Human digestive system consists of following parts. mouth, buccal cavity, pharynx, esophagus, stomach, small intestine ,large intestine , rectum, anus
- The location ,gross morphology and function of the above should be explained
- Dentition
- Structure and role of teeth
- Action that should be taken to maintain dental health
- Generalized structure of gut wall
  - Mucosa
  - Sub mucosa
  - Muscle layers
  - Serosa
- Explain that the arrangement of tissue layers of the alimentary canal is according to a basic plan
- Major variations in the basic plan occur in the mucosa. Variations in the stomach, small intestine and large intestine should be explained in relation to their functions
- Peristalsis

- Associated glands
  - Salivary glands – structure and functions
  - Pancreas – structure and functions
  - Liver – structure and functions
- Endocrine – function of the following hormones
  - Gastrin
  - Cholecystokinin-Pancreozymin
  - Secretin
  - Enterogastrone
- Components of food and their function
  - Carbohydrates
  - Proteins
  - Lipids
  - Vitamins
  - Mineral elements
  - Water
  - Fibers
- Sources of food and deficiency symptoms
- Vitamin deficiencies and symptoms
- Fe, Ca and I deficiencies and symptoms
- Food related disorders in the alimentary canal
  - Gastritis
  - Constipation
- Gastritis
  - Glands of the stomach wall are stimulated and secrete excess HCl causing damage to the mucosa
  - Due to the damages of mucosa layer of the stomach, blisters are formed
  - Secretion of excess HCl depends on;
    - Prolonged starvation
    - Consumption of alcohol
    - Suffering from diseases such as T.B. and syphilis
    - Mental stress
  - Control:
    Behavioral adjustments should be highlighted
  - Constipation
    - Inhibition of the reflex action in defecation may lead to constipation
    - Pain of the anus, difficulty in defecating
    - Control:
      Behavioral adjustments should be developed to carry out defecation properly, adequate fiber in the diet

  - Practical :
    - Study the basic histological structure of the alimentary canal of man and relates the major variations in different regions of their functions.

Unit 5 – Respiration

Competency 5.1.0 : **Investigates the process of gaseous exchange among animals**

Competency Level 5.1.1 : **Explores the diversity of respiratory structures in the animal kingdom**

Number of Periods : **04**

Learning Outcomes :

student should be able to;

- state the characteristics of respiratory surfaces.
- explain diffusion and its relation to surface to volume ratio.
- describe respiratory structures in animals.

Suggested learning - teaching process

- Conduct a brain storming session on how animals exchange gases highlighting then following points.
  - respiration is a process of obtaining energy
  - animals have different respiratory structures depending mainly on the environment they live.
- Following instructions are for the students to engage in the activity
  - Out of the following set of respiratory structures in animals select the set of structures assigned to your group
    - body covering, trachea
    - external gills, internal gills
    - book lungs, lungs
  - Study the type of respiratory structures in animals using resources provided
    - Describe the respiratory structures with suitable diagrams
    - Explain the characteristics of respiratory surfaces
    - Be prepared to present your findings to the class.
- Make an elaboration according to an appropriate sequence .

Guidelines

Characteristics of respiratory surfaces

- Explain that the area where gaseous exchange takes place with the environment is called the respiratory surface
- Gaseous exchange takes place in all organisms by the physical process of diffusion
- An effective respiratory surface must have the following properties.
  - It must be permeable, and wet so that gases can pass through
  - It must be thin because diffusion is only efficient over the thin surfaces.

- It should possess a large surface area to allow sufficient volumes of gases to be exchanged according to the organism's need.
- It should possess a good blood supply.

Diffusion and surface to volume ratio

- Respiratory gas exchange occurs due to diffusion. In small animals diffusion through body surface is adequate as they are simple and the energy requirement is very low.
  In large animals, the complexity and the energy requirement is high. Therefore, to fulfill this requirement this is not adequate.
  When surface volume ratio decreases, sufficient area is needed for gas exchange and thus respiratory structures with large surface area were developed.
- Respiratory structures in animals
  - Body surface e.g., Earthworm, flat worm
  - External gills e.g., Polycheate worms(*Arenicola),* tadpole, salamander
  - Internal gills e.g., Bony fish, lobster
  - Trachea eg: Insects, Millipedes, Centipedes
  - Book lungs e.g., Spider, scorpion
  - Lungs e.g., Mammals (Human), Reptiles, Birds.

Competency 5.1.0 : **Investigates the process of gaseous exchange among animals**

Competency Level 5.1.2 : **Relates the structure of the human respiratory system to its functions.**

Number of Periods : **06**

Learning Outcomes :

The student should be able to:

- explain the gross structure of the human respiratory system.
- describe the mechanism of ventilation of lungs.
- explain the respiratory cycle & lung volume.
- explain the exchange of gases between blood & air ,blood & tissue.
- describe the regulation of respiration in man.
- state the disorders of the human respiratory system.

Suggested learning – teaching process :

- Lead a discussion to highlight the relationship between structure and functions of human respiratory system using models, preserved specimens, charts, animations or web resources (to be done as a practical activity)
- Advise students to collect information on the following disorders of human respiratory system
    - Impacts of smoking
    - Impacts of dust
    - Silicosis & Asbestosis.
- Let the students observe & record the effect of exercise on respiratory rate and pulse rate
- Prepare students for a presentation.
- Make an elaboration covering the specified content.

Guidelines

- Gross structure of the human respiratory system.
- The gross structure and location of components of human respiratory system -nostrils, nasal cavity, pharynx, larynx, trachea, bronchi, bronchioles, alveolar sacs (lungs)
- The structure of each related with the function should be explained.
- The walls of respiratory passage are lined with ciliated pseudo columnar epithelial cells & goblet cells. (Cartilages are present in larynx, trachea and bronchi)
- Mechanism of ventilation of lungs
    - Mechanism of lung ventilation should be explained with the aid of diagrams.

- The role of inter coastal muscles & diaphragm in inspiration & expiration should be explained

- Respiratory cycle & lung volume
- Exchange of gases between blood & air
- Oxygen dissolves in mucous and diffuses across the thin epithelium of alveoli & endothelium of the capillaries. It passes first into the blood plasma & combines with haemoglobin to form oxyhaemoglobin
- Explain exchange of gases between blood & tissues
- Regulation of respiration
- Regulation of breathing by chemo receptors and respiration control centre in medulla oblongata
- Disorders of the human respiratory system
- The effect of smoking on the smooth functioning of the respiratory system
- It should be pointed out that smoking tobacco will increase the risk of illness, disability and death from diseases such as bronchitis and lung cancer. In this regard, the following points may be highlighted.
- Cigarette smoke stimulates the secretion of mucus by the goblet cells and inhibits the action of cilia in the respiratory tract causing accumulation of mucus in bronchioles and blocking them, leading to bronchial inflammation or bronchitis. As a result, breathing may become difficult.
    - Due to loss of action of cilia, dust particles are also collected in the lung, resulting in an increase in phagocytic cells in the lung tissue. Due to release of large amounts of lytic enzymes by these cells, alveolar tissue is destroyed thus reducing the effective area of gas exchange.
    - CO present in tobacco smoke is absorbed into the blood and combines irreversibly with haemoglobin thus decreasing the amount of oxyhaemoglobin produced. Therefore the oxygen transport through blood is decreased.
      Nicotine present in tobacco smoke temporarily increase the rate of heart beat and constriction of peripheral blood vessels causing a temporary increase in blood pressure.
      Long term exposure to cigarette smoke results in the proliferation of cells in the bronchial epithelium, forming a mass of abnormal cells. A cancer may develop among these cells. If these cells break free, the cancer may spread to lungs and or to other organs. Passive smoking will also result in the above mentioned ill effects.
    - Occupational hazards associated with the exposure to particles of silica & asbestos.
      The need for taking precautions in occupations generating dust and the toxic fumes

- **Silicosis**
  This may be caused by long-term exposure to dust containing silica compounds. High risk industries are,
  1. Quarrying granite, slate, sandstone
  2. Mining hard coal, gold, tin, copper
  3. Stone masonry and sand blasting
  4. Glass and pottery work

When silica particles are inhaled they accumulate in the alveoli. The particles are ingested by macrophages, some of which remain in the alveoli and come out in to the connective tissue around bronchioles and blood vessels close to the pleura. Progressive fibrosis is stimulated which eventually obliterates the blood vessels and respiratory bronchioles.

Gradual destruction of lung tissue leads to pulmonary hypertension and heart failure.

- **Asbestos related diseases-Asbestosis**
  Those who are involved in making or using products containing asbestos are at risk. This occurs when asbestos fibers are inhaled with dust. In spite of their large size the particles penetrate to the level of respiratory bronchioles and alveoli. Macrophages accumulate in the alveoli and the shorter fibers are ingested. The larger fibers will be surrounded by macrophages, protein materials and iron deposits. The macrophages that have engulfed fibers move out of the alveoli and accumulate around respiratory bronchioles and blood vessels, stimulating the formation of fibrous tissue. These cause progressive destruction of lung tissue and pulmonary hypertension.

- Practical:
  - Study of human respiratory system using models/diagrams and observation of effects of exercise on respiratory rate and pulse rate

Unit 06 – Transport

Competency 6.1.0 : **Investigates processes involved in transport of materials in organisms**

Competency Level 6.1.1 : **Investigates the concepts and processes involved in transport of water and minerals in plants**

Number of Periods : **08**

Learning Outcomes :

The student should be able to :

- explain the need for transport of materials in plants.
- describe the pathway of water and mineral movement through and between the cells of the plant body.
- elaborate on the concepts and principles underlying transport of water and minerals in plants.
- explain the upward movement of water & minerals in a plant.
- conduct experiments to determine solute potential and water potential of cells.

Suggested learning - teaching process:

- Recall previous knowledge related to the transport of materials in plants.
- Engage students in collecting information from sources (print and electronic) on transport of water and minerals in plants.
- Prepare them to make presentations on their findings with the aid of flow charts and diagrams.
- Make an elaboration according to an appropriate sequence.

Guidelines :

- **Need for transport**
  - Water and minerals move upward through the xylem
  - Dissolved sugars and hormones are transported in the phloem
- **Methods of water and solute movement**
- Basic principles underlying movement of water across membranes, phenomena of diffusion, imbibition, osmosis, mass flow and concept of water potential.
- Explain following methods of movement of water.
  - Diffusion - take evaporation as an example
  - Osmosis as a special kind of diffusion taking place when two solutions of different concentrations are separated by a selectively permeable membrane which allows passage of water molecules but not of solute molecules.
  - Imbibition as adsorption of water molecules to hydrophilic substances such as proteins, agar etc,
  - Mass flow as a method of movement of water and dissolved solutes in bulk (not in the form of molecules) due to pressure gradient or gravity.

- **Concept of water potential:**
  - Any system containing water has a water potential. Water potential is related to kinetic energy of water molecules, affected by factors like pressure, dissolved substances, hydrophilic substances, etc.
  - Water potential is denoted by Ψ and is measured by the units of pressure (atm, Pa, M Pa).
  - Pure water has the highest water potential.
  - Arbitrarily, the water potential of pure water at atmospheric pressure is considered as zero.
  - When solutes dissolve in water, the water potential is decreased and it becomes negative.
  - Therefore, the water potential of most naturally occurring aqueous systems is negative.
  - As the solute concentration increases, the water potential decreases.
  - Therefore, the water potential is inversely proportional to solute concentration of the system.
  - The component of water potential due to the solute concentration is called solute potential and is denoted by Ψs.
  - When pressure is increased the kinetic energy of water molecules are also increased, thereby increasing the water potential of the system.
  - Therefore, water potential is directly proportional to pressure of the system.
  - The component of water potential due to pressure is called pressure potential and is denoted by Ψp.
  - Always water moves from a system of high water potential to a system of low water potential.

- **Water potential of a cell**
  - Cell is a system that contains water. Therefore, it has a water potential.
  - The protoplast (all the components – cell membrane, protoplasm and the vacuole) is an aqueous system that contains solutes and hydrophilic substances. Therefore, it has a solute potential which is negative and denoted as Ψs.
  - If the cell is in a turgid condition protoplast exerts a pressure on cell wall which is called turgor pressure (Tp), whereas, the cell wall exerts an equal and opposite pressure on the protoplast which is called wall pressure (Wp). Therefore, the cell contents are under a high pressure condition which increases the water potential. This component of water potential is called the pressure potential and denoted as Ψp.
  - Therefore, the water potential of the cell Ψw is given as in the following equation.
  - $\Psi w = \Psi s + \Psi p$

- **Entry of water into vacuolated cells, turgor and plasmolysis**
  - Explain isotonic , hypotonic and hypertonic solutions in terms of water potential.
  - Discuss how solute potential, pressure potential and water potential changes when a cell is placed in water and in hypertonic solutions and hypotonic solutions.
  - Water moves in and out of cells according to water potential gradients. This happens when tissues are immersed in solutions.
  - Explain how plasmolysis and turgor occur, and the concept of incipient plasmolysis.
  - Turgor or turgidity of a cell is the rigidity, It gains by absorption of water and developing a positive pressure potential. Pressure in the cell vacuoles presses cytoplasm onto the cell wall. Cell wall is elastic to a certain degree and the cell inflates.
  - Plasmolysis is the contraction of the cytoplasm away from cell wall due to loss of water.
  - Vacuole is the major water reservoir of a plant cell.
  - Demonstrate plasmolysis using *Rhoeo* epidermal tissue under microscope.
  - Incipient plasmolysis is a state when the cell is neither turgid nor flaccid. It is the instant at which the cell begins plasmolysis.

- Explain how water moves in and out of cells in solutions and in tissues.

- **Structure of plant root**
  Describe the structure of primary roots of monocotyledonous and dicotyledonous plants .
- **Transport of water in plant roots.**
  Roots absorb water when the water potential of root cells is lower than that of soil solution. Cellulose cell walls and intercellular spaces in roots are totally permeable to water and solutes. Suberinized and lignified cell walls are not permeable to water. Water and solutes pass through the cortex into xylem in different paths given below.
  - Appolast
  - Symplast
  - Vacuolar pathway

- **Transport of water within a plant**.
  Concepts of apoplast, symplast and vacoular pathway in relation to movement of water and solutes can be discussed as follows.
  1. Apoplast is the system of interconnected cell walls and intercellular spaces through which water and solutes can move freely. This also includes lumens of dead cells in xylem. The casparian strips of endodermis are suberinised, making them impermeable to water, separates apoplast of the cortex of root from apoplast of the vascular cylinder of the root.
  2. Symplast is the interconnected network of cytoplasm of the whole plant.
     Cytoplasm of neighboring cells is connected through plasmodesmata which pass through pits in cell walls. After entering the cytoplasm through the cell membrane of one cell, water can move in to the symplast pathway along water potential gradient.

  3. Vacoules are large water reservoirs in plants cells. Therefore ,Water moves from cell to cell through vacuoles along water potential gradient. When water moves from vacuole to vacuole between cells it has to go through vacuolar membrane (tonoplast), cytoplasm, plasma membrane and the cell wall of the first cell and then cell wall, plasma membrane, cytoplasm and vacuolar membrane of the second cell along the water potential gradient. This path of movement is vacuolar pathway.
     Vacuolar pathay has more resistance than appoplast or symplast.

- Casparian strips of endodermis block the apoplast pathway thereby allowing solutes to pass through the symplast , where selective absorption occurs , only ions that are needed by the plant is allowed to pass through the endodermis.

- **Upward movement of water and minerals in the plant**
  - Water potential gradient from soil solution to atmosphere through the plant, high adhesive and cohesive forces of water in the xylem and transpiration pull as the underlying principles of water and solute movement through the xylem
  - Adhesion-cohesion-tension theory
  - Mass flow of water and solutes through the xylem

- Practical:
  - Determination of solute potential of epidermal peels of *Rhoeo*
  - Determination of water potential of *Colocasia* petioles/Potatoe strips

Competency 6.1.0 : **Investigates processes involved in transport of materials in organisms.**

Competency Level 6.1.2 : **Investigates the process of gaseous exchange in plants**

Number of Periods : **01**

Learning Outcomes :

The student should be able to :

- describe the structure of leaves.
- relate the structure of stoma to its function.
- describe the gaseous exchange through stomata and lenticels.
- observe the structure of stomata and lenticels through microscope

Suggested learning - teaching process:

- Provide opportunities for the students to observe stomata and lenticels through microscope and/or other relevant sources (print or electronic).
- Advise students to gather information on the structure and function of stomata using relevant sources (print or electronic)
- Prepare the students for a presentation on their findings.
- Make an elaboration according to an appropriate sequence.

Guidelines :

- Leaves of plants as the main surface for gaseous exchange
- Structure of leaves
- Structure and function of stomata
  - Investigate the structure of plant leaves as seen with transverse sections of mesophytic dicot and grass leaves.
  - Discuss the shapes, special structure and pattern of thickenings of cell walls and the presence of chloroplasts in the guard cells.
  - Illustrate the structures of kidney shaped and dumbell shaped guard cells
  - Gaseous exchange through stomata and lenticels.
  - Explain that opening and closing of stomata at different times of the day takes place due to change of turgidity of guard cells. Quick changes of water potential inside guard cells cause them to absorb water from neighboring epidermal cell or to lose water to those cells. Decrease of solute potential in guard cells in the presence of light has been explained by several mechanisms including, photosynthesis, starch-sugar conversion and K^+ ion influx.

Competency 6.1.0 : **Investigates processes involved in transport of materials in organisms.**

Competency Level 6.1.3 : **Investigates the processes of water loss in plants.**

Number of Periods : **03**

Learning Outcomes :

The student should be able to :

- describe the route of transpiration.
- list the factors affecting transpiration.
- describe adaptations in plants to minimize transpiration.
- elaborate on how root pressure develops in plants and how it affects guttation.
- compare and contrast the relative advantages and disadvantages of transpiration and guttation.
- design and conduct experiments to determine the rates of transpiration from leaves & shoots under different environmental conditions.

Suggested learning –teaching process:

- Provide students with relevant sources (print or electronic) on transpiration and guttation.
- Advise students to gather information and prepare for a presentation.
- Facilitate the students to conduct laboratory and field experiments and observations on transpiration and guttation and to maintain records.
- Prepare the students for a presentation on their findings.
- Make an elaboration according to an appropriate sequence

Guidelines :

- **Transpiration**
- **Route of Transpiration**
  - Transpiration is the loss of water vapour from the plant mainly through stomata and to some extent through lenticels and cuticle. Highlight following points in explaining stomatal transpiration. Evaporation of water from wet cell walls increases density of water vapour. Each stoma has a shell of water vapour through which diffusion takes place. In still air diffusion shells of neighbouring stomata overlap to form a thin layer next to leaf surface. Thickness of this layer depends on surface features of leaf.
  - In moving air water vapour is carried by mass flow. Explain that rate of transpiration is regulated to a large extent by stomata.
- **Factors affecting the rate of transpiration**
  - Discuss how external factors like humidity, wind, temperature, light, available water in soil and concentration of CO_2 and the internal factors like number and distribution of stomata, internal structure of leaf and amount of water in plant affect the rate of transpiration.
  - Modification of plants to minimize transpiration
- **Root pressure, guttation**
  - Explain root pressure and guttation.When there is a positive root pressure some herbaceous plants exude liquid water from hydathodes. Make observations of hydathodes and the process of guttation.
  - Practial:
    - Determination of rates of transpiration from leaves and shoots

Competency 6.1.0 : **Investigates processes involved in transport of materials in organisms**

Competency Level 6.1.4 : **Investigates the processes involved in translocation of food in plants**

Number of Periods : **02**

Learning Outcomes :

The Student should be able to:

- describe the structure of the phloem tissue.
- relate the structure of the phloem tissue to its function.
- elaborate the processes involved in translocation of food throughout the plant body.

Suggested learning - teaching process:

- Engage students to survey literature and gather information on ringing experiments and experiments done using aphids on translocation.
- Provide the students with relevant sources (print or electronic) on translocation.
- Allow the students to observe L.S and T.S of stem to study the structure of phloem tissue.
- Advise students to prepare for a presentation on their findings.
- Make an elaboration according to an appropriate sequence

Guidelines :

- **Phloem translocation**
  - **Important features of phloem translocation**

    Explain that the phloem tissue of the vascular plants is the tissue, which transport organic compounds between plant organs. The substance transported is mainly sucrose made by conversion of photosynthetic products and destinations are storage organs and growing points. Sucrose is a good candidate for transport because it is a very soluble but relatively inactive substance compared to other carbohydrates. However, phloem also transport other organic compounds like amino acids, vitamins, growth substances, chemicals applied to plants and some inorganic ions like K^+, phosphate etc.
  - Make microscopic observations on the structure of phloem using cross sections of stems.
  - Identify different types of cells – sieve tube elements, companion cells, parenchyma and phloem fibers- and explain their functions.
  - **Phloem tissue**

    Structure of the phloem tissue

    Diagrammatic representation of an electron micrograph to illustrate the fine structure of sieve tube elements & companion cell.
  - **Mechanism of translocation of organic nutrients through phloem**
    - Explain important features of phloem translocation including following points.
      - Transport can take place in both directions at different times.
      - Amount of material transported and the rate of transport is very high.
    - Distance of transport can also be high in some plants.
    - Transport takes place with hydrostatic pressure, as evident in tapping coconut etc.

- **Explain the pressure-flow hypothesis of phloem transport with following points**.
  - Tissue from which translocation begins is called the source, and the tissue of destination is called the sink.
  - Some modified companion cells, known as transfer cells actively secrete sucrose or other compounds into sieve tubes against concentration gradient using metabolic energy in a process called phloem loading.
  - As a result of phloem loading, solute potential in sieve tubes increase, causing decrease in water potential and movement of water from adjacent xylem, building up high hydrostatic pressure in the sieve tube.
  - Mass flow takes place from source to sink under a pressure potential gradient.
  - At the sink substances are removed from sieve tubes actively in a process called phloem unloading, causing decrease in solute potential, increase of water potential and movement of water to the xylem tissue from sieve tubes

Competency 6.1.0	**:**	**Investigates processes involved in transport of materials in organisms**
Competency Level 6.1.5	**:**	**Investigates the organization of circulatory systems in animals**
Number of Periods	**:**	**02**
Learning Outcomes	**:**	

The student should be able to :

- elaborate on the open and closed circulatory systems.
- describe the single and double circulation.
- elaborate the features of double circulation.

Suggested learning - teaching process:

- Use charts or suitable diagrams to explain single and double circulation.
- Instruct students to survey literature and gather information on the types and methods of circulatory systems.
- Provide the students with relevant sources (print or electronic) on single and double circulation.
- Advise students to prepare for a presentation on their findings.
- Make an elaboration according to an appropriate sequence.

Guidelines :

- **Need of transport in animals**.
    - Oxygen and nutritive materials have to be transported from site of absorption to site of usage. Wastes have to be carried to disposal sites. Other materials too have to be transported from source to various parts of the body. It should be pointed out that in animals it is necessary to move materials to and from all parts of the body.
    - In unicellular organisms, transport is done by diffusion due to the small distance and low energy requirement.
    - First animals to develop a circulatory system are Annelids.
- **Main circulatory system in animals.**
    - Explain open and closed circulatory systems with examples.
    - Explain the single and double circulatory systems with examples.
- Differences between main circulatory systems should be stated.

Competency 6.1.0 : **Investigates processes involved in transport of materials in organisms**

Competency Level 6.1.6 : **Relates the structure of the human circulatory system to its functions**

Number of Periods : **10**

Learning Outcomes :

The student should be able to

- describe the blood circulatory system & lymphatic system.
- explain the structure & function of heart.
- describe the features of cardiac cycle.
- interpret the electrocardiogram.
- explain systolic & diastolic pressure.
- describe hypertension & hypotension as conditions leading to cardiovascular diseases
- explain the coronary circulation & consequences of blockage of coronary arteries.
- describe bypass surgery, open heart surgery & heart transplant.

Suggested learning-teaching process:

- Provide students with literature (print or electronic) on human circulatory system .
- Engage students in making summary on human circulatory system .
- Prepare the students for a presentation of the subject content.
- Make an elaboration according to an appropriate sequence.

Guidelines :

Structure & functions of the human circulatory system:-

- The human circulatory system has evolved from the basic plan of vertebrate circulatory system. It consists of heart, blood vessels and blood.
- Basic plan of the vertebrate circulatory system(Presence of ventral muscular heart, ventral aorta, six pairs of lateral aortic arches arising from the ventral aorta which eventually merge to form the median single dorsal aorta from which the arteries that distribute blood to various regions and organs of the body arise)
- **Human circulatory system and lymphatic system**
- **Human circulatory system**
- Changes that have taken place in vertebrate circulatory systems from the basic plan.
- Basic plan of the human circulatory system should be shown in a diagram and should be pointed out that it is a closed system with double circulation.
- Basic characteristic features of circulatory system
  - Circulating fluid – blood
  - Pumping device – heart
  - Blood vessels
- Within the circulatory system these components are organized to promote an efficient exchange of materials between blood & tissue fluid .
- **Lymphatic system**
  - The lymphatic system consists of lacteals, lymph capillaries & lymphatic nodes. The flow of lymph is slow & occurs when the vessels are squeezed by contractions of nearby body muscles.

- Lymph vessels from all parts of the body join together to form two large ducts, namely; the right lymphatic duct & thorasic duct.
- Lymphatic system helps to perform specific & non-specific immune responses.

- **Structure & function of the heart**
  - The location, structure and function of heart should be explained using diagrams.
- Cardiac muscle
- **Cardiac cycle**
  - The cardiac cycle should be explained as the sequence of events that take place during the completion of one heart beat. The events of the cardiac cycle should be explained in a sequence as follows.
  - Contraction of atria
  - Contraction of ventricles
  - Relaxation of atria and ventricles
- **Electro cardiogram**
  - Myogenic stimulation of cardiac contraction
  - Position of SA node, AV node , bundle of His, and Purkinje fibers should be explained.
  - The change in electrical potential across the membrane of cardiac muscle fiber can be detected by attaching electrodes in the surface of the body because, body fluids & tissues are good conductors of electricity and the tracing of this pattern of electric activity displayed on a oscilloscope is called Electro Cardio Gram. (ECG)
  - By examining the pattern of waves and time interval between cycles & parts of cycles, in the normal ECG tracing information about the state of cardiac muscle can be obtained.
- **Explain Systolic & Diastolic Pressure**
  - Blood pressure as the pressure exerted by blood on the walls of blood vessels.
  - Pressure exerted by blood on aortic wall during the contraction of ventricle - systolic pressure
  - pressure exerted on aortic wall by blood during relaxation of ventricle - diastolic pressure.
  - Blood pressure of a normal adult should be stated as 120/80 mm Hg.
  - It should be stated that this varies with sex, age, time of the day, activity, stress and posture.
  - Factors responsible for maintaining blood pressure within normal limits- cardiac output, blood volume, dialation & constriction of arterioles, elasticity of artery walls, amount of blood returning to the heart through veins.
  - **Hypertenstion and hypotension**.
  - Possible reasons and consequences of hypertension & hypotension should be explained briefly
- **Coronary circulation & consequences of blockage of coronary arteries**
  - The right & left coronary arteries arising from the aorta, supply the arterial blood to the heart. Venous blood returns to coronary sinus which empties into the right atrium. Some of the venous blood enters heart through small channels that open directly into the chambers of the heart.
  - Blockage will cause decreased blood supply to coronary arteries and particular parts of the heart muscle will cease to function which leads to chest pain known as angina.
  - If this condition is not treated on time, the heart muscle supplied by the blocked vessel may die due to lack of adequate oxygen. This condition is known as “heart attack”.

- Due to this, heart beat rhythm may he abnormal and the heart may cease to be an effective pump.
- The other vital organs such as brain may be deprived of inadequate supply of oxygenated blood and heart attack may be fatal.

- **Surgical interventions**
  - Bypass surgery, open heart surgery and heart transplants.
  - Many surgeries are performed on the heart.
  - When coronary arteries are blocked that blocked region is by-passed with parts of a vein taken from the leg and this is called by-pass surgery .
  - When there are defects in the valves, open heart surgeries are conducted to rectify the defect.
  - If the heart is too weak to perform its functions, sometimes a healthy heart taken immediately from a person who has died due to brain damage, is transplanted.

Competency 6.1.0 : Investigates processes involved in transport of materials in organisms.
Competency Level 6.1.7 : Inquires into the role of blood.
Number of Periods : 06
Learning Outcomes :

The student should be able to ;

- explain composition of blood.
- state respiratory pigments in man.
- state respiratory pigments in other animals.
- describe the transportation of respiratory gases & other substances.
- state other functions of blood.
- explain the blood counts.
- explain blood groups.

Suggested learning -teaching process:

- Provide students with literature (print or electronic) on role of blood in humans
- Encourage students to gather information on the relevant content.
- Prepare the students for a presentation of the subject content.
- Make an elaboration according to an appropriate sequence.

Guidelines:

- Composition of blood - type of blood cells, their structure & main functions
- Respiratory pigments in man
- Haemoglobin in vertebrates.
- Respiratory pigments in other animals
  - Haemoglobin, Haemocyanin, Chlorocrurin and Haemoerythrin
- Transportation of respiratory gases and other substances and other functions of blood .
- Blood tests as diagnostic tools.(Methods and equipment not necessary)
- Blood count
- ESR(Erythrocyte Sedimentation Rate)
- Chemical composition of blood
  - Triglycerides
  - Bile pigments.
  - Glucose
  - Haemoglobin content
- Antibodies – Dengue and HIV, Filaria
- Nature of blood cells – Thalassemia, Sickle cell anemia
- **Blood Groups**
  - A, B, AB & O blood groups, Rh factor & the importance of these in blood transfusions .
- Practical:

  Study the circulatory system of man using specimens/models/diagrams.

Unit 7 – Coordination & Homeostasis

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.1 : **Inquires in to the processes & systems involved in coordination**

Number of Periods : **02**

Learning Outcomes :

The student should be able to:

- discuss the need for coordination.
- describe the systems contributing to coordination
- discuss the contribution of the blood circulatory system for coordination.
- state similarities & differences (in relation to coordination) of the nervous system & the endocrine system.

Suggested learning - teaching process

- Recall students' experiences related to responses to various stimuli
- Engage the students in collecting information on the following using web resources and books
  - Need for coordination
  - Contribution of the blood circulatory system for coordination
  - Similarities and differences of the nervous system and the endocrine system
- Prepare the students for a presentation of the subject content
- Make an elaboration according to an appropriate sequence

- **Guidelines**

- Need for coordination
- Systems contributing to coordination
- Animals unlike plants, have two different but related systems for coordination
  1. Nervous system
  2. Endocrine system
- Contribution of the blood circulatory system for coordination.
- Endocrine system lacks ducts and releases its secretion into the blood stream.
- Differences and similarities of the nervous system & the endocrine system.
  (in relation to coordination)

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.2 : **Elaborates on the organization of nervous systems among animals**

Number of Periods : **02**

Learning Outcomes :

The student should be able to:

- describe the pattern of nervous organization in animals
- tabulates characteristic features of nervous organization in animals using models, diagrams and other relevant resources

Suggested learning - teaching process

- Show diagrams /pictures of unicellular, multi cellular, invertebrate and vertebrate organisms to students.
- Ask them to identify some external features and conduct a discussion on the variety of external features highlighting the differences that could be expected in internal structures and organization of systems
- Instructions given below are for the students
- Consider the organisms assigned to your group
  - *Amoeba*, Jelly fish
  - Liver fluke, Earth worm
  - Snail, Cockroach
  - Star fish, Rabbit
- Identify the main features of nervous organization in each organism
- Compare the nervous organization patterns of the given organisms
- Prepare the students for a presentation of the subject content
- Make an elaboration according to an appropriate sequence

Guidelines :

Types of nervous organization of animals

- All multicellular animals except sponges use a network of nerve cells to gather information about the external environment and body, process and integrate that information, and to issue signals to the muscles and glands.
- Unicellular
  No nervous organization ,ability to respond to stimuli. Cell functions as the receptor and effecter.
- Multicellular
  - Cnidaria – Development of nerve cells. Presence of a nerve net composed of multipolar neurons, synapses. Conduction tracts in sea anemones. Development of receptors.
  - Platyhelminthes – longitudinal solid nerve cords, organized from a nerve ring or pair of cerebral ganglion in the anterior region of the body - cephalization. Development of receptors. E.g., eyespots, sensory cells.
  - Annelids – Cerebral ganglia, double ventral nerve cord, ventral ganglia, giant nerve fibers in some. Receptors E.g., eyes and sensory cells.
  - Athropoda – More developed nervous system than that of Annelids. Cerebral ganglion present. Well developed receptor organs of various type. E.g., eyes, antenna, palps
  - Mollusca – Well developed nervous system .Consists of ganglia and nerve fibers Presence of Receptor organs. E.g., well developed eyes
  - Echinodermata – Radial nerve cord & nerve net
  - Chordates – Single, dorsal, hollow nerve cord. Anterior region enlarged to form the brain. Complexity increased gradually. Highest complexity is in mammals.
  - Practical: Study of patterns of nervous systems in animals using models/ diagrams.

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.3 : **Investigates the gross structure and functions of the human nervous system**

Number of Periods : **04**

Learning Outcomes :

The student should be able to:

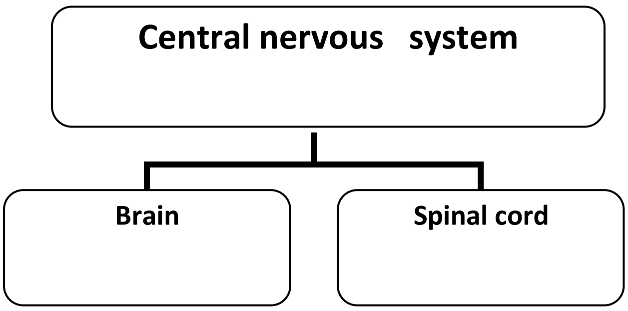
- explain the organization & main parts of the human nervous system.
- describe the central nervous system,
- describe the peripheral nervous system,
- describe the autonomic nervous system, & the functions
- state the overall function of the nervous system.

Suggested learning - teaching process

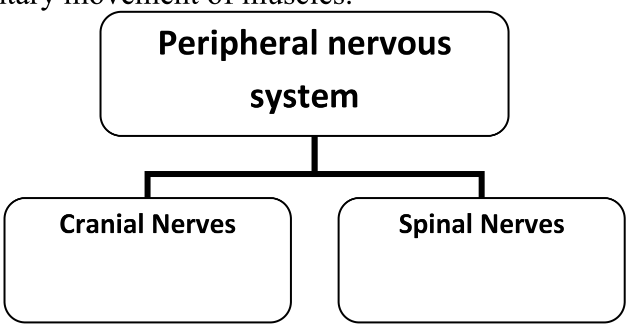
- With the help of reading materials, web resources and diagrams ask the students to find information on:
  - structure and function of main parts of the human nervous system
- prepare them for a presentation
- Make an elaboration according to an appropriate sequence

Guidelines :

- Organization and main parts of the human nervous system.



- The human brain has millions of neurons and is organized in to functional areas.
- The spinal cord is a cable of neurons extending from brain down through the backbone.
- Presence of three membranous coverings
- Presence of two zones in spinal cord should be explained.
- Messages from the body and the brain run up and down the spinal cord (the body's "information highway")
- In addition to relaying messages, the spinal cord also functions in reflexes, the sudden, involuntary movement of muscles.



- The peripheral nervous system consists of nerves and ganglia. Nerves are cable like collections of axons, usually containing both sensory and motor neurons.
- Ganglia are aggregations of neuron cell bodies
- Briefly explain the cranial and spinal nerves
- Autonomic nervous system
  - The autonomic nervous system should be explained as the part of the peripheral nervous system that is concerned with the controlling of involuntary activities.
  - General organization of the two main parts of the autonomic nervous system ie, the sympathetic and parasympathetic systems should be explained using a diagram.
  - The responses evoked by the parasympathetic and sympathetic systems should be listed.
  - It should be pointed out that the effects produced by one system usually oppose those produced by the other. It should also be pointed out that the sympathetic system have the general result of preparing the body for an emergency.
- Overall function of autonomic nervous system. (Parasympathetic and sympathetic)
- Nervous system is responsible for coordination and homeostasis.

Competency 7.1.0	**:**	**Investigates the structures & functions involved in coordination and homeostasis of organisms**
Competency Level 7.1.4	**:**	**Explores how nerve impulses are generated and transmitted**
Number of Periods	**:**	**06**
Learning Outcomes	**:**	

The student should be able to:

- describe the organization of the human nervous system.
- explain the structure of neurons
- explain the associated cells
- explain the physiology of neurons
- describe a synapses
- describe the role of neurotransmitters
- explain the reflex arc

Suggested learning - teaching process

- Engage the students by asking them questions on what they already know about neurons.
- Allow students to explore different sources and find out and present information on the following;
  - structure of neurons
  - associated cells
  - physiology of neurons
  - reflex arc
  - synapses
- Make an elaboration according to an appropriate sequence

Guidelines :

- Organization of the human nervous system
- Structure of neurons
- Neuron is considered to be the basic structural unit of the nervous system.
- Explain basic structure of a vertebrate motor neuron, cell body, dendrites, axon
  - Associated cells
  - Neuroglea,
- Neurons are supported both structurally and functionally by neuroglea. They are around ten times more numerous than neurons
- Schwann cells.
  - Myalinated axons.
- Physiology of neurons
- Explain how resting potential occur using active transport and passive diffusion of Na^+ K^+
- Resting membrane potential
- A potential difference exists across plasma membrane of the cell (axon's plasma membrane). Inside the cell there is more negative charge compared with the electrical charge of the extracellular fluid outside. The plasma membrane is electrically polarized. This cellular voltage measured across the membrane is called the membrane potential, in a neuron it is referred to as the resting potential (When an impulse is not transmitted)
- The neuron has a resting membrane potential of about -70 mV

- Resting membrane potential depends on three factors
  1. Differences in the concentrations of specific ions inside the cell compared with the extracellular fluids.
  2. Selective permeability of the plasma membrane to K^+ ions , Na^+ ions
  3. Na^+ K^+ pump
- Action potential
  - Explain how action potential occur
  - Duration of an action potential is 2 milli seconds
  - There are three phases-depolarization, repolarization and hyperpolarization
  - Describe how depolarization occurs using Na^+ and K^+ channels in the plasma membrane of the axon.
  - An action potential is generated when the voltage reaches a certain critical point known as the threshold level.
  - Propulsion of action potential.
  - Once initiated, the action potential is a self-propagating wave of depolarization that travels down the length of the axon.
  - Repolorization phase
  - Hyperpolarization phase
  - Impulse is a moving action potential
  - Action potentials are propagated along the axon by the effect of Na^+ entering the axon
  - This creates an area of positive charge and the flow of current is set up in a local circuit between this active area and the negatively charged resting region immediately ahead
  - The current flow in the local circuit reduces the membrane potential in the resting region and this depolarization produces an increase in Na^+ permeability and the development of action potential
  - Immediately after the action potential another action potential cannot be obtained This time period is known as refractory period.
  - This avoids the reverse conduction of impulse in an axon.
- Synapses
  Explain that a synapse is a functional junction between two excitable cells such as nerve and muscle.
- Synapses can be of different types.
  - Neuron – neuron
  - Neuron – skeletal muscles
  - Neuron – receptors
- In most synapses, there is a narrow gap called the synaptic cleft between the pre and postsynaptic cells. The presynaptic membrane signals the postsynaptic membrane by means of chemical neurotransmitters that diffuse across the cleft.
- Mention the three types of neurotransmitters.
- Acetyl choline ,Adrenaline/ Epinephrine, Noradrenaline/Norepinephrine
- Explain the role of only acetyl choline
- Neurotransmitter that is released from the motor neuron is acetylcholine (Ach).
- The Ach must be removed after it is released. The removal is accomplished by the enzyme, acetyl cholinesterase, which is present in the synaptic cleft.
- Transmission of nerve impulses through synapses
  1. Transmission of action potential to pre synaptic membrane
  2. Influx of Ca^{++}
  3. Release of Acetyl choline

4. Diffusion of Acetyl choline to post synaptic membrane
5. Binding of Acetylcholine with receptor molecules
6. Permeability of postsynaptic membrane to ions changes. Action potential generated in postsynaptic membrane
7. Breaking of receptor –Ach complex
8. Ach + receptor $\rightleftharpoons$ Ach-Receptor complex

   $\downarrow$ acetylcholine esterase

   Acetyl +Choline

9. Due to the dissociation of Ach, Ach – Receptor complex undergo the backward reaction.

- Speed of transmission depends on following factors.
  - The velocity of the action potential propagateing along an axon is large. This is because large diameter of an axon presents less internal resistance to the ions flowing along its length.
  - The velocity of the action potential propagating along an axon is greater if the axon is myalinated. Action potentials in myalinated axons are produced only at the nodes of Ranvier.
- Reflex arc

  The functional unit of the vertebrate nervous system is the reflex arc. A reflex action is a relatively fixed sudden, involuntary response pattern to a simple stimulus.(The response is predictable and automatic. Not requiring conscious thought.) Many of the activities of the body such as breathing are regulated by reflex action
- Reflex arc consists of at least three neurons.
- Afferent / sensory neurons
- Efferent /motor neurons
- Inter neurons

  A sensory neuron transmits impulses from the receptor to the central nervous system, where it synapses with an associated neuron called inter neuron. Then an appropriate motor neuron transmits impulses to the muscles or glands (effectors).

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.5 : **Explores into the structure & functions of the human brain**

Number of Periods : **06**

Learning Outcomes :

The student should be able to:

- describe main parts of the human brain
- relates the main parts of the human brain to their functions.

Suggested learning - teaching process

- Engage the students by asking questions on what they already know about the human brain.
- Let them collect information from different sources and present their findings with suitable diagrams on main parts of the human brain and their functions.
- Make an elaboration according to an appropriate sequence

Guidelines :

- Human Brain has millions of neurons and is organized into functional areas
- Cerebrum, thalamus and hypothalamus are derived from embryonic forebrain
- Corpora quadrigemina and red nucleus derived from embryonic mid brain
- Cerebellum,pons varolli and medulla from embryonic hind brain
- Meninges
- The central nervous system is surrounded by three layers of membranes called meninges.
    - Outer membrane – tough dura mater attached to the skull
    - Inner membrane – Thin pia mater lies next to the nervous tissue
    - Arachnoids membrane – lies in between these two membranes
- Sub arachnoid spaces - They are filled with cerebrospinal fluid and partitioned with connective tissue strands and blood vessels
- Cerebro ventricles & cerebrospinal fluid
    - Four expanded cavities within the brain called cerebro ventricles
    - These cavities are filled with a fluid & is called cerebrospinal fluid
    - Most of this fluid is contained in the central canal of the spinal cord & ventricles
- Brain stem
- Pons varolli
    - Located in front of the cerebellum, below the mid brain and above the medulla oblongata
    - Contains a dense mass of neurons and fibers which form a bridge between the two hemispheres of the cerebellum
        - Functions :-
        - Helps to integrate the information traveling up & down
        - Regulate the ventilation of lungs
- Medulla oblongata
    - One of the most vital parts of the brain
    - It contains the cardiovascular centre, breathing centre
        - Functions :-
            - Regulates the rate & force of heart beat
            - Controls blood pressure
            - Influence heart & breathing rate
            - Controls involuntary reflexes such as sneezing, coughing, swallowing, & vomiting

- Mid brain
  - Located between the cerebrum and pons varolli
  - Consists of groups of nerve cells and nerve fibers which connect the cerebrum with lower parts of the brain and the spinal cord
  - Functions
    - Reflex movements of the eye muscles are controlled from this part
    - Reflex movements of the head , neck, and trunk (in response to visual and auditory stimuli)
    - Changes the size of the pupil, size & shape of the lens in the eye
- Cerebellum
  - Located behind the pons varolli & immediately below the posterior portion of cerebrum
  - consists of two hemispheres, greatly convoluted. Grey matter forms the surface and white matter lies deeply
  - Functions :-
    - Coordination of voluntary muscular movement, posture and balance
- Cerebrum
  - Consists of two main parts - Cortex and Medulla
  - Gross structure of the cerebrum
  - Lobes-frontal, parietal, temporal, occipital
  - Superficial part of the cerebrum is composed of nerve cells or the grey matter, forming the cerebral cortex and the deeper layers consists of nerve fibres or white matter
  - Cerebral cortex consists of convolutions and fissures to increase the surface of the cerebrum
  - Cerebral cortex-Sensory, motor, associated areas
    - Functions:-
    - Mental activities involved in memory, intelligence, sense of responsibility, thinking, reasoning, moral senses and learning
    - Sensory perception including the perception of pain, temperature, touch, sight, hearing, taste and smell
    - Initiation and control of voluntary muscle contraction
    - Associated areas are responsible for recognition and interpretation of sensory information
- Thalamus
  - Consists of two masses of nerve cells and fibres situated within the cerebral hemispheres just below the corpus callosum, one on each side of the third ventricle
  - Integrates sensory information and relays it to the higher centres of the brain
- Hypothalamus
  - Composed of a number of groups of nerve cells .It is situated below and in front of the thalamus ,immediately above the pituitary gland
  - Controls output of hormones , control of autonomic nervous system (control of hunger, thirst, body temperature, heart and blood vessels and defense mechanism)

Competency 7.1.0 : **Investigates the structure & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.6 : **Explores the functions of different sensory organs**

Number of Periods : **05**

Learning Outcomes :

The student should be able to:

- explain the human sensory structures
- state basic characteristics of the human sensory structures.
- describe the types of sensory structures
- elaborate on the selected sense organs of animals

Suggested learning - teaching process

- Show a picture/ video clip on human sensory structures/ animal receptors and highlight the importance
- Divide the students into groups as given below or any other appropriate way:
  - Chemo receptors
  - Thermo receptors
  - Photoreceptors
  - Mechanoreceptors
  - Pressure receptors
  - Vibration receptors
  - Pain receptors
  - Eye spots, simple eyes, compound eyes
- Let the students study selected sense organs of animals using diagrams/ models and relevant sources (printed and electronic)
- Get them to present their findings highlighting the following
  - Functions
  - Occurrence
- Make an elaboration according to an appropriate sequence

Guidelines :

- Human Sensory Structures (Receptors)

  Explain that the activity of an animal depends on the input of information from the internal and external environment, and such information that brings about a change in activity or behavior of the animal is called a stimulus.

  A receptor should be explained as a specialized organ of the body that detects a stimulus .Sometimes cells or nerve endings act as receptors.

  - It should be pointed out that the following features are present in receptors
    1. Structure is designed to receive specific stimuli. ex: olfactory, light ,thermal
    2. Act as transducers-structures transforming one form of energy into nerve impulse
    3. Consist of special types of cells .e.g., olfactory/taste
    4. Always connected with nervous system
    5. Contain sensitive receptor cells. Respond to minimum threshold level
    6. Adaptation
  - There are different types of receptors to detect different types of stimuli
  - Chemoreceptors
    - Detect stimuli related to chemical substances. ex: mediating the senses of smell and taste.
    - Always substances get dissolved in water to stimulate the sensory cells

  - Taste receptors

- Structure of a taste bud should be explained with the aid of a diagram. The distribution of various areas of the tongue for the four taste sensations should be shown. It should be pointed out that substances to be tasted dissolve in the fluid surrounding the microvilli of the sensory cells and diffuse to receptor cells.
  - Olfactory Receptors
  - The sensation of smell is due to airborne substances and they dissolve in the layer of mucus in the olfactory epithelium and stimulate the sensory cells.
- Thermo receptors
  - Stimulated by temperature
  - In man there are organs of Ruffni body which are (stimulated by temperature) sensitive to high temperatures
  - Bulbs of Krauses's which are sensitive to low temperatures
  - Both these types are present in the dermis
  - Many free nerve endings present in the skin are also sensitive to temperature changes
- Photo receptors
  - Stimulated by light. In eyes photo receptor cells are concentrated in the retina .
  - The eye's light sensitive cells are the rods and cones
    - Cones
    - Rods
- Mechano Receptors
  - Sensitive to pressure in touch, tension (stretch), sounds, displacement of body.
  - In man touch receptors sensitive to small pressures are found close to the surface of the skin and there are small free nerve endings
  - These may be in the epidermis or attached to hairs.
  - e.g., Meissners corpuscles: sensitive to touch, Merkel's discs
  - Pressure and stretch receptors
    - Pacinian corpuscles are present in the dermis, found in joints, tendons, muscles, and mesenteries
  - Vibration Receptors
    - Most of the touch receptors act as vibration receptors.
  - Pain receptors
    - Special nerve endings found in the skin surfaces
- Briefly discuss Cochlea- in mammals
- Types of receptors found in other animals
  - It should be pointed out that the first animals to develop photoreceptors are Coelenterates (ie: eye spot –in jelly fishes) ,although unicellular animals are also sensitive to light .
  - The following points should be highlighted in the discussion. Concentrated light sensitive cells, known as eye spots without forming images are found in free living flat worms.
    - Simple eyes are found in annelids, mollusks
    - In Arthropods compound eyes are present. They are formed of several units known as ommatidia. (ie: Crustacea,Insecta).
    - In Diplopodes, Chilopodes and Arachnides simple eyes are present.
- Practical
  - Study of selected sense organs of animals using diagrams/models/charts

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.7 : **Relates the structure of the eye & ear to their functions**

Number of Periods : **06**

Learning Outcomes :

The student should be able to:

- describe the basic structure & function of the human eye.
- describe the basic structure & function of the human ear.

Suggested learning -teaching activities

- Engage the students by asking them some questions to refresh their knowledge on human eye and ear
- Make them go through available resources and find information on the following
  - Basic structure and functions of the human eye
  - Basic structure and functions of human ear
- Let the students study the structures of human eye/ear using diagrams / models (To be done as a practical activity)
- Instruct the students to present their findings to the class
- Make an elaboration according to an appropriate sequence

Guidelines :

- Explain the basic structure and function of the Human eye with the help of a diagram
- Explain the basic structure and function of the Human ear with the help of a diagram
- Practical
  - Study the structure of human eye and ear using diagrams/models/charts

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**

Competency Level 7.1.8 : **Analyses the role of human endocrine system**
Number of Periods : **07**
Learning Outcomes :

The student should be able to:

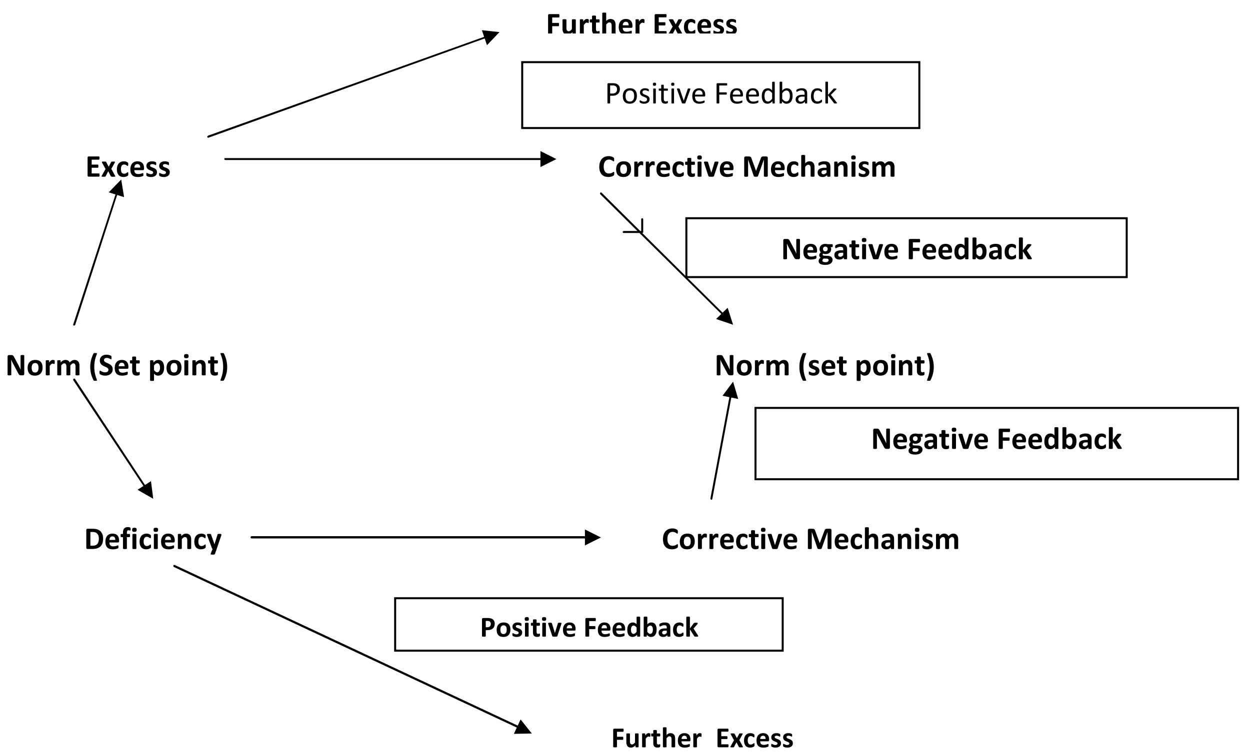
- describe the human endocrine system with their locations & functions.
- explain the feed back mechanism and its relevance to the endocrine system.

Suggested learning - teaching process

- Instruct the students to find information on the following endocrine glands using printed and electronic sources and to present to the class in a suitable way (Group activity preferred)
  - Hypothalamus
  - Pituitary gland
  - Thyroid gland
  - Parathyroid gland
  - Thymus gland
  - Adrenal glands
  - Islets of Langerhans
  - Gonads
- Let them find information on negative and positive feed back mechanisms and its relevance to endocrine system
- Make an elaboration according to an appropriate sequence

Guidelines :

- Human Endocrine System –
  - The endocrine system includes all of the organs that function exclusively as endocrine glands.
  - Explain the location and the functions of the following.
    Hypothalamus, Pituitary gland, Thyroid gland, Parathyroid gland, Thymus gland Adrenal gland, Islets of Langerhans ,Gonads (Testes & ovaries)



Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms.**

Competency Level 7.1.9 : **Investigates how a constant internal environment is maintained**

Number of Periods : **05**

Learning Outcomes :

The student should be able to:

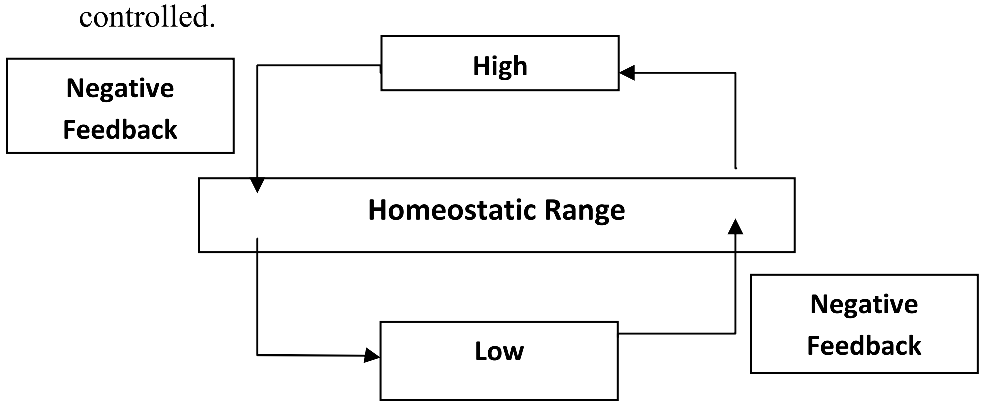
- explain homeostasis with respect to the internal & external environment.
- describe homeostasis of man in regulating body temperature, blood glucose & osmoregulation
- explain the role of the liver in homeostasis.

Suggested learning - teaching process

- Highlight the importance of homeostasis by quoting a suitable example
- Let the students find information on the following using suitable resources and present to the class
    - Homeostasis
        - Internal & external environment
        - Homeostasis of man
            - Regulation of body temperature
            - Regulation of blood glucose
            - Osmoregulation
        - Role of liver in homeostasis
- Make an elaboration according to an appropriate sequence

Guidelines :

- Homeostasis
    - Homeostasis is defined as the maintenance of a constant internal environment
    - Homeostasis is essential for life, and most of the regulatory mechanisms of the vertebrate body are concerned with maintaining homeostasis.
    - Internal & external environment. Internal environment is the immediate surroundings of the cells which provides the cells with the medium in which they have to live.
    - Surrounding of plants and animals are referred to as external environment.
    - Homeostasis of man
      To maintain internal environment constant, the vertebrate body uses a type of control system known as a negative feedback.
    - In homeostasis corrective mechanism is triggered by the very entity that should be controlled.



- Major factors in the internal environment that must be controlled are
  - Concentration of chemical constituents e.g., glucose, ions
  - Maintenance of relative amounts of water and solutes.
  - Temperature
- Regulation of body temperature
  - Normal body temperature 36.9^0C (98.4^0F)
  - The homeostatic control of body temperature is regulated by the negative feedback mechanism
  - Response to cold: Detected by stimulation of free nerve endings, Krause's end bulbs, shunt vessels, constriction of superficial blood vessels of the skin, production of extra heat ,increase of metabolic rate (increase of production of thyroxin, adrenaline and oxidation of fat in liver),contraction of papillary erector muscle, shivering
  - Response to heat: Detected by free nerve endings and Ruffini corpuscles
  - Lowering of hair, dilation of superficial blood vessels of the skin, sweating, decrease in metabolic rate (decrease in secreting thyroxin, adrenaline, decrease in oxidation of fat in liver)
  - Hypothalamus detects temperature fluctuations inside the body. The skin receptors detect temperature changes at the surface.
  - In temperature regulation of man there is a voluntary contribution too. e.g., fanning when hot,curling up, covering the body with warm clothes when cold

  - Regulation of blood glucose
  - Normal value of glucose in the human blood stream is around 80mg-120mg per $100cm^3$
  - If this level increases,
    1) It may be broken down into CO_2, H_2O (cellular respiration)
    2) It may be built up into glycogen and stored.
    3) It may be converted into fat and sent to the body's fat deposits for storage
  - Homeostatic scheme for the control of glucose in the mammalian body
- Osmoregulation
  - Osmoregulation in human ensures that the total volume of its blood plasma and the concentration of dissolved substances in the plasma and tissue fluids all remain constant.
  - This is achieved in two basic ways
    I) Controlling the amount of water
    II) Controlling the amount of salt gained and lost by the body.
  - An analysis of a person's daily input and output of water and salts reveals that the production of urine plays an important part in water and salt losses.
  - The mechanisms involved in osmoregulation take place in kidney by the help of ADH hormone.

- Role of the liver in homeostasis
  The functions of liver should be reviewed to show that it regulates the physical nature & chemical composition of the internal environment to great extent. In this regard, the following points should be highlighted.
    1. Regulation of glucose level
    2. Regulation of lipid content
    3. Synthesis of non essential amino acids
    4. Detoxification
    5. Heat production to assist the thermoregulation
    6. Elimination of sex hormones
    7. Breaking down and Elimination of haemoglobin
    8. Storing blood
    9. Storage of vitamins (A,D,E,K)
    10. Synthesis of blood proteins
    11. Synthesis of Cholesterol
    12. Urea production

Competency 7.1.0 : **Investigates the structures & functions involved in coordination and homeostasis of organisms**
Competency Level 7.1.10 : **Investigates the basic structure & functions of the human skin**
Number of Periods : **02**
Learning Outcomes :

The student should be able to:

- explain the basic structure & functions of the human skin.
- describe the basic layers of the human skin

Suggested learning - teaching process

- Use appropriate information from Power point presentations, web based information and other sources to highlight the following
  - Basic layers of the human skin
  - Hairs
  - Glands
  - Receptors
  - Functions of the skin
- Make an elaboration according to an appropriate sequence

Guidelines :

- Structure and functions of human skin should be explained using the following.
  - Basic Layers of the human skin
    - Can divide into two parts -epidermis & dermis
    - Epidermis consist of many layers including malphigian layer
    - Dermis consists of cold receptors, heat receptors, sebaceous glands, erector pili muscle, sub cutaneous fat, sweat glands, blood vessels & nerve endings
  - Functions of skin
    1. Acts as a sense organ
    2. Maintenance of body temperature
    3. Sebaceous glands help to keep the hair & skin surface water proof & flexible, protection from bacteria.
    4. Sweat glands help in temperature regulation, excretion
    5. Protection from U.V. rays and desiccation
    6. Excretion
  - Sweating involves the secretion of watery fluid from sweat glands in the skin, which contains extra water & salts.
  - Through sweating, unwanted materials can remove from the body. Therefore, skin acts as an excretory organ.

Unit 8 – Excretion

Competency 8.1.0 : Analyses the contribution of the excretory system in maintaining a healthy life

Competency Level 8.1.1 : Examines the relationship between metabolism and excretory substances

Number of Periods : 04

Learning Outcomes :

The student should be able to:

- explain the process of excretion & its importance.
- describe the relationship between excretory products & metabolism.
- explain the end products of nitrogenous excretion.
- compare advantages & disadvantages of excreting above end products.
- describe the relationship between the end products & living environment.
- state the other end products of excretion
  - CO_2
  - Bile pigments.

Suggested learning – teaching process

- Let the students to gather the information on following excretory products in their respective groups.
  - NH_3, Urea
  - Uric acid, creatinine
  - CO_2, Bile pigments
- Guide them to do a presentation highlighting the following points.
  - advantages and disadvantages of excreting above end products
  - relationship between the end products and living environment
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- Excretion is the removal of the waste products of metabolism from the body (eg.,CO_2,H_2O ,NH_3), These are the excretory substances the body produce where defecation - removal of undigested food from gut is not considered as excretion.
- If these end products are not removed from the body they will be toxic to the body.
- Protein and nucleic acid digestion give ammonia which is a weak base, and glucose will give CO_2 as the end product which is a weak acid, so acid base balance will be altered.
  - Protein denaturation will occur due to the changes in acid base balance
- Removal of excretory products helps to maintain constant condition of homeostasis
- The first product of nitrogenous excretion is NH_3 in all animals.
- **Relationship between excretory products and metabolism.**
  - Carbohydrate
    - By aerobic respiration CO_2+ H_2O are produced
    - By anaerobic respiration lactic acid is produced
  - Fats
    - Aerobically $CO_2 + H_2O$ are produced
    - Protein

- By deamination of excess amino acids NH_3 is produced
- In liver urea is produced in Ornithine cycle

- Nucleic acid
  - By metabolism of nucleic acids NH_3 is synthesized
- End products of nitrogenous excretory products
  - NH_3
  - Uric acid
  - Urea
  - Creatinine
- Use the structures of the above end products to emphasis the following points.
- Advantages and disadvantages of excreting above end products
  - **Ammonia**
    - Extremely toxic to the nervous system
    - Can be eliminated from the body surface by diffusion
    - Advantages
      - No carbon loss from the body (refer to the structure)
      - No energy is required for the synthesis because first by product of nucleic acid and amino acid is ammonia
    - Disadvantages
      - Highly water soluble and large quantity of water is needed to excrete ammonia
      - Eg: aquatic invertebrates, aquatic larval forms of vertebrates, fresh water fishes
  - **Urea**
    - Less soluble in water compared to ammonia
    - Less toxic.
    - Advantages
      - Less toxic compared to ammonia, so it can be stored.
      - Less water is needed to excrete so helps in water conservation.
    - Disadvantages
      - Carbon loss is high (refer to structure)
      - Urea has to be synthesized in liver ,need energy
      - Eg, Adult amphibians, Mammals
  - **Uric acid**
    - Low solubility
    - Advantages-
      - Least toxic compared to ammonia and urea
      - Can be stored in the body
      - Water is not required for its excretion, so water conservation is high
    - Disadvantages
      - Carbon loss is high.
      - Eg:Insects, birds, reptiles

- **Creatinine**
  It is a breakdown product of creatine, which is an important part of muscle. Creatinine is removed from the body entirely by the kidneys.
- **Other end products of excretion**
  - CO_2 – eliminated by lungs or respiratory organs
  - Bile pigments – synthesized in liver and excreted by kidney and gut

Competency 8.1.0 : **Analyses the contribution of the excretory system in maintaining a healthy life.**

Competency Level 8.1.2 : **Investigates the diversity of excretory structures of animals.**

Number of Periods : **0**2

Learning Outcomes :

The student should be able to :

- list the different excretory structures in animals.
- explain the different excretory structures in animals by using diagrams.

Suggested learning – teaching process

- Let students collect information of following excretory structures of animals using various resources like web based information, books etc.
- Using the information collected guide the students to study the diversity of excretory structures of animals.
  - Body surface
  - Contractile vacuoles
  - Flame cells
  - Nephridia
  - Malpigian tubules
  - Green glands
  - Sweat glands
  - Salt glands
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- The chemical reactions that occur in organisms result in the formation of waste products, often toxic, which must be disposed in some way. The disposing of these waste products is called excretion. The structures through which excretion take place are called excretory surfaces.

- Excretory structures (Fine structures of the followings are not necessary)
- **Body Surface -** The cells of organisms having a relatively simple structure are usually in direct contact with the environment and their excretory products are immediately removed by diffusion.
- **Contractile Vacuoles**- *Amoeba, Paramecium* and other unicellular protists have contractile vacuoles which are small membrane lined sacs located in the cytoplasm. It is an organelle.
- **Flame Cells**– It is a single celled excretory structure. Found in phylum Platyhelminthes
- **Nephridia** - Annelids Eg :earth worms have a system of tubules that open both to the inside and to the outside of the body which are called Nephridia. It is a multicellular, tubular structure. Blood system is entangled with excretory system.
- **Malphegian tubules** – In insects (Eg: cockroach) the excretory organs are malphigian tubules.
- **Green glands / Antennal glands** – found in prawns (crustaceans). Two large green glands ventral in the head and anterior to the oesophagus, serve to remove waste from body and body fluids.
- **Sweat glands** – Found over the entire human skin. There are coiled tubular glands situated in the dermis and connected to a sweat duct which open as a pore on the surface of the skin.
- **Salt glands –** Marine birds drink sea water and then excrete the salt through salt glands. Paired, found near the eyes in marine birds and marine reptiles.
- Practical
  - Study of major types of excretory structures in animals using diagrams and charts

Competency 8.1.0 : Analyses the contribution of the excretory system in maintaining a healthy life

Competency Level 8.1.3 : Investigates the gross structure and function of the human urinary system

Number of Periods : 09

Learning Outcomes :

The student should be able to

- describe structure & the function of human urinary system.
- list the parts of the human urinary system.
- state the location, blood supply & structure of the kidney.
- illustrate the parts of the kidney.
- explain the nephrons as the structural & functional unit.
- describe the process of urine formation.
- explain the impact of hormones on the functions of the kidney.
- discuss the osmoregulation, blood pH regulation, secretion of erythropoietin, renin & maintenance of blood volume & blood pressure.
- state the disorders of the human urinary system.
- explain the preventive measures of disorders.
- describe the diagnostic role of urine.

Suggested learning process teaching

- Lead a disscusion using preserved specimens, animations etc. to highlight the following points.
  - major parts of human urinary system
  - structural & functional relationship of human urinary system
  - nephrone as the structural and functional unit
  - process of urine formation
  - hormonal control
  - kidney as a main homeostatic organ
- Let the students collect information on the followings regarding human excretory system
  - bladder and kidney stones (Renal calculi)
  - measures for prevention of disorders
  - diagnostic role of urine
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- **Human Urinary system**.
  - Parts of the human urinary system.
  - Main parts - Kidneys (2) , Ureters (2) , Bladder & Urethra
  - The kidneys form urine which passes through ureters to the bladder for excretion. The urinary bladder is a reservoir for urine. The urethra is a canal extending from the (neck of the) bladder to the exterior.
  - Kidney
  - Location of the kidney-
    - In the abdominal cavity, below the diaphragm, on either side of the vertebral column, at the level between thoracic & lumbar vertebrae , retroperitoneal cavity, close to posterior body wall (abdominal wall)
    - The left kidney lies slightly above the right.
  - Blood Supply

    The kidneys receive blood from aorta via the renal arteries & renal veins return blood to the inferior vena cava.
  - Gross structure of the kidney
    - Kidney is bean shaped.
    - Covered by renal capsule
    - The kidney consists of two main parts.
      - Outer cortex & inner medulla
      - Cortex is granulated due to the presence of glomeruli.
      - Medulla is composed of renal pyramids, which have striated appearance.
      - Pyramids project in to the pelvis which leads into the ureter.
      - Renal columns are present between renal pyramids which consist of cortical tissues.
      - Renal artery & renal vein pass through the pelvis.
    - Nephron as the structural & functional unit.
    - **Structure of the Nephron** – microscopic view of the structure
      - Explain the microscopic structure - one million in each kidney
      - Nephron consists of,
        - Bowman’s capsule
        - Proximal convoluted tubules
        - Descending limb of loop of Henle
        - Ascending limb of loop of Henle
        - Distal convoluted tubule
      - There are 2 types of nephrons

        Cortical Nephron & Juxta medullary nephron

- Which differ in their positions in the kidney. Cortical nephrones are found in the cortex & have short loop of Henle.
- Juxta medullary nephrons are found close to medulla (junction of cortex & medulla) & they have long loop of Henle which extends deep into the medulla.
- Several nephrons open into a collecting duct.
  Malphigian corpuscles –glomerulus & Bowman's capsule
- Blood enters the kidney by the renal artery which branches into finer & finer arteries before entering the glomerulus of a nephrone as afferent arterioles. (afferent means – to & efferent means from)
- Bowman's capsule – cup shaped, network of capillaries, called glomerulus located inside the Bowman's capsule.
- After filteration blood leaves the glomerulus by an efferent arteriole & flow through a network of capillaries (vasa recta) in the cortex which surround proximal & distal convoluted tubules & loop of Henle in the medulla.
- The capillaries of the vasa recta run parallel to the loops of Henle & collecting duct in the medulla. These networks of blood vessels, return blood to the general circulation.It contains substances which are useful to the body.
- Formation of urine

There are 3 processes occur in a nephron.

1. Ultrafilteration 2. Selective reabsorptron 3. Secretion

- **.Ultrafilteration**
  - Filteration of the blood under high pressure into the cavity of Bowmans' capsule.
  - Filteration occurs through the capillary walls of glomerulus & inner wall of Bowman's capsules.
  - The substances filtered are – water, glucose, amino acids, urea, vitamins, drugs, ions and hormones
  - The substances not filtered are – blood cells & plasma proteins.

- **Selective reabsorption**

  Some of the substances present in the filtrate reabsorbed to the capillary network of the tubules.

  - Proximal convoluted tubule.

    Obligatory reabsorption of water (80%) – by osmosis.Irrespective of the water content in the body

$$\left.\begin{array}{l} Na^{+} \\ \text{Glucose} \\ \text{Amino acids} \end{array}\right\} \text{active transport}$$

$$\left.\begin{array}{l} Cl^{-} \\ HCO_3^{-} \\ \text{urea} \\ K^{+} \end{array}\right\} \text{passive transport}$$

- Descending limb of loop of Henle.
  Water- passive by osmosis
  Na^+ - active transport

- Ascending limb of loop of Henle.
  Na^+ active transport
  Cl^- passive transport

- Distal convoluted tubule.
  Water – in the presence of ADH
  Na^+ Absorbs actively
  HCO_3^- and Cl^- Passive

- Collecting duct
  Water (4.5%) reabsorbs passively in the presence of ADH
  Actively secrete H^+
  In the presence of ADH hyper tonic urine is produced

- **Secretion**
  Some of the substances in the blood capillaries secrete into the tubules
  Substances secreted are H^+, K^+, NH_4^+, creatinine, drugs, vitamin B

- **Impact of hormones on the functions of the kidneys**
  - ADH - When percentage of water in blood decreases, ADH secretion increases which causes water reabsorbtion increasing.In the presence of ADH water is reabsorbed in distal convoluted tubule and collecting duct.
  - Aldosterone –promote absorbtion of Na^+ and water

- When salt concentration (Osmotic pressure decreases) decreases, secretion of aldosterone increases. Sodium is the major extracellular solute & needed for the maintenance of normal blood volume & pressure. By stimulating the kidneys to reabsorb salt & water aldosterone thus maintains the normal blood volume & pressure essential to life.
- **Other functions of the kidney** (Kidney as a main homeostatic organ)
  - Osmo-regulation
  - Maintain the constant osmotic pressure in the blood.
  - Blood pH regulation
  - Secretion of hormones
    - Erythropoietin – increases the production of red blood cells.
  - Maintenance of blood volume and blood pressure
- Disorders of the human urinary system.
  - Bladder & kidney – stones (called **renal calculi**, *renes means*, "kidney" and *calculi* means, "pebbles") are solid concretions formed in the kidneys from dissolved urinary minerals.
    The majority are calcium oxalate stones, followed by uric acid stones.

- Causes
  - Family history of kidney stones
  - Diet high in protein
  - Not drinking sufficient amount of fluids
- Majority of patients are within the age group of 20-50 years
- Measures for prevention
  - Drinking plenty of water
- Diagnostic role of urine
  - UFR – Urine Full Report
  - Urine culture reports

Unit 9 – Support and movement

Competency 9.1.0 : Inquires in to the types of supporting systems and movement in organisms

Competency Level 9.1.1 : Inquires in to the structure and functions of the skeletal systems of animals

Number of Periods : 06

Learning Outcomes :

The student should be able to :

- state the main types of skeletons of animals.
- describe the organization of hydrostatic skeleton with examples.
- describe the organization of exoskeleton with examples
- describe the organization of endoskeleton with examples
- explain the microscopic structure of human bones & cartilage.
- describe the functions of the skeletal system

Suggested learning - teaching process

- Lead a discussion emphasizing the given skeleton types and examples of animals for each skeletal type.
- Lead a brain storming session on the following functions of skeletal system
  - support
  - protection
  - movement
  - storage & release of calcium
  - storage & release of phosphates
  - production of blood cells
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- In the animal kingdom, three major types of skeletons i.e., Hydrostatic skeletons, exoskeletons and endoskeletons are found.
- Hydrostatic Skeleton - A fluid secreted within the body is enclosed by the body wall which is composed of two muscle layers (longitudinal and circular) which act antagonistically. The combined effect of muscle contraction and fluid pressure aids in locomotion and maintain the shape and form of the animal. e.g.,Coelom fluid in Annelida
- Exoskeleton – In arthropods, it is composed of chitin. A non cellular material; hardened by proteins (insects) and calcium carbonate (crustaceans), presence of flexible membrane for mobility, presence of waxy outer layer to prevent desiccation; ecdysis is needed for growth; processes for muscle attachment; very efficient as a supporting and locomotive device for small animals.
  - Arthropods are the main group that possess exoskeleton.
  - Give examples for other groups.
  - Form and functions of exoskeleton should be explained.
  - Calcium carbonate exoskeleton - Mollusca
  - Bony plates – reptiles
  - Radiolarians

- Endoskeleton – endoskeleton is the supportive system of many animals ,i.e., some unicellular protists (i.e. Radiolarians), sponges, some Molluscs, Vertebrates
- These are rigid internal skeletons to which muscles are attached; made up of either cartilage or bone, composed of living tissue; can grow steadily within the animal, different types of joints exist between bones that are held in position by ligaments. e.g., Vertebrates
    - Plates of calcium carbonate – Echinodermata
    - Bones – Chordates
    - Cartilage – Chordates
- Elaborate the microscopic structure of human bone and cartilage tissues.
- Functions of the skeletal system
    - Support – All skeletons provide a rigid framework for the body and are resistant to compression and tension forces. They help to maintain the shape of body.
    - Protection – They protect the delicate internal organs.
    - Movement – Skeletons composed of rigid material provide a means of attachment for the muscles of the body. Parts of the skeleton operate as levers on which the muscles can pull. When this occurs, movement takes place.
    - Storage & release of calcium; Some hormones regulate the storage and release of calcium. When the blood Ca^{++}level rises too high, hormone stimulate the uptake of Ca^{++}into bones. Likewise blood Ca^{++}level falls hormone stimulate the release of Ca^{++} by bones.
    - Production of blood cells – in the bone marrow

Competency	**9.1.0**	**:**	**Inquires in to the types of supporting systems and movement in organisms.**
Competency Level	**9.1.2**	**:**	**Investigates the structure and functions of the axial skeleton of man .**
Number of Periods		**:**	**08**

Learning Outcomes

The student should be able to :

- describe the organization of the human skeleton.
- list the parts of the axial skeleton.
- study the gross structure of human skull & vertebral column with reference to functions of various parts

Suggested learning - teaching process

- Show a video/pictures/ charts to students and lead a discussion highlighting the following points.
  - different types of skeletal systems in animal kingdom
  - skeletal system helps in the movement
  - human skeletal system can be divided in to axial skeleton and appendicular skeleton
- Following instructions are for the students to engage in the activity
- Pay attention to the parts of the human skeletal system given below
  - skull
  - vertebral column
  - ribs and sternum
- Elaborate on the assigned theme given to you under the following sub headings after matching the parts of the skeletal system with the provided resources
  - how the bones are arranged in each part
  - structure related to its function
  - specialized characters of each part
- Discuss the contribution of each part to the following functions.
  - support
  - protection
  - movement
  - storage & release of calcium
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- Axial skeleton
  - Skull
  - Vertebral column
  - Ribs and sternum
- Appendicular
  - Girdles
  - Limbs
  - Axial skeleton of man

- skull – skull is made up of 2 parts
  (1) Cranium
  (2) Facial
- Composed of 22 bones

Cranium is made up of 08 bones

Frontal bones	– 1	Details are not necessary
Parietal	– 2	
Occipital	– 1	
Temporal	– 2	
Ethmoid	– 1	
Sphenoid	– 1	

- Cranium
- Cranial capacity – 1.5 L
- Functions of cranium
  - Protects and encloses brain.
  - Protects the inner ear, middle ear, olfactory organs and eyes
- On the inferior surface of the cranium there is foramen magnum to provide passage to spinal cord. Two smooth rounded knobs (Occipital condyles) on either side of the foramen magnum articulates with the Atlas vertebra, providing nodding movements.
- Fontenelles – soft membranous regions allow slight compressions at birth facilitating parturition. Fontenelles become replaced by bones within 1-2 years of life. Name the main fontenelles and state their functions
- Sinuses

  Contain air and are present in the sphenoid, ethmoid, maxillary and frontal bones. They all communicate with the nose and are lined with ciliated mucus membrane
- Functions
  1. Give resonance to the voice
  2. Lighten the bones of face and the cranium
  3. Make it easier for the head to balance on top of the vertebral column.
- Main processes
  - Lower jaw (Mandible)
    a. Condyloid process
       Articulates with the temporal bone to form the temporal- mandibular joint
    b. Coronoid process
       Give attachment to muscles and the ligaments
  - Cranium
    a. Occipital condyles (1 pair)
       Situated in occipital bone at the base of the skull to form a hinge joint with Atlas vertebra.
- Processes in temporal bone
  a. Mastoid process
     For the attachment of muscles behind the ear

b. Styloid process
   Muscle attachment
c. Zygomatic process
   Arrives from the temporal bone to form zygomatic arch for muscle attachment

- Facial region
  - Situated below the cranium, composed of 14 bones
  - Upper jaw is fused with cranium
  - Lower jaw is movable
  - Hard palate is bony and soft palate is cartilaginous – It separates the buccal cavity from nasal cavity.
  - Lower jaw articulates with the cranium, zygomatic arch is the surface for muscular attachment for moving the lower jaw.
- Vertebral Column

  Consists of 33 linearly arranged vertebrae, strong flexible rod, support body and head, It consist of 24 separate irregular bones, 5 bones fused to form sacrum and 4 fused to form coccyx. There are 4 distinct regions; cervical (7) , thoracic(12), lumber (5), sacral (5).
- In addition ,vertebral column consists of coccyx
- There are 4 curvatures.
  1. Cervical
  2. Thorasic
  3. Lumber
  4. Saccral
- They are of two types.
  1. Primary
  2. Secondary
- Embryo has one curvature
- When the secondary curvatures are formed the primary curvature is confined only to thoracic and sacral regions which are known as primary curvatures.
- Primary curvatures
  - Explain that in the foetus there is only one curvature-
  - They are concave towards forward side.
- Secondary curvatures
  - Formed after birth, first cervical curvature develops at about 03 months of birth. Then the child can hold his head upright.
  - Second, lumber curvature develops when the child is around 7-8 months. Then the child can hold his body upright.
  - These secondary curvatures are convex towards front.
  - Explain these with diagrams.

- Main function of curvatures is maintaining the erect posture. Other functions of vertebral column are:
  1. Vertebral column provides the protection for spinal cord
  2. Vertebral foramens provides spaces for spinal nerves and blood vessels and lymph vessels
  3. Allow movements of the body
  4. Supports the skull
  5. Intervertebral discs act as shock absorbers and protect the spinal cord.
  6. Give attachments to ribs and girdles
- Types of vertebrae
  Structure of the typical vertebrae should be explained using diagrams and important variations of other vertebrae should be shown giving reasons.
- Intervertebral disc
  Presence of intervertebral discs to serve as shock absorbers and the correct way of lifting heavy objects should be shown in order to avoid 'Slip disc'
- Ribs & Sternum
  Presence of 12 pairs of ribs and sternum to provide protection to thoracic organs should be shown. The importance of the sternum in the production of red blood cells should be stated.
- Explain the gross structure of human skull and vertebral column in relation to functions of various parts as mentioned above using models/diagrams
- Practical
  - Study the gross structure of human skull and vertebral column in relation to functions of various parts using specimens/ models/diagrams

Competency 9.1.0 : Inquires in to the types of supporting systems and movement in organisms

Competency Level 9.1.3 : Investigates the structure and functions of the appendicular skeleton of man

Number of Periods : 06

Learning Outcomes :

The student should be able to;

- describe the organization of the human skeleton.
- list the parts of the appendicular skeleton.
- explain the gross structure of appendicular skeleton in relation to functions of various parts using models/diagrams

Suggested learning -teaching process:

- Demonstrate the parts of appendicular skeleton to the students and lead a discussion to highlight the following points.
- Appendicular skeleton is made up of limbs and the two girdles
- Bones in the limb structure are arranged accordingly to adapt for the functions such as grasping, weight lifting and movement, support, walking etc.
- Guide students to make a presentation of the given topic related to the appropriate functions given below.
- Topics
    - upper limb
    - lower limb
    - pectoral girdle
    - pelvis
- Functions
    - support
    - protection
    - movement
    - grasping
    - strength
    - posture
    - walking
    - production of blood cells
    - storage of Ca^{++}, PO_4^{3-}
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines:

- Appendicular skeleton

  It should be shown that appendicular skeleton is made up of limbs and the two girdles. The gross structure of pectoral girdle and pelvis should be explained in relation to function.
- Differences between male and female pelvises should be explained.
- Structure of upper limb should be explained and shown how it is adapted for grasping, weight lifting and movement over a wide range. (flexibility)

- The structure of lower limb should also be explained in relation to strength, erect body position (posture), bearing of body weight and walking.
- Arches of foot should be explained in relation to above functions.
- Explain the structure of upper limb in relation to its flexibility
- Incomplete ball and socket joint in glenoid cavity is shallow. Permitting vast range of movement.
- Fore arm of upper limb exhibits pronation and supination
- In distal end of humerus there are two articulatory surfaces; capitulum for radius and trochlear for ulna.
- On the capitulum head of the radius can be rotated. Due to that at the wrist, carpals articulate only with radius
- Opposable thumb- between bones of relevant carpal and first metacarpal there is a special joint permitting thumb to move perpendicular to other fingers. This leads to opposable nature of thumb. This articulation permits precision grip which is unique to man.
- Disorders and abnormalities.
- Osteoporosis
  - Reduction of bone tissue causes osteoporosis
  - Leads to immobility in joints and may cause fractures
  - Factors affecting osteoporosis.
  - hormonal imbalances (specially at menopause)
  - Osteoarthritis

    Articular cartilage at the joints gradually become thinner and eventually the bones begin to degenerate; the outcome is pain
- Practical
  - Study of human pectoral and pelvis and appendicular skeleton using specimens/models/diagrams

Competency 9.1.0 : Inquires in to the types of supporting systems and movement in organisms.
Competency Level 9.1.4 : Explores the locomotary structures in animals.
Number of Periods : 02
Learning Outcomes :

The student should be able to

- explain the types of locomotary movement.
- illustrate the structure of pseudopodia, flagella, ciliary and muscle.

suggested learning – teaching process

- Highlight the following points using a power point presentation
  - Movement can occur at cellular level, organ level & organism level.
  - Movement of the whole organism from place to place is termed as locomotion
  - Uses of locomotion.
  - Types of locomotory movements with examples (animations).
  - Prepare the students for a presentation
  - Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- Movement
- It can occur at
  - Cellular level
  - Organ level
  - Organism level
- Movement of the whole organism from place to place is termed locomotion
- Locomotion is used for
  - finding food
  - avoiding capture by predators
  - dispersal
  - finding new and favourable habitat
  - bringing together individuals for reproductive activity
- Types of locomotary movement

- Pseudopodial (Fine details of the structures are not necessary)– Amoeboid cells such as *Amoeba* and phagocytic white blood cells can change their shape, and this is the basis of how they move. When the cell moves, the fluid, inside endoplasm flows inside moving rigid ectoplasm to form a temporary projection called, pseudopodium

- Flagellar movement(Fine details of the structures are not necessary) -Flagella and flagella like structures such as sperm tails achieve their propulsive action by undulations passing along the flagellum from base to tip, driving the organism in the opposite direction .

- Ciliary movement(Fine details of the structures are not necessary)
  In *Paramecium,* each cilium held out straight from the body, swings back through an arc of about 180^0, propelling the organism forward like the oars of a rowing boat. On completing its movement, the cilium returns to its original position, bending as it does not have rigidity at that time.

- Muscular Movement
  The muscle tissue is composed of muscle cells known as muscle fibres which are capable of contracting and relaxing. To fulfill its function of supporting the body and permitting movement, the skeleton works in conjunction with muscles.

Competency 9.1.0 : Inquires in to the types of supporting systems and movement in organisms

Competency Level 9.1.5 : Investigates the basic structure and physiology of different types of muscle tissues

Number of Periods : 06

Learning Outcomes :

The student should be able to;

- describe the basic structure & physiology of muscle tissue.
- explain the basic characteristics of muscle tissue.
- state the types of muscles.
- describe the basic structure & functions of the muscle tissue.
- explain the structure of the sarcomere & basic mechanism of skeletal muscle movement.
- explain the basic concepts of the sliding filament theory.

Suggested learning -teaching process

- Highlight the basic characteristics of muscle tissue using microscopic slides
- Guide the students to draw diagrams of different types of muscle tissues with the help of microscopic slides
  - smooth muscle
  - cardiac muscle
  - skeletal muscle
- Lead a discussion to highlight the following points
  - Structure of the sarcomere and basic mechanism of skeletal muscle movement
  - Basic concepts of sliding filament theory
  - Prepare the students for a presentation
  - Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- Muscle tissue
- Different types of muscle tissues
  - smooth muscle
  - cardiac muscle
  - skeletal muscle

Skeletal muscle	Smooth muscle	Cardiac muscle
• Shape: long ,cylindrical, unbranched ,arranged parallel to each other	Fusiform, unbranched	Short, cylindrical, branched
• each muscle fiber(cell) has many nuclei (the nuclei are located near the surface of each fibre)	uninuclear	uninuclear

• striated	non striated	striated
• sarcomere present	sarcomere absent	sarcomere present
• Intercalated discs absent	Intercalated discs absent	Intercalated discs present
• nerve supply by central – nervous system and Peripheral nervous system	by autonomic nervous system	by autonomic nervous system
• neurogenic	neurogenic	myogenic
• No rhythmic contraction	• Some rhythmic .Others non rhythmic	rhythmic contractions
• fatigue easily	fatigue slowly	does not fatigue
• voluntary	involuntary	involuntary

- Properties of muscle tissue
  1. Extensibility
  2. Elasticity.
  3. Excitability or irritability.
  4. Contractility.

  .
- Extensibility

  The ability to stretch or contract
- Elasticity

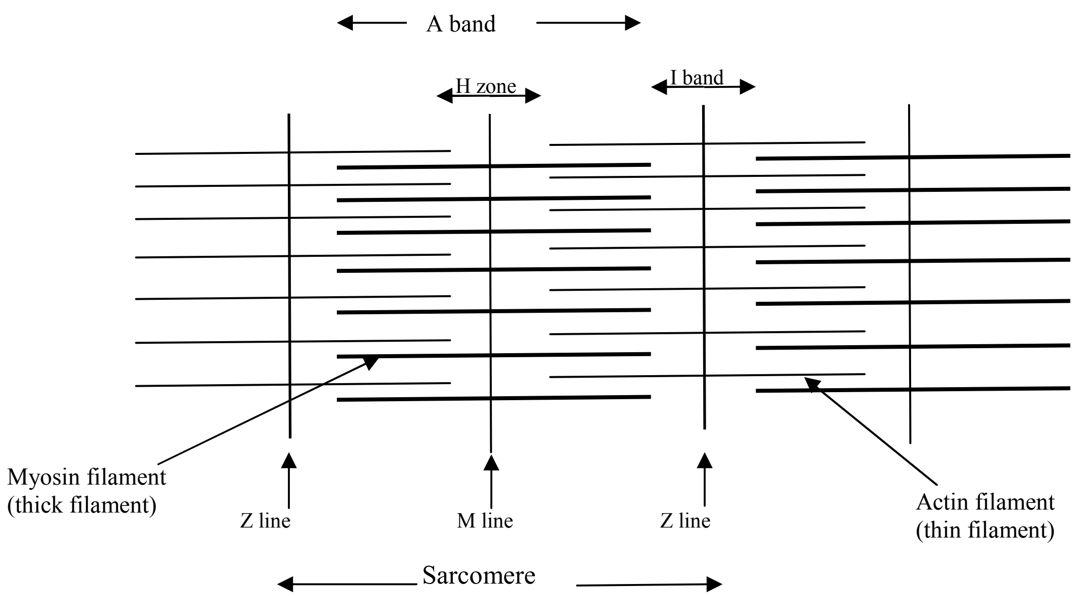
  The ability to return to its original length after being stretched or contracted.
- Excitability or irritability

  Ability to receive and respond to stimuli
- Contractility

  Ability to contract or shorten
- Structure of the sarcomere and basic mechanism of skeletal muscle movement
  - Muscles are made up of smaller muscle fibers
  - Muscle fibers are made up of smaller units called myofibrils
  - A myofibril is made up of two types of filaments which run longitudinally, there are thin filaments and thick filaments
  - The thin filaments are made of a protein called actin and the thick filaments are made of protein called myosin
  - The banding pattern results from the organization of the myofilaments within the myofibril

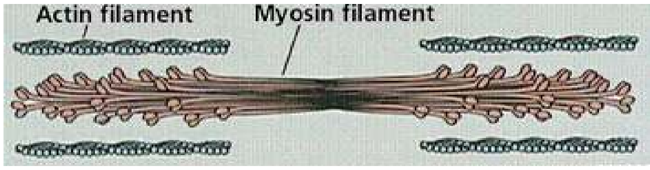
- The thick myofilaments are stacked together to produce the dark bands called A bands. The thin filaments alone are found in the light bands or I bands, only actin filaments are present in the I bands
- In the A band where the filaments do not overlap and only myosin filaments are present is called the H zone
- The middle of each light band is called the Z line
- The structure of the myofibril repeats from Z line to Z line
- This repeating structure called sarcomere is the smallest subunit of muscle contraction

- Structure of the sarcomere

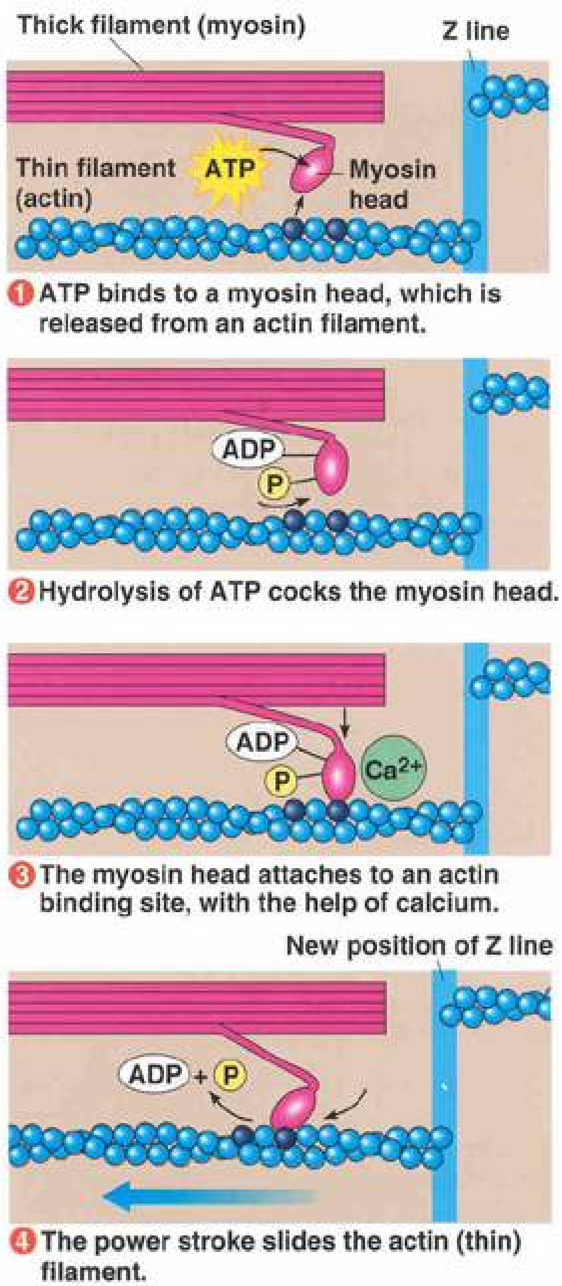


- The Sliding filament theory of muscle contraction

  - Myosin filaments contain "heads"
  - Actin filaments contain binding sites
  - ATP is necessary for the contraction to occur
  - The muscle contracts by the actin and myosin filaments sliding past each other
  - When muscle contracts with the usage of ATP the dark bands / A bands remain the same length and the light bands / I bands and the H zones get shorter



- Power Strokes
  - Actin filaments slide towards the center of sarcomere when muscle contracts. Away when it relaxes
  - Myosin heads attach to binding sites forming cross bridges
  - When activated the cross bridges tilt inward towards center in a short powerful stroke
- Muscle Contraction
  - ATP is required for the “heads” to detach and move to the next binding site
  - A series of power strokes causes noticeable muscle contraction
  - With no ATP the myosin heads do not detach


Thick filament (myosin)
Z line
Thin filament (actin)
ATP
Myosin head
1 ATP binds to a myosin head, which is released from an actin filament.
ADP
P
2 Hydrolysis of ATP cocks the myosin head.
ADP
P
Ca2+
3 The myosin head attaches to an actin binding site, with the help of calcium.
New position of Z line
ADP + P
4 The power stroke slides the actin (thin) filament.

Competency 9.1.0 : Inquires in to the types of supporting systems and movement in organisms.
Competency Level 9.1.6 : Inquires in to the types of support and types of movements in plants
Number of Periods : 08
Learning Outcomes :

The student should be able to:
- describe how support is provided to plants
- explain movement in plants

Suggested learning- teaching process
- Make students gather information from various resources like internet, books etc. in their respective group and to make a presentation of the relevant topic given based on the following points.
  - Tropic movement
  - Tactic movement
  - Nastic movement
  - Tissues that provide supportive strength in primary & secondary plant bodies
- Prepare the students for a presentation
- Make an elaboration of the subject content according to an appropriate sequence.

Guidelines

- Plants are stationary. Most of these responses take the form of growth movements & are slow
- Tropisms are growth movements of a point of a plant in which the direction of stimulus determine the direction of responses
  - phototropic responses
  - geotropism responses
  - thigmotropic responses
- Functions of Auxins in tropic movements
- Role of Auxins in plant movements
- Synthesis and distribution of Auxins
- Auxins & geotropism

- Tactic movements
  These movements are best observed in protista Eg.C*hlamydomonas,*
  Gametes in higher plants show tactic movements.

- Nastic movements
  Plants respond to a variety of stimuli that do not come from any particular direction e.g., temperature, humidity & the general level of illumination. These are called nastic responses.
  e.g., The opening & closing of a flower

- Thigmonastism
  Nastic responses to touch

- Nictinastism
  Flowers of certain daisies open in the light & close in the dark, *Sesbania* leaves – closing & opening

UNIT 10 – REPRODUCTION, GROWTH AND DEVELOPMENT

Competency 10.1.0 : Inquires into the reproductive process in organisms.

Competency Level 10.1.1 : Inquires into different patterns of reproduction.

Number of Periods : 04

Learning Outcomes : The student should be able to;

- list the different types of asexual reproduction with examples.
- briefly explain bisexuality, unisexuality, parthenogenesis, formation of gametes and fertilization.

Suggested Learning Teaching Process:

- Provide students with relevant sources (print/electronic) on different patterns of reproduction.
- Facilitate students to extract important points and make a summary.
- Encourage students to make a presentation on their findings.
- Make an elaboration to highlight important points.

Guidelines:

- The teacher should explain what is meant by reproduction. This should include;
    - Production of new generation of individuals of the same species.
    - Fundamental characteristic of living beings.
    - Ensure the survival of the species.
- There are two types of reproduction
    - Asexual
    - Sexual

- Describe asexual, sexual reproduction with examples and their advantages and disadvantages.

- Asexual reproduction

Genetically identical cells/ offsprings are produced from a single parent/ cell through mitosis.

- Fission

Single organism divides mitotically to produce genetically identical organisms.

1. Binary fission

2. Multiple fission

- Binary fission

Reproduction of unicellular organisms by mitosis into two equal daughter cells.
Eg. *Paramecium, Amoeba*, Bacteria

- Multiple fission

Production of many identical daughter cells by dividing one mother cell, which undergo mitosis.
Eg. *Plasmodium*

- Budding

New individual is produced as an outgrowth of a cell or parent's body and become separated from the rest.
Eg. Cnidarians [if remains attached to the parent's body forms colonies], yeast

- Fragmentation

Breaking of an organism into several parts, each of which grows to form a new organism.
Eg. *Planaria*, Ribbon worm, *Spirogyra*

- Formation of asexual spores/ structures

Formation of uninucleated or multinucleated structures which form fungal hyphae, filamentous bacteria or adults of some other organisms.

E.g; Conidiospores
Gemma in *Marchantia*

- Sexual reproduction

Offspring is formed by union of two gametes from different sexes.

- Bisexuality

One individual has both female and male reproductive structures/ production of both male and female gametes by the same individual

Eg; Earth worm
Hibiscus

- Unisexuality

One individual bears either ovary or testes/ production of male or female gametes by different individuals

Eg; Man
Cycas

- Parthenogenesis

Special form of reproduction.
Female produces offspring from unfertilized egg.
Eg. Honeybee
Some lizards

- Gamete formation

Gamete is a specialized haploid unicellular reproductive cell.
In Animalia gametes are formed by meiosis, in most protista and kingdom plantae gametes are formed by mitosis /in gametophyte.

- Fertilization

Fusion of gametes and the formation of zygote is fertilization.
There are two forms of fertilization

- External
- Internal

- External fertilization

Where male release their gametes into an external environment (water) and fertilization taking place there / out of the female reproductive system.
E.g., Most bony fishes and amphibians

- Internal fertilization

Males introduce their gametes into female reproductive tract and fertilization occurs there. Usually takes place in terrestrial environments to prevent desiccation of gametes.
Eg; Insects, reptiles, birds, mammals, members of kingdom plantae.

- Advantages and disadvantages of sexual and asexual reproduction

  - Sexual reproduction

    - Advantages

    1. Production of new variations leading to evolution.

    - Disadvantages

    1. Two individuals are needed for production of offspring.
    2. Time consuming.

- Asexual reproduction
- Advantages
    1. Only one parent is required.
    2. Genetically identical offspring are produced.
    3. Rapid multiplication in number
- Disadvantages
    1. Many will fail to germinate, without suitable place for germination. (spores)

Competency 10.1.0 : **Inquires into the reproductive process in organisms.**

Competency Level 10.1.2 : **Inquires structure and function of male reproductive system.**

Number of Periods : **08**

Learning Outcomes : The student should be able to,

- list the main structures and their functions of male reproductive system.
- briefly describe the major steps of spermatogenesis.
- elaborate the structure and function of sperm cell.
- state the composition of semen.
- draw a flowchart to elaborate the hormonal regulation of male reproductive system.

Suggested Learning Teaching Process:

Let the students study diagrams/ charts and other sources on male reproductive system.

Make them study the basic histological structure of the human sperm and testis.

Ask the students to find out the accessory glands related to male reproductive system.

Encourage students to present their findings to the whole class.

Make an elaboration to cover the subject content.

Guidelines :

- **Structure and function of male reproductive system**.
- Main structures and the relationship between the functions should be explained as below.
  - All the structures except testes are located in the abdominal cavity.
    - Scrotal sac - external sac of skin housing the testes

  Function – optimum sperm production, survival and [1-2 ^{0}C less than the body temperature is optimum for it] protection.

  - Testes – paired, oval shaped consist of several, fine highly coiled seminiferous tubules

Function – production of sperms and testosterone.

- Seminiferous tubules

  Walls of the seminiferous tubules consist of a layer of cells as germinal epithelium from which sperm originates. There is a sequential arrangement of cells of different developmental stages of spermatogenesis as given below.

  1. Outer most germinal epithelium 2n and Sertoli cells
  2. Spermatogonia (2n)
  3. Primary spermatocytes (2n)
  4. Secondary spermatocytes (n)
  5. Spermatids (n)
  6. Sperm cells (n)

a. Sertoli cells

   Different cells that undergo spermatogenesis are attached to sertoli cells. These cells are present in the wall of the seminiferous tubules, stretching from the outer layer to the lumen.
   Function –
   Secretion of Inhibin
   Nutrition (For cells in different stages of spermatogenesis)
   Attachment -

b. Leydig cells or interstitial cells

   Found in interstitial spaces in- between the seminiferous tubules.
   Function – secretion of testosterone, male sex hormone.

- **Basic structure and function of a sperm cell**

  It should include head, neck, middle piece and tail. It is microscopic and elongated.

1) Head
   - Flat, circular and contains nucleus (large) which is haploid.
   - Contains paternal genetic materials which carry paternal characters to the zygote.
   - Regulates cellular activities.
   - Acrosome is a modified lysosome.
   - Contains hydrolytic enzymes ,trypsin, hyaluronidase and pepsin

   -To digest egg membrane/penetrate the egg membrane.

2) Mid piece
   - Contains numerous mitochondria.
   - To provide energy to swim towards the ovum.

3) Neck
   - Constriction between head and mid piece. In the neck pair of centrioles are present. They are right angle to each other. Axial filament starts from one centriole. It runs to the end of the tail /forms the flagellum.

4) Tail
   - Tail is a long flagellum.
   - Helps in swimming towards ovum.
   - Also helps the sperm to enter the ovum.
   - Consist of 9+2 microtubules ,3/4 is covered by cell membrane and uncovered area is end piece.
   - Provide propulsion mechanism in swimming towards the egg cell.

- Life expectancy is 48-72 hrs. after ejaculation.
- Duration of spermatogenesis-about 72 days.

  (production of mature sperm cells from spermatogonia in seminiferous tubules)

- Process of spermatogenesis include the stages given below.
  - Primodial germ cells of the embryonic testes differentiate into spermatogonia (2n).
  - At the beginning of puberty by repeated mitosis produce primary spermatocytes (2n).
  - By first meiotic devision haploid secondary spermatocytes are produced.
  - Each secondary spermatocyte completes the second stage of meiosis division and forms spermatids (n).
  - Spermatids differentiate into mature spermatozoa.

This process starts at puberty and lasts till old age. FSH –initiation of spermatogenesis. LH ,FSH and testosterone required for maintenance of spermatogenesis.

- Epididymis

  Coiled tube starting from testes and ending in vas deferens, in contact with testes.
  Function-Storage of sperms, physiological maturation of sperms (sperms become motile and gain the ability to fertilize), secretion of part of seminal fluid.

- Vas deferens

Two ducts ,one from each epididymis joins with a duct from the seminal vesicles, forms short ejaculatory duct.

Function-Transportation of sperms from epidydymis to urethra

-Storage

- Ejaculatory duct-Each of the seminal vesicles empties their contents into the ejaculatory duct.
  Fuses with the duct arising from the bladder to form urethra.
  Function -Transport of seminal vesicular secretion.

- Urethra and penis

Urethra-starts from urinary bladder and pass through prostate gland to the penis.

Function-Transport both urine and semen.

- Penis- Cylindrical, muscular structure with spongy erectile tissue and urethra.

  Function
  - Ejaculation of semen into vagina.
  - Transport of urine/urination

- Accessory glands related to the male reproductive system
  - Seminal vesicles
    - Paired, joins with the vas deferens
    - Bulk of the semen is produced. Alkaline secretion with mucous, fructose, prostaglandin and vitamin C.
  - Functions
    - Neutralizes the vaginal acidity
    - lubrication
    - Seminal vesicular fluid is an energy source for sperms
    - Supply medium for sperms to swim.
  - Prostate glands.

    Single, surrounds the urethra immediately under the bladder, Secrets slightly alkaline fluid with mucous.
  - Functions
    - Neutralize the vaginal acidity and lubrication
    - Neutralize the acidity of any remaining urine in urethra

- Semen

  Sperms and the secretions of sexual accessory glands and epididymis

  Usually ejaculate 2-5 ml.

  Sperm count 20 million/ml.
- Functions
  - Provides liquid medium for sperms.
  - Neutralize the vaginal acidity.

Hormonal regulation of male reproductive system

- Hormonal regulation of spermatogenesis
  - It is controlled by hypothalamus and anterior pituitary.
  - Hypothalamus releases GnRH (Gonadotrophin Releasing Hormone).
  - GnRH stimulates anterior pituitary to secrete Follicle stimulating hormone (FSH) and Luteinizing Hormone (LH).
  - Follicle Stimulating Hormone stimulates spermatogenesis by stimulating sertoli cells to complete the development of spermatozoa from spermatids (Initiation of spermatogenesis).
  - LH stimulates the synthesis of testosterone by Leydig cells.
  - This is (LH) therefore also known as interstitial cells stimulating Hormone(ICSH).
  - Testosteron stimulates growth and development of spermatogonia to form sperms.
- Increase in the level of testosterone results in decrease in secretion of GnRH From hypothalamus.
- This in turn result in declining level of LH and FSH . Testosterone also acts directly on the anterior pituitary to reduce LH secretion.
- If spermatogenesis proceeds too rapidly Inhibin is released from sertoli cells, which reduce the secretion of FSH.
- When the rate of spermatogenesis is low, Inhibin is not secreted and FSH stimulates spermatogenesis.
- Histological structure of seminiferous tubule /testes should be examined under light microscope
- Testosterone –stimulates development and maintenance of male secondary sexual characteristics and all parts of the reproductive system.

Practical:

Study of the male reproductive system using models/diagrams.

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.3 : **Inquires structure and function of female reproductive system**

Number of Periods : **08**

Learning Outcomes : The student should be able to,

- list the structures and functions of female reproductive system.
- briefly describe the major steps of oogenesis and the hormonal regulation of it.
- elaborate the structure and function of human ovum.
- list the changes that occur in puberty.
- illustrate the hormonal regulation and the structural changes that occur in menstrual cycle.
- briefly describe menopause.

Suggested Learning Teaching Process:

- Let the students study diagrams/ charts and other sources of female reproductive system.
- Make them study the basic histological structure of the ovum and ovaries, ask the students to find out the menstrual cycle and its hormonal regulation.
- Encourage students to present their findings to the whole class.
- Make an elaboration to cover the subject content.

Guidelines:

- Structure and function of female reproductive system
  - Whole system is located in the pelvis.
  - Basic structure should be explained with the aid of diagrams.
  - Main structures and the relationship between the function should include the following

- Ovaries
  - Paired ,almond shaped.
  - Production of ova and female sex hormones –oestrogen and progesterone.
  - Cross section of ovary has to be examined under light microscope.

- Fallopian tubes/oviducts.
  - Duct with a funnel like opening at distal end and connected with the uterus by the proximal end, lined by ciliated epithelium
  - Transportation of secondary oocyte or morula towards the uterus.
  - Fertilization taking place.

- Uterus

  Pear shaped ,muscular organ narrows to form a neck. Leads to the vagina via cervix. Made out of 3 layers.
  - Endometrium(stratified epithelium)
  - Myometrium (smooth muscles)
  - Perimetrium(fibrous connective tissue)

  Implantation of embryo and accommodation of fetus. Provide contractions for birth.

- Vagina

  Muscular tube with stratified epithelium connecting external and internal organs of reproduction. Mucus secreting gland located near the opening.

  During the child birth making the birth canal, During intercourse provides passage for the penis to release semen.

- Process of oogenesis should be explained with the aid of diagrams.
- Fetal ovaries contain oogonia. Shortly before birth some transform into primary oocytes.
- Primary oocytes were produced during the fetal development. They are remained at prophase of meiosis 1 throughout child hood.

- Starting at puberty a single primary oocyte completes the meiosis 1 each month, involving unequal cytokinensis, producing large secondary oocyte (n) and smaller polar body.
- Second meiotic division which produces the ovum and another polar body only if a sperm cell penetrates the secondary oocyte.
- Menstrual Cycle

Production of eggs begins in the ovaries of the fetus before birth but the final development of the individual egg is completed in adult life only after fertilization. At birth two ovaries contain up to 2 000 000 primary follicles.

The release of the egg cell from the ovary (secondary oocyte) after rupturing of the Graffian follicle is known as ovulation, which occurs from one of the two ovaries alternatively once about every 28 days from puberty(at the age around 12 years) until menopause (at the age of 45-55 years). The egg on release is drawn into the fallopian tube funnel by ciliary action and moves downwards. Further development of secondary oocyte occurs only after a sperm fuses with it, if not fertilized it is lost from the body via the vagina about 3 days later. After discharge of the egg, ruptured ovarian follicle develops into corpus luteum which becomes an endocrine gland. The changes that take place in the ovary and the endometrium during ovarian cycle (menstrual cycle) should be explained. The changes in the blood levels of LH, FSH, progesterone and oestrogen should also be shown and the role of these hormones in the control of menstrual cycle should be explained.

- Structure and function of ovum should be explained including the following;
  - Microscopic but one of the largest cells in the body.
  - Spherical.
  - Alecithal(no yolk)-because it is nourished from the mother.
  - Haploid.
  - Life span 24 hours.
  - Contains maternal genetic material.

    -Carries maternal characters to the zygote and regulate the activities of the cell.
  - Dense cytoplasm with lipid droplets and lysosomes (cortical granules)

-Initiation of cortical reaction in fertilization.

- Surrounded by plasma membrane/vitelline membrane-protection.
- Perivitelline space-provides space for polar bodies.
- Outside the perivitelline space is the zona pellucida, an acellular coat.

  -Prevents polyspermy.
- Polar bodies retain excess chromosomes resulted due to the meiosis.
- Zona pellucida has special sperm receptor sites.
- Acrosomal enzymes destroy these receptor sites ,so sperms can no longer bind to the zona pellucida.
- Outside zona pellucida is a cellular layer called corona radiata.

- Structure and function of ovaries
  - Elongated and flattened, almond shaped.
  - Consist of germinal epithelium (single layer of cuboidal epithelium)
  - Stroma consists of cortex and medulla.
  - Cortex mainly consists of follicles of different stages of maturity and dense connective tissues, corpus luteum and corpus albicans.
  - Medulla mainly consists of loose connective tissues, blood vessels and nerves.
  - Follicles-primary follicles, mature follicles/graffian follicles
    - Primary follicles

    Consists of primary oocyte(2n) surrounded by a single layers of follicular cells
    - Graffian follicles

    Primary oocyte undergoes first meiotic division. A fluid filled cavity called antrum in the follicle is surrounded by several follicle cells. This houses the secondary oocyte (n) which can undergo fertilization. Production of estrogen is the main function of the Graffian follicle.
  - Corpus luteum

    Consists of glandular cells, yellow coloured central cavity. Production of oestrogen and progesterone

- Corpus albicans

  Consists of inactive fibrous tissues .
- Germinal epithelium –Single layer of cuboidal epithelial cells .Production of ova begins with the mitosis of the primordial germ cells in the embryonic germinal epithelium.
- At birth ovaries contain 2 ,000, 000 primary follicles

- Menopause

Cessation of ovulation and menstruation cycle due to less responsiveness to FSH and LH. Usually it occurs between 45-55 years.

- Practical:
  - Study of the female reproductive system using models/diagrams.

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.4 : **Inquires into the processes involved in fertilization up to birth**

Number of Periods : **05**

Learning Outcomes : The student should be able to,

- state the location of fertilization.
- describe the process of fertilization at microscopic level.
- explain how implantation occurs.
- describe the structure and functions of placenta, fetal membranes and umbilical cord.
- explain pregnancy and its duration.
- state the major fetal changes associated with each trimester of pregnancy.
- explain the process of parturition and the positive feedback system.
- describe how nutrition and protection are provided and bearing the developing embryo.
- summarizes the process of parturition.

Suggested Learning Teaching Process:

- Provide students with relevant books and other sources on processes involved from fertilization up to birth
- Help the students to summarize what they learned.
- Ask the students to prepare a report on the processes involved from fertilization up to birth.
- Provide opportunity to present their findings to the whole class.
- Make an elaboration to cover the subject content.

Guidelines:

- Sequence of fertilization at microscopic level

Following deposition of sperms in the female reproductive tract, it's secretions brings about certain molecular changes on the plasma membrane of sperms. This results in increase of the mobility of the sperm (hyper activation) and this phenomenon is called capacitation.

Capacitated sperm penetrates through the corona radiata and reaches zona pellucida, combines with the receptors of the zona pellucida. This causes the release of hyaluronidase and proteases (e.g., tripsin) from the acrosome of the sperm (acrosome reaction). Enzymes spill from the vitalline membrane of the egg cell and the head of the sperm fuses with the vitalline membrane and blocks the entry of other sperms (polyspermy).

Sperm head enters into the cytoplasm of egg. Lysosomes of the (cortical granules) outer region release their enzymes outside of the vitelline membrane and zona pellucida gets thickened and hardened and prevent polyspermy.(cortical reaction).The entry of sperm stimulates the completion of secondary meiotic division of the secondary oocyte and releases the secondary polar body(released to perivitalline space) and ovum. Secondary polar body immediately degenerates and the nucleus of the sperm swells as it's chromatin becomes less tightly coiled. At this stage the nuclei of the sperm and secondary oocyte are called pronuclei.

Then the male pronucleus fuses with the female pronucleus. This is the actual act of fertilization. The new nucleus formed has two sets of chromosomes one from the egg and one from the sperm. The cell is now diploid (2n) and is known as zygote. This new nucleus divides immediately by mitosis.

- Implantation

As the zygote passes down the fallopian tube it divides by successive nuclear divisions into a small mass of cells called morula. Morula rearranges to form a hollow ball of cells with a fluid filled cavity called blastocoel. It is lined by single cell layer called –tropoblast which forms tropoblastic villi, which helps in attachment to the endometrium-this process is called implantation. Implantation commences by day 7 and is completed by day 14. Nutrients are absorbed across these villi from maternal blood sinus. They are lined by an epithelium with microvilli to increase the absorptive surface area.

- Placenta

Found only in mammals. Only organ composed of cells derived from two organisms; mother and fetus. It is known as deciduous alantochorion placenta.

Placenta is a disc shaped structure. Arises from the chorion, allantois and uterine wall. Finger like processes(chorionic villi) containing capillary loops project into maternal blood space in the uterine wall. Maternal and fetal blood do not mix. Across the thin barrier, exchange of material by diffusion and active transport occurs.

From the maternal blood, foetus obtains oxygen, water, glucose, amino acids, lipids, some proteins, minerals, vitamins and hormones. Several antibodies, drugs(including alcohol),viruses(Hepatitis B, Rubella),toxins and diverse substances absorbed from mother's body tobacco smoke can also pass to the foetus. From the fetus water, urea, hormones and carbon dioxide pass to the maternal blood. Placenta is also an endocrine gland which produces hormones including hCG at the initial stages and later progesterone , oestrogen and placental lactogen.

- Functions of placenta
  - Exchange material between mother and foetus
  - Endocrine [oestrogen, progesteron, human placental lactogen, chorionic gonadotrophins]
  - Attachment of the fetus to mother
  - Acting as a barrier for certain materials
  - Prevention from coagulation of blood due to Rh factor and different blood groups, and relatively high blood pressure of maternal circulation.

- Fetal membranes

  The outer cells of the blastocyst (trophoblastic villi) which project into the surrounding tissue of the endometrium. Nutrients absorbed across these villi. The cells of the inner cell mass divide. The embryo grows continuously and outer cells and tissues give rise to the amnion and yolk sac. Amnion surrounds the fluid filled cavity(amniotic cavity) in which the embryo is suspended and cushioned against mechanical damage. Yolk sac has no obvious function and later becomes buried in placenta.

  The fourth embryonic membrane i.e. the allantois develops from the hind gut and grows in close contact with the chorion and participates in the formation of placenta.

- Umbilical cord

  Connecting cord from the placenta to the foetus.

- **Pregnancy and its duration**

  Once the egg has been fertilized conception has been achieved. In human the duration of pregnancy (from fertilization to parturition) is approximately 40 weeks.

- **Major fetal changes associated with each trimester of pregnancy**

The major developments at every three months should be stated. In this regard, the pictures/diagrams of the developing foetus at each trimester should be shown and the following points should be highlighted.

By the end of the 3^{rd} month ,the foetus is about 7.5 cm long and weighs about 25-30 g. The eyes are almost fully developed, eyelids are fused, nose has developed, external ears present, appendages are fully formed, nails developed, major blood vessels developed and heartbeat can be detected. Head is large in proportion with compared to the rest of the body.

By the end of the 6 th month ,the foetus is 25-35 cm long and usually weighs about 550-700 g. Eye lids are separated and eyelashes are formed. Skin wrinkled. Head is large. Face has human features and hair is present. Fine hair covers body. Many bones are ossified .Head becomes less disproportionate to rest of the body.

By the end of the 9th month (40 weeks),the foetus is around 50 cm long and usually weighs around 3000 g. Head and body has become more proportionate. Fine hair that covered the body is shed, nails extend up to end of the fingers ,testes has descended to scrotum. Bones of the head hardened except for fontanelles. All organ systems are well developed. After about 40 weeks parturition takes place.

- Birth

When the foetus reaches certain size (relative to the uterus), birth (parturition) occurs. From the 16 th week of gestation oestrogen and progesterone are produced by placenta. Oestrogen stimulates formation of oxytosin receptors in myometrium. Immediately before birth there is a sharp drop of progesteron level.

Oxytocin produced by the foetus and mother's hypothalamus stimulates powerful contractions of myometrium of the uterus by action through oxytosin receptors. Oxytocin also stimulates placenta to produce prostaglandins which also induce myometrial contraction. These contractions propels the foetus towards vagina.

Head of the foetus and the muscular contractions stimulates the stretch receptors of the uterine wall and cervix.
This stimulation causes release of more oxytocin and prostaglandins causing further contraction of the myometrium until birth occurs. (Positive feed back mechanism)

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.5 : **Inquires into the nutrition and the development of the child**

Number of Periods : **02**

Learning Outcomes : The student should be able to,

- describe the gross structure and function of mammary glands emphasizing on system of ducts and lobules.
- describe the nervous & hormonal control of production and ejection of milk.
- state the major components of breast milk.
- state the major functions of breast milk.
- criticize the advantages of breast feeding over bottle feeding.
- explain the importance of food, warmth and protection to achieve the optimum physical and mental development at different stages of the infant and child.

Suggested Learning Teaching Process:

- Provide the students with relevant books and leaflets on the nutrition and development of child.
- Lead a discussion on the structure and function of mammary glands, major components of milk and the advantages of breast feeding.
- Ask the students to prepare a booklet and present it to the whole class.
- Make an elaboration according to appropriate sequence.

Guidelines :

- **Mammary glands**

Mammary glands/ breasts contain milk secreting glands. These glands are made up of milk secreting cells. There are about 15-20 milk production systems consisting of milk secreting cells. Each system consist of several lobules (alveoli) which store milk. Ducts and alveoli surrounded by smooth muscles and fat cells. Lobules/ alveoli lead to ducts and ducts empty the secretion to sinuses that open on the nipples through larger ducts separately.

On the nipple and areola (area/areola tissue) around the nipple are tactile receptors.

Nervous and hormonal control of production and ejection of milk

In normal women due to prolactin inhibiting factor (PIF) secreted by hypothalamus, secreting of prolactin from anterior pituitary is inhibited.

The breasts increase in size during pregnancy due to the development of the milk glands ,controlled by progesterone and ducts by oestrogen.

For milk to be produced, the hormone prolactin must be produced, which is secreted by anterior pituitary. Human placental lactogen is also involved.

Throughout the pregnancy presence of progesterone inhibits the secretion of prolactin. Therefore milk secretion is inhibited. At birth when the oestrogen and progesterone levels fall, due to the loss of placenta, prolactin is no longer inhibited and it stimulates the alveoli to secrete milk.

Nerve impulses pass from the receptors of nipple and areola (areola tissue) to hypothalamus via spinal cord and release oxytosin from posterior pituitary. This causes the contraction of smooth muscle fibers surrounding the alveoli and forces milk through ducts and sinuses out of the nipples. Sucking also stimulates the release of prolactin by means of another reflex to the hypothalamus.

Nutrition in early neonatal stage

- Until the age of 6 months the infant should be fed only with mother's milk because mother's milk provides all nutrients needed in required amounts. From the age of 6 months until the age of 2 years, together with supplementary food, breast feeding should be continued.
- At the age of around 6 months semisolid food should be introduced. Rice, potatoes, cereals can be used to prepare semisolid food. Vegetables should also be added in preparation of the semisolid food. Fruits should also be given from this age.
- About two months after commencing supplementary feeding, infant should be fed at least 4 times a day. When the child is 8-9 months old, this may be 4-6 times.
- By the age of two years, the child should be trained to feed on the usual diet of the other members of the family.

- **Mental development of infant and child**

  The baby is totally dependent upon the parents for food, warmth and protection for a long time. Most systems of the baby's body including the nervous system are immature and show important developments in the first few months. Rapid mental development takes place and the baby matures quickly and soon becomes able to manipulate objects that it can grasp. By the end of 11-14 months it will have acquired head and hand control and have learnt to sit. It can also pull itself up, stand and then begins to walk without aid. Vocalization starts within two months and speaking is established during the first year and by the age of two years the baby will have a vocabulary of about 200 words.

- It should be highlighted that the period of mental development is very long in the humans compared to other mammals .This is associated with large and complex brain. Parental care involves processes of providing education and training too. This has been a significant factor in the success of human being during the process of evolution

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.6 : **Develop an awareness on reproductive health**.

Number of Periods : 04

Learning Outcomes : The student should be able to,

- list out the major body changes associated with puberty.
- state the early signs of pregnancy.
- illustrates the pregnancy tests.
- state family planning and its importance.
- relate the contraception methods with the relative physiological process taking place in brief.
- list out the sexually transmitted infections.

Suggested Learning Teaching Process:

- Advise the students to collect information on reproductive health from maternity hospitals, sexually transmitted disease clinics, family planning centers etc.

- Ask the students to prepare leaflets, posters, booklets etc. and organize an exhibition.

- Make an elaboration according to appropriate sequence

Guidelines :

- Puberty and associated major body changes

  During puberty major physical and mental changes occur due to increasing secretion of GnRH leading to higher levels of FSH followed by increased LH. These gonadotrophins trigger maturation of the reproductive system and development of secondary sex characteristics, by increasing of secretion of sex hormones from the gonads.

  In girls growth spurt is followed by first menstruation at about age 12-13.

  - Major body changes
    - Reproductive system reach maturity.
    - The menstrual cycle and ovulation begin.
    - Breasts develop and enlarge.
    - Pubic and auxillary hair begins to grow.

- There is an increase in the rate of growth in height and widening of the pelvis.
- There is an increase in the amount of fat deposited in the subcutaneous tissue.
- Scalp hair increases.

- **In boys** first ejaculation of viable sperms at age 13-14.
- Major body changes
  - Growth of muscle and bone and a marked increase in height and weight.
  - Enlargement of the larynx and deepening of the voice.
  - Growth of hair on the face, arm pits , chest, abdomen and pubis.
  - Enlargement of the penis, scrotum and prostate gland.
  - Maturation of the seminiferous tubules and production of spermatozoa.
  - Shoulders broaden.

- Early signs of pregnancy - due to hormonal changes.
  - Cessation of menses
  - Morning sickness (vomiting ,nausea, dizziness)
  - Food cravings and or aversion to certain food
  - Breast tenderness
  - Presence of hCG in urine in 14 days or in blood after 10 days
  - Frequency of urination increases.
  - Change in colour of areola of breast (in some)
  - Constipation (in some)

- Pregnancy tests

  Mainly based on testing for the presence of hCG in urine and blood.

  Concentration of human chorionic gonadotrophin in blood increases in pregnant women.

  Present in blood after 10 days and present in urine after 14 days

  In the first three months hCG is highest and then decreases

- Family planning

  Due to the limited nature of resources and for sustainable uses of the existing resources it is advocated that the family size of the human should be limited. The economic realities of the parents may also require to control the family size and / or delay child bearing.
- Birth control methods

  Unwanted pregnancies are avoided by birth control methods.
- Common temporary methods are
  - Oral contraceptives – for females
    - Mainly high concentration of oestrogen , progesterone. Prevents follicle maturation, implantation.
    - Negative feedback inhibits LH,FSH.
    - Thickening of cervical mucosa.
  - Condom – males
    - Prevents sperm entry
  - IUD (loop) – females
    - Prevents implantation
    - Inflammation reaction
  - Depo provera - females
    - Prevention of implantation by making endometrium thin.
    - Thickening of cervical mucosa; prevents sperm transport.
    - Prevents ovulation.
- Common permanent methods
  - Males – vasectomy

    Prevents release of sperms
  - Females – tubal ligations

    Prevents ovum from entering uterus

- **Sexually transmitted infections**

Infection	**Pathogen**	**Main mode of transmission**	**Main symptoms**
Gonorrhoea	*Neisseria gonorroea*	Sexual contact, Mother to child at birth	In Males-Burning feeling/discomfort when passing urine, Yellow discharge with pus from genito-urinary tract. Accompanied by fever ,headache Females-Fallopian tubes become filled with pus, sterility.
Syphilis	*Treponema pallidum*	Sexual contact Mother to baby at birth	Sores or chancres (painless ulcers) on any part of the body(vagina, lips, fingers, nipples), fever, skin rashes.
AIDS-(Acquired Immuno deficiency syndrome)	HIV-(Human Immuno deficiency virus)	Sexual contact, Transfer of body fluids (blood, serum) Use of unsterilized needles, Mother to fetus-during pregnancy,at birth and during lactation	Loss of appetite and weight Fever Persistent dry cough Lymphoma(concerns lymphatic system- Pneumonia and other diseases resulting from breakdown of the immune system)
Genital herpes	Herpes simplex virus	Sexual contact	Itchy, painful sores around genital area, fever in some cases.

- Infertility

  Inability of a couple of reproductive age to achieve a pregnancy within one year of regular intercourse (during the fertile phases of the menstrual cycle), without using any contraceptive method.

- Assisted reproduction

  In vitro fertilization-

  Placing of oocytes and sperms in close proximity outside the body, to facilitate fertilization and placing the embryo back in the womb.

Competency 10.1.0 : Inquires into the reproductive process in organisms

Competency Level 10.1.7 : Gains experience in productive use of methods of plant propagation

Number of Periods : 04

Learning Outcomes : The student should be able to,

- explain briefly the methods of vegetative reproduction in plants.
- state how vegetative reproduction differ from sexual reproduction.
- state methods of vegetative propagation of plants.
- describe briefly use of stem cuttings, bud grafting and stem grafting for propagation.
- recognize plant tissue culture as a laboratory technique to maintain live plant tissues in-vitro.
- list the constituents of culture media used in plant tissue culture.
- state the functions of plant growth substances in tissue culture.
- state different explants used in plant tissue culture.
- describe briefly the steps of micropropagation.
- state uses of tissue culture techniques including micropropagation.

Suggested Learning Teaching Process:

- Ask the students to collect the vegetatively reproducing organs of the plants.
- Advise them to observe and identify the features of those organs.
- Arrange the field trip to research institutes, Institute of Fundamental Studies, agriculture offices etc. to show the methods of vegetative propagation of plants such as cuttings, grafting and tissue culture.
- Make a presentation on what they gained.
- Make an elaboration according to appropriate sequence.

Guidelines:

- Vegetative reproduction is the most common form of asexual reproduction in higher plants.
- Vegetative parts of plants produce propagating organs.
- Underground stems like rhizomes, corms, bulbs and tubers. Runners growing horizontally at ground level. Bulbils arising from aerial parts. Adventitious buds arising from parts of plants other than stems.Some of these also store food and are means of surviving adverse conditions as perennating organs.

Rhizomes

A horizontally growing under ground stem. Often close to the soil surface.

Bears aerial shoots, scaly leaves, dormant buds, roots and adventitious roots

Examples for rhizomes; *Musa, Zingiber, Curcuma, Canna*

Corms

A short swollen underground stem growing vertically, bears aerial shoots, scaly leaves, dormant buds, roots and adventitious roots.

Examples for corms; *Colocasia, Alocacia,, Gladiolus*

Bulbs

Very short underground stems with swollen leaf bases forming a bulb.

Examples for bulbs; *Allium*, *Crinum*

Runners

- Lateral branches growing from axillary buds of the erect stem growing horizontally over the soil surface and producing new shoots and adventitious roots.
- Examples for runners; *Centella*, *Cyperus, Pistia*

Tubers

- Underground branches of stems which are swollen and used as storage organs. Tubers bear scaly leaves and dormant axillary buds. Used as a perennating organ.
- Examples for tubers; *Solanum*

Bulbils

- Axillary buds of aerial stems growing into small shoots with leaves and separating from main stems to produce new plants.
- Examples for bulbils; *Ananas*, *Dioscoria*

Adventitious buds

- Buds arising from vegetative parts other than stems like leaves producing new plants.
- Examples for adventitious buds; *Bryophyllum, Begonia*

- **Methods of plant propagation**
  - **Stem cuttings**

- Cut pieces of stems with axillary buds are rooted in soil artificially, sometimes with the use of auxins.

- Examples for use of stem cuttings, *Manihot, Ipomoea, Camelia* (Tea), *Rosa*.

Bud grafting

- Transplanting an axillary bud from one plant on the stem of another rooted plant.

- Transplanted bud is the scion. It is grafted onto the stock. Scion and stock can be of different varieties or closely related species.

- Procedure involves careful removal of piece of bark with axillary bud, opening of the bark of the stock plant with a sharp knife, transplanting the scion so that cambial tissues come in contact, wrapping with ribbon and keeping until scion fuses with stock.

- Advantages of bud grafting includes, propagating plants faster, with same characters, as in mother plant uniting roots and shoots of different varieties etc.

- Examples for bud grafting. Fruit plants like *Mangifera,* Ornamental plants like *Rosa.*

Stem grafting

- Similar in many ways to bud grafting except that a shoot instead of a bud is used as the scion.

- **Plant tissue culture**

- Growing tissues of plants in sterile artificial culture media under in-vitro conditions.

- Many plant cells are totipotent, having the ability to generate a total plant when suitable conditions are provided.

- Roles of plant growth substances in culture media. Cytokinins and auxins are involved in cell division and differentiation of cells.Auxins favour root growth while cytokinins favour shoot growth.

- Constituents of culture media includes,water, inorganic nutrients, a carbon source (sucrose is used mostly), plant growth substances and other organic requirements.

- Proportion of auxins and cytokinins in the medium determine the growth characteristics.

- Several different parts of a plant, including apical and lateral buds, stem, leaf, stamens, embryos etc. can be used as explants to initiate a tissue culture.
- Maintaining sterile conditions of the medium and using aseptic conditions are necessary.
- Callus is a friable mass of undifferentiated and dividing cells that is produced often from the explants in tissue culture.
- Formation of roots and shoots can be induced on the callus by manipulating culture medium and conditions.

- **Steps and basic procedure in micro propagation**

- Micro propagation is the use of tissue culture techniques to produce plants in large numbers.

- Steps and procedure of micro propagation includes preparation of a suitable explants and a suitable culture medium under sterile conditions, culture initiation, induction of shoots, multiplication of shoots, induction of roots, and acclimatization of plantlets.

Benefits of micro propagation includes producing plants in large numbers, with same genotypes, rapidly, in small spaces, irrespective of climatic conditions, ability to propagate plants which do not produce viable seeds, ability to produce disease free plants etc.

Tissue culture is used for purposes other than micro propagation like cryopreservation of germ plasma, producing genetically modified plants, obtaining haploid plants etc.

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.8 : **Uses the trends in life cycles, to relate the adaptations of plants for terrestrial life.**

Number of Periods : **10**

Learning outcomes **:** The student should be able to,

- explain significance of sexual reproduction in comparison to asexual reproduction.
- explain that alternation of generation involves a haploid gametophyte generation producing gametes and diploid sporophytic generation producing spores for reproduction.
- explain that in the evolution of land plants gametophytic generation gradually reduced and the sporophytic generation became dominant as adaptation to land habit.
- uses important features of reproduction and life cycles of *Pogonatum, Nephrolepis, Selaginella, Cycas* and a typical angiosperm to explain the adaptations to the terrestrial life.

Suggested Learning Teaching Process:

- Provide the students with specimens, prepared slides, pictures and literature of relevant plants.
- Guide the students to build up the life cycles of each plant.
- Give opportunity to present their findings.
- Make an elaboration according to appropriate sequence.

Guidelines

Sexual reproduction of plants

- Many terrestrial plants reproduce asexually as well as sexually. Both of these methods have advantages and disadvantages.

- Delay of meiosis after fertilization in life cycle has resulted in creating a diploid generation. Diploid generation produce spores by meiosis to produce a haploid gametophytic generation.

- All terrestrial plants have reproductive organs (gametangia and sporangia) protected by sterile layers of cells. After fertilization the zygote is retained within the gametophyte to produce an embryo which is nourished by the gametophyte.

- With the evolution of land plants diploid generation acquired adaptations needed for successful colonization of land.

- Gametophytic generation of the life cycle has reduced in structure with the evolution of land plants and has become dependent on the sporophyte in seed plants.

Diversity in the life cycles of terrestrial plants

- By the study of life cycles of following plants, track how plants evolved better and better for a terrestrial life.. *Pogonatum, Nephrolepis, Selaginella, Cycas,* a typical Angiosperm (Angiosperm) .

- **Life cycle of *Pogonatum***

- Describe the life cycle of *Pogonatum* stating the following stages.
- Spores, protonema, male and female gametophytes, archegonium, antheridia, antherozoid, egg cell ,zygote, embryo, sporophyte
- Lead a discussion on to what extent the stages mentioned above are adapted to the terrestrial environment.

Details of the vegetative and reproductive structures of various stages represented in the life cycles including diagrams are not expected from the students.

Life cycle of *Nephrolepis*

- Describe the life cycle of *Nephrolepis* stating the following stages.
- Sporophytic plant,sori, sporangia ,spores, protothallus, archegonia, antheridia, antherozoid, egg, zygote and embryo
- Lead a discussion on to what extent the stages mentioned above are adapted to the terrestrial environment.

Details of the vegetative and reproductive structures of various stages represented in the life cycles including diagrams are not expected from the students.

Life cycle of *Selaginella*

- Describe the life cycle of *Selaginella* stating the following stages.
- Sporophytic plant,strobilli,megasporangia,microsporangia,megaspores,microspores,male and female gametophytes, antherozoid, egg, zygote, embryo
- Explain how heterospory has contributed to the evolution of seed habit
- Lead a discussion on to what extent the stages mentioned above are adapted to the terrestrial environment.

Details of the vegetative and reproductive structures of various stages represented in the life cycles including diagrams are not expected from the students.

Life cycle of *Cycas*

- Describe the life cycle of *Cycas* stating the following stages.

- Sporophyte,male sporophyte,female sporophyte,cone

  Microsporophyll-microsporangium,microspores, male gametophyte, antherozoid

Megasporophyll-megasporangium,ovule, female gametophyte, archegonia,ovum, zygote, embryo,seed

- Lead a discussion on to what extent the stages mentioned above are adapted to the terrestrial environment.

Details of the vegetative and reproductive structures of various stages represented in the life cycles including diagrams are not expected from the students.

Life cycle of a typical Angiosperm (Anthophyta)

Describe briefly typical life cycle of an angiosperm and explain how adaptations to terrestrial life, acquired in the evolution, as seen in the life cycles of non-flowering plants are extended further in angiosperms. Angiosperms are the most successful land plants which are represented by diverse forms colonizing many different habitats.

Competency 10.1.0 : **Inquires into the reproductive process in organisms**

Competency Level 10.1.9 : **Examines structures and functions associated with sexual reproduction in flowering plants**

Number of Periods : **04**

Learning Outcomes: The student should be able to,

- elaborate the structure and function of a flower.
- describe pollination and fertilization in flowering plants.
- state the significance of development of seeds and fruits.
- explain parthenoocarpy with examples.
- identify the major changes occurring in seed germination.
- describe the significance of seed dormancy.

Suggested Learning Teaching Process:

- Provide the students with parts of a typical flower
- Ask the students to gather information on pollination, fertilization and development of fruits and seeds by using electronic / printed matter.
- Based on the gathered information ask them write an assignment.
- Guide them for a presentation.
- Make an elaboration according to appropriate sequence.

Guidelines

- Reproduction of Flowering plants
- Structure and functions of the flower
    - (Details of diversity of inflorescence and floral morphology are not expected to be taught. The students should be familiar with common technical terms used to describe floral features like, polypetaly, gamopetaly, epipetaly, hypogyny, perigyny, epigyny, corolla, stamen, uniloculy, and multiloculy. Drawing floral diagrams or floral formulas are not necessary.)

- Angiosperms are characterized by flowers and fruits.
- Describe a typical structure of a flower. Compare the flower with a strobilus. Sepals and petals as sterile leaves, stamens as microsporophylls and carpels as megasporophylls.
- Describe how pollen are produced and released by stamens.
- Describe the structure of a typical ovary. Describe the structure of an ovule and how embryo sac, or the female gametophyte, develops.

Pollination and fertilization

- Describe the typical structure of a pollen grain and how they are carried for pollination.
- Define self pollination as the deposition of pollen of a flower in the stigma of the same flower, and cross pollination as the deposition of the pollen of a flower on the stigma of a different flower of the same plant or a different plant.
- Explain that in many annual plants (e.g. *Oryza*) seeds are usually produced by self pollination, but most plants are adapted for cross pollination. General characteristics of flowers like colour, smell etc. are mechanisms to favour cross pollination. In addition some plant species show special types of adaptations for cross pollination.
- Explain the significance of cross pollination. Cross pollination results in cross fertilization. Cross fertilization allows shuffling of genes within a species, producing new genetic combinations and increased genetic variation within the species. Many adaptations shown by flowers prove that these features are very important for survival.
- Explain how pollen germinates in stigma and how process of fertilization takes place.
- Explain what is double fertilization , and the significance of double fertilization.

Embryo, developments of fruits and seeds

- Explain how seed develops from an ovule and parts of a seed.
- Explain how a fruit develops from an ovary and typical parts of a fruit.

Parthenocarpy

- Development of fruit from ovary without fertilization. Parthenocarpic fruits do not develop seeds (seedless).
- Parthenocarpy takes place naturally in some species(eg. Banana) and can be induced with plant growth substances in some fruit plants(eg.Grapes and Oranges).
- Parthenocarpy is different from parthenogenesis, which is development of infertile seeds without fertilization.

Germination of seeds and seed dormancy

- Development of embryo within a seed is inhibited at one stage of maturation of seed, naturally, preventing germination of seeds within fruit.
- Many seeds have mechanisms of inhibiting seed germination until satisfactory environmental conditions are found and remain dormant, even when water, oxygen and suitable temperature are provided. Explain common causes of seed dormancy, ie. presence of inhibitors, thick / strong seed coats, presence of seed coats impervious to water etc.
- Explain how seeds germinate. Absorption of water, activation of enzymes, mobilization of food resources followed by rapid growth process of the embryo extending radical through the seed coat. Radicle shows positive geotropism and plumule shows negative geotropism.

Competency 10.1.0 : Inquires into the reproductive process in organisms

Competency Level 10.1.10 : Investigate the role of plant growth substances

Number of Periods : 03

Learning Outcomes : The student should be able to,

- explain general characteristics of plant growth substances
- state major types of plant growth substances
- state the functions of auxins, cytokinins, gibberellins, abscisic acid and ethelene in plant life.
- agricultural uses of plant growth substances.

Suggested Learning Teaching Process:

- Ask them to collect information on growth substances and tabulate the functions.
- Make a presentation to the whole class.
- Make an elaboration on the subject content.

Guidelines:

Explain why plant growth substances do not satisfy the definition of hormone, and the general characteristic features of a growth substance.

IAA is the common natural auxin, produced at stem apices, young leaves etc. Transported through parenchyma cells in unidirectional manner. Natural functions of auxin include elongation of cells, maintenance of apical dominance, regulating tropic movements, inhibition of leaf abscission, induction of cambial activity, induction of root growth, induction of fruit growth etc.

Natural cytokinins are compounds related to adenine, produced at root apices and dividing cells of many tissues, transported through xylem. Natural functions include promotion of shoot growth, inhibiting apical dominance, delay senescence of leaves, inducing cell division by interacting with auxin.

Gibberellins or gibberellic acids are produced mainly in young leaves, roots and germinating seeds, transported through parenchyma cells. Functions include elongation of stems, activating enzymes in seed germination.

Abscisic acid (ABA), produced mainly in root caps and immature seeds, transported through xylem. Its functions include inhibition of seed germination, closure of stomata at water stress conditions, Inhibition of bud growth and cambium activity in the winter in plants growing in temperate countries.

Ethelene produced mainly in fruits and parenchyma cells of several other tissues and transported in parenchyma cells and phloem. Helps in stem elongation, induce ripening of fruits, induce flowering in some plants, abscission of leaves and fruits.

Natural plant growth substances as well as synthetic compounds which act similar to natural plant growth substances are used in agriculture. These includes use of IBA for induction of roots in stem cuttings, use of auxins to induce parthenocarpy and fruit development, Use of 2,4-D and MCPA as weedicides, use of cytokinins to extend freshness of cut leaves and flowers, use of gibberllins to induce seed germination and elongate stems, use of ethelene to induce fruit ripening etc.

Competency 10.1.0 : Inquires into the reproductive process in organisms

Competency Level 10.1.11 : Examines the external and internal changes taking place in the growth and development of a plant.

Number of Periods : 08

Learning Outcomes : The student should be able to,

- illustrates the primary structure of a plant body.
- recognize differences of growth between monocotyledonous and dicotyledonous plants.
- distinguish between primary and secondary growth.
- describe the structure of the growing regions of primary plant body.
- describe how differentiation of tissues takes place at growing regions.
- illustrates the gross histological structure of primary stems and roots of monocotyledonous and dicotyledonous plants.
- describe how secondary growth of stems and roots takes place.
- describe the structure as seen in a cross section of a stem after secondary growth.

Suggested Learning Teaching Process:

- With the help of prepared slides, relevant books etc. allow the students to draw the line, detailed diagrams and write notes on
    - Structure of the apex of root and stem.
    - Primary structure of monocotyledonous and dicotyledonous stems.
    - Primary structure of dicotyledonous and monocotyledonous roots.
- Help the students for a presentation.
- Make an elaboration according to appropriate sequence.

Guidelines

Primary structure of plant body

- Growth involves irreversible increase of dry mass or volume associated with the development of an organism. Often it is associated with increase of cell number.

- Significance of growth of living organisms. How growth of plants differ from growth of animals. Annual plants show a definite or determinate growth while woody perennials show indefinite or indeterminate growth. Parts of plants show determinate growth.

- Localization of growing regions in the primary structure of plants, apical, lateral and intercalary meristems.

- Structures of root apex and shoot apex of plants, apical meristem, regions of cell division, cell elongation and cell differentiation. Organization of meristematic tissues.

- Explain how primary tissues are differentiated from meristematic tissues in the root apex and stem apex

- Measurement of growth in terms of increase in weight, length or volume in plants or parts of plants, growth curves. Carry out laboratory exercises to measure growth rates of suitable plant materials using dry weight, length or volume as parameters and represent the results graphically.

- Primary structure of monocotyledonous and dicotyledonous stems and roots. Guide the students to identify different tissue types, their functions, study their distribution and make drawings in transverse sections of primary stems and roots as seen under light microscope.

Secondary growth of plants

- Explain briefly how secondary vascular cambium and cork cambium arise in dicot stems and roots.
- Give a description of the activities of vascular cambium and cork cambium
- Explain the distribution and functions of different tissues in a dicot stem after secondary thickening.
- Explain primary features of wood, growth rings, heart wood, sap wood, soft wood and hard wood.
- Practical:
- Study of cross sections of primary stem and primary root of a Monocot and of a Dicot
- Microscopic and macroscopic examination of secondary structure of Dicotyledonous wood

UNIT 11- HEREDITY.

Competency	**11.1.0**	**:**	**Explores the basic principles of genetics for applications.**
Competency Level	**11.1.1**	**:**	**Inquires the Scientific basis of Mendel's experiments**
Number of Periods		**:**	**06**
Learning Outcomes		**:**	The student should be able to;

- explain the terms such as monohybrid, monohybrid test cross, dihybrids, dihybrid test cross, multiple test cross etc.
- describe monohybrid cross and define Mendel's first law.
- describe dihybrid cross and define Mendel's second law
- show how ratios of genotypes and phenotypes of multiple factor crosses can be predicted

Suggested Learning-Teaching Process :

- Use power-point presentations and other sources to highlight Mendel's experiment.
- Advice students to collect information on Mendel's experiments and to make a presentation covering following points
    - Monohybrid cross
    - Dihybrid cross
- Make an elaboration to cover the specified subject content

Guidelines

Monohybrid crosses

- Give a short description of Mendel's Experiments with garden pea plants and explain in detail one monohybrid cross performed by Mendel (eg.Tall x short). He made monohybrid crosses with seven different pairs of contrasting characters and recorded the results. All gave similar results. Give a table summarizing his results.

  Meanings of the following terms should be clarified**.** Pure lines, contrasting characters, monohybrid crosses, reciprocal crosses, parents, progeny, F_1 and F_2 generations.

- Explain how Mendel presented hypothesis to explain experimental findings. His hypothesis was built on the principles of dominance and segregation**.**

  Explain what are genetic factors**,** alleles, homozygote, heterozygote, genotypes, phenotypes, Recessive, Dominant

Monohybrid test crosses

- Mendel planned and carried out monohybrid test crosses for verification of his hypothesis. Explain his argument and test results.
- Clarify what are test crosses, distinguish from back crosses

Genes and alleles

- Introduce the terms genes and alleles and explain the meanings. Although these terms were introduced to genetics subsequent to Mendel's experiments they are now used to explain Mendelian principles.

Mendel's first law

- Define Mendel's First Law**;** *Factors(genes) which determine genetic characters exist in pairs(of alleles). They segregate in the formation of gametes so that each gamete carries only one of them.*
- Explain the significance of progeny ratios in Mendel's experiments, and how the ratios 3:1 and 1:1 are achieved by simple rules of probability.

Dihybrid crosses

- Describe a dihybrid cross done by Mendel and the results. F_2 progeny of all dihybrid crosses gave four phenotypes in 9:3:3:1 ratio.
- Present Mendel's hypothesis of independent segregation.
- A Punnet square can be used to explain how the 9:3:3:1 ratios are obtained among the F_2 progeny.

Dihybrid test crosses

- Explain how the hypothesis of independent segregation was tested and confirmed by Mendel with dihybrid test crosses.

Mendel's second law

- Define Mendel's 2nd Law; *Pairs of alleles which determine different characters segregate independently at reproduction. Any one allele of a pair may join with any one of another pair.*

Multiple factor crosses

- Crosses involving multiple genetic factors. Principle of independent segregation can be extended to more than two genes. Explain how ratios of genotypes and phenotypes of multifactor crosses can be predicted using basic statistics.

Competency 11.1.0 : **Explores the basic principles of genetics for applications.**

Competency Level 11.1.2 : **Analyse the contribution of chromosomes for inheritance of characters.**

Number of Periods : **02**

Learning Outcomes : The student should be able to;

- state the significance of mitosis
- state the significance of meiosis
- explain how independent segregation of chromosomes takes place in meiosis

Suggested Learning-Teaching Process :

- Provide students to study the different stages in mitosis and meiosis using diagrams, slides or power-point presentations.
- Advice students to find the importance of mitosis and meiosis
- Ask them to present their findings
- Make an elaboration according to appropriate sequence

Guidelines

Chromosomal basis of inheritance

By the time Mendel's publications were discovered, chromosomes, mitotic and meiotic processes of cell division had been observed under microscope and described by several scientists. Sutton and Boveri presented the chromosomal theory of inheritance. Explain the parallel behavior of Mendel's genetic factors and chromosomes.

- Mitosis – Explain the genetic significance of mitosis
- Meiosis - Explain how independent segregation and independent assortment of chromosomes takes place in meiosis. Explain the significance of genetics in meiosis

Competency 11.1.0 : **Explores the basic principles of genetics for applications.**

Competency Level 11.1.3 : **Examines the patterns of inheritance of Mendelian traits in man**

Number of Periods : **01**

Learning Outcomes : The student should be able to;

- state some Mendelian characters in human
- analyze and predict results of Mendelian inheritance in human families by using pedigree charts

Suggested Learning-Teaching Process :

- Use various sources to show Mendelian characters in human
- Provide the students with the pedigree charts
- Allow the students to analyze the pedigree charts and predict results of Mendelian inheritance in the families
- Prepare the students for a presentation on their findings
- Make an elaboration according to an appropriate sequence.

Guidelines

- Human Mendelian inheritance
    - Mendelian characters in humans. Explain with a few common examples like tongue rolling, attached ear lobes, widow's peak, dimples, straight thumb etc.
    - **Pedigree** charts are used to analyze and predict results of Mendelian inheritance in human families. Explain how this can be practiced with some examples.

Competency 11.1.0	:	**Explores the basic principles of genetics for applications.**
Competency Level 11.1.4	:	**Uses concepts and principles to explain genetic patterns that deviate from Mendel's laws**
Number of Periods	:	**08**
Learning Outcomes	:	The student should be able to;

- describe non-Mendelian inheritance
- state the examples of non-Mendelian inheritance
- describe some non-Mendelian inheritance such as incomplete dominance, co-dominance, polyallelism, gene interaction, polygenic inheritance and gene linkage
- explain human sex determination
- state human sex linked characteristics

Suggested Learning-Teaching Process :

- Recall students experiences related to Mendels experiments and its results
- Engage students in collecting information on the following using web resources and books.
  - Incomplete dominance
  - Codominance
  - Polyallelism
  - Gene interaction
  - Polygenic inheritance
  - Gene linkage
- Prepare the students for a presentation of the subject content
- Make an elaboration according to an appropriate sequence

Guidelines

- Some patterns of inheritance deviate from simple Mendelian rules. In crosses ratios of 3:1 and 9:3:3:1 seem to be modifications of these. Describe following types of non-Mendelian inheritance with examples.

Incomplete dominance

- Explain with example of flower color in *Mirabilis* plant. Heterozygous F_1 is different from parents, F_2 ratio is 1:2:1. Explain why incomplete dominance takes place.

Codominance

- Explain with examples of human M and N blood groups and A and B blood groups. Both alleles are dominant and the heterozygote shows characters determined by both alleles.

Polyallelism

- Explain with example of human A,B,O blood groups, that some genes have more than two forms of alleles, all of which are found in relatively high frequencies in populations. Alleles can show dominance and codominance.

Gene Interactions

- There are several different forms of gene interactions. Explain what is meant by the terms epistasis, dominant epistasis, recessive epistasis and give example such as flower colour of *Lathyrus odoratus* for recessive epistasis, and feather colour of House fowl for dominant epistasis. Describe some examples of epistasis. Common examples are inheritance of flower color in sweet pea(*Lathyrus odoratus*), inheritance of coat color in mice, inheritance of plumage color in white leghorn and white wyandotte breeds of chicken. Explain how 9:3:3:1 ratio is modified in these examples.

Polygenic Inheritance

- Distinguish qualitative traits giving some examples. When many genes act in F_2 progeny very similarly to bring one phenotype with additive effects, resulting phenotype is a quantitative character. Genes involved in polygenic inheritance often are segregating independently and have alleles showing dominance. With a cross between two extreme parents describe how the class distribution of the character obtained in F2 generation. Relate the number of genes to the number of classes. Explain the significance of polygenic inheritance in plants, animals and humans.

Gene Linkage

- Define gene linkage. Explain with an example its effect on crosses. Describe how test crosses are used to test linkage, what are parental and recombinant progeny, how recombinants are obtained. Explain the relationship between frequency of crossing over in meiosis and frequency of recombinants. Use diagrams to explain linkage and crossing over.

Human Sex Determination

- Explain how sex is determined in humans by X and Y chromosomes, and why males and females are born in approximately same frequency.

Human Sex Linked Inheritance

Explain what sex linked characters are. Using hemophilia as an example, explain the pattern of inheritance of the disease in human families. Explain why the expected results are not obtained, but the resulting ratios. Explain why sex linked characters are restricted to males.

Competency 11.1.0	:	**Explores the basic principles of genetics for applications.**
Competency Level 11.1.5	:	**Examines the molecular basis of genetics**
Number of Periods	:	**06**
Learning Outcomes	:	The student should be able to;

- describe the physical and chemical properties of DNA
- explain the structure of gene and the relationship with chromosomes
- discuss the function of gene and mechanism of protein synthesis

Suggested Learning-Teaching Process :

- Recall students knowledge on the structure of DNA
- Provide students with literature (print or electronic) on protein synthesis
- Let the students study the resource material and extract the following points
    - DNA replication
    - RNA types – m RNA, t RNA, r RNA
    - Protein synthesis mechanism
- Instruct the students to present their findings
- Make an elaboration according to an appropriate sequence

Guidelines

DNA

- Describe the molecular structure, chemical and physical properties. significance of base ratios, complimentary strands, denaturation and renaturation, absorption of UV by DNA. Describe how self replication of DNA takes place in cells.

Chromosomes and genes

- Explain what genes are in structural terms and how they are carried in chromosomes. Chromosomes are long molecules of DNA highly condensed with histone proteins. Explain what is meant by a genome of a species.

Gene expression and protein synthesis

- Explain biological function of a gene. Primary structure of proteins is determined by genes. There is a collinear relationship between genes and proteins. Base sequence of DNA determines the amino acid sequence in proteins.

Genetic code

- Explain what is genetic code and its basic features, universal nature and its significance, Startcodons, and stopcodons.

RNA

- Explain how RNA is different from DNA in structure and function. Briefly describe three types of RNA- mRNA, rRNA and tRNA and their functions in the process of protein synthesis.

Mechanism of protein synthesis

- Brief description of the two steps transcription and translation, functions of RNA polymerase and ribosomes, and tRNA on the formation of polypeptides

Competency 11.1.0 : **Explores the basic principles of genetics for applications.**

Competency Level 11.1.6 : **Explores comparatively the influence of genetic variations created by mutations on the survival of organisms.**

Number of Periods : **04**

Learning Outcomes : The student should be able to;

- explain the causative factors of mutations
- state the types of mutations and the examples
- explain the significance of mutation in evolution
- discuss human genetic disorders created by mutations

Suggested Learning-Teaching Process :

- Use web resources and diagrams to show mutations
- Engage students in collecting information from sources on mutation
- Prepare them to make presentations on their findings
- Make an elaboration according to an appropriate sequence

Guidelines :

Mutations

- Explain what mutations are and how they occur. Most point mutations occur as mistakes of pairing of bases in DNA replication. Most chromosomal mutations occur due to mistakes of chromosome pairing and crossing over at meiosis. Briefly explain different types of mutations, recessive mutations, dominant mutations, lethal mutations, chromosomal mutations**,** somatic mutations. Examples of recessive mutation is Haemophilia, Albinism, dominant mutation is polydactyl. Lethal mutation is Haemophilia. Chromosomal mutation is Down's syndrome & somatic mutation is cancer.

Significance of mutations in evolution

- Mutations could bring advantageous or disadvantageous characters. Mutations are the major source of genetic variation and natural selection works on the genetic variation within populations.

Mutagens

- Distinguish between spontaneous mutations and induced mutations. Induced mutations are caused by external mutagens like UV, X-rays and chemicals.

Human genetic disorders caused by mutations

- Taking some examples explain some genetic disorders in humans are inherited as mutations. Some of them are caused by single gene mutations. Common examples are albinism, Huntingdon's disease, cystic fibrosis, thalassemia, sickle cell anaemia, haemophilia; others are due to change in the number of chromosomes. Common examples are Downs syndrome, Turner and Klinefelter syndromes.

Genetic counseling

Experts can provide advice and assistance to persons with genetic disorders and their family members regarding the genetic nature of such disorders and how they are inherited.

Competency 11.1.0	:	**Explores the basic principles of genetics for applications.**
Competency Level 11.1.7	:	**Investigates evolution of life by using changes in gene frequencies**
Number of Periods	:	**03**
Learning Outcomes	:	The student should be able to;

- investigate the genetic diversity within population
- state the causes for genetic polymorphism
- explain Hardy-Weinberg equilibrium

Suggested Learning-Teaching Process :

- Discuss the genetic diversity within natural population
- Ask the students to gather information on the causes of genetic polymorphism
- Prepare them for a presentation
- Make an elaboration according to the appropriate sequence

Guidelines

- Explain that there is genetic diversity within natural populations. With regard to many characters members of populations are polymorphic. Mutations, independent segregation of chromosomes, crossing over at meiosis, random breeding etc. are causes of genetic polymorphism. Allelic polymorphism is the simplest. Explain what is meant by gene pool.

Hardy-Weinberg equilibrium

- Explain how the frequencies of alleles remain unchanged in random breeding genetically static populations, using Hardy-Weinberg equation. Genotypic frequencies of simple Mendelian characters in a population can be calculated, using Hardy-Weinberg equation. Discuss the factors like mutation, selection, non-random breeding, migration and random genetic drift in large population disturb Hardy-Weinberg equilibrium in most populations.

Competency 11.1.0 : **Explores the basic principles of genetics for applications.**

Competency Level 11.1.8 : **Uses the theory of natural selection to analyze the process of evolution of life**

Number of Periods : **02**

Learning Outcomes : The student should be able to;

- explain the process of evolution
- state the two theories of evolution
- elaborate theory of Lamarck
- elaborate theory of natural selection

Suggested Learning-Teaching Process :

- Provide students with electronic or printed articles on the two great theories of evolution
- Ask the students to gather information on the theories of evolution
- Prepare the students for a presentation
- Elaborate the subject content in an appropriate sequence

Guidelines :

Natural Selection and Evolution

- Factors that affect Hardy - Weinberg equilibrium are also agents of evolution. Gradual changes in populations leads to speciation. In 19^{th} century there has been much interest among biologists regarding the possible mechanisms of evolution. Two great theories had been presented.

Lamarck's theory of inheritance of acquired characters.

- Organisms acquire adaptations during their life time according to the needs of the environment. These adaptations are passed onto their progeny so that the progeny is better adapted to live in that environment. Explain this with some examples.

Darwin-Wallace theory of Natural Selection

- Give a brief account of Charles Darwin and his work. Darwin and Russel Wallace presented similar ideas about evolution. Their common theory of natural selection was based on specific observations and deductions made on natural populations. Important observations are 1. Great reproductive potential 2.Static population sizes and 3. Diversity within populations. Deductions are 1. Struggle for existence and 2. Survival of the fittest.

  Darwin or Wallace did not present any ideas regarding inheritance of characters. Discuss that present knowledge of genetics is quite compatible with the theory of natural selection.

Competency 11.1.0 : **Explores the basic principles of genetics for applications.**

Competency Level 11.1.9 : **Examines the principles of selective breeding in obtaining modified varieties of plants and animals**

Number of Periods : **03**

Learning Outcomes : The student should be able to;

- explain the importance of plant and animal breeding
- state some breeding techniques in plant and animal
- explain the genetic principles in the breeding techniques

Suggested Learning-Teaching Process :

- Recall the students knowledge on the types of reproductive methods
- With the help of printed/ electronic documents gather information on artificial selection, in breeding and out breeding, hybrids, inter specific breeding, polyploidy, mutagenesis and genetic modifications.
- Prepare the students for a presentation
- Make an elaboration with appropriate sequence

Guidelines

Plant and Animal Breeding.

Explain the importance of breeding programs for crops and domesticated animals and the role they have played in the history of agriculture. Briefly explain the following techniques and the genetic principles on which they are based.

Artificial Selection.

- Most ancient and important of the techniques in agriculture. This has made the crop plants and domesticated animals very different from their wild relatives.

Inbreeding and out breeding

- Some plants are adapted for natural inbreeding. Explain its significance and usefulness of inbreeding as a technique in agriculture.

Crossing.

- Crossing and hybridization between varieties of the same species is a common practice in agriculture and horticulture. Discuss the advantages. Explain what is meant by hybrid vigour.

Interspecies crosses

- Species have genetic barriers for interbreeding but there are exceptions. New species have been made by crossing different species.

Polyploids.

- Some plants are naturally evolved polyploids. Polyploid plants have been produced in agriculture. Explain how polyploids are different from their parents.

Mutagenesis.

- Induction of mutations can produce novel and useful characters in plants.

Genetic Modification.

- Producing GM organisms using gene technology is expanding rapidly as a technique to produce better crops and better live stocks. Discuss this with a few examples.

Competency 11.2.0 : Gets updated on Gene technology

Competency Level 11.2.1 : Gets updated on techniques and methods of gene technology

Number of Periods : 06

Learning Outcomes : The student should be able to;

- discuss the in-vitro experiments with DNA
- describe the uses of DNA probing and the main steps in this technology
- explain the methods involved in recombinant DNA technology

Suggested Learning-Teaching Process :

- With the help of power-point presentation engage the students in the techniques related to molecular genetics
- Using web resources, printed matters etc. gather information on the main steps of this gene technology
- Ask the students to present their findings
- Make an elaboration according to an appropriate sequence

Guidelines

- Techniques and methods of gene technology

  Extensive knowledge that has accumulated in the last few decades about DNA and how it functions has led to the development of gene technology. This has made the subject biology very different from what it was in the past. Modern biology cannot be followed without a basic knowledge in gene technology.

In-vitro Experiments with DNA.

- DNA has physical and chemical characteristics which enable scientists to extract it from cells, modify and reintroduce into living cells. Following are some of the basic techniques used in study and modification of DNA outside living cells. (Detailed study of test tube extraction of DNA and DNA blotting are not necessary)

Extraction of DNA

- Briefly mention DNA can be readily extracted from bacterial cultures. Dissolution of other cell components, DNA precipitation and centrifugation are basic methods involved. Density gradient centrifugation is a special technique to separate DNA according to its density.

Enzymes working with DNA.

- Some of the enzymes which are naturally acting on DNA in its maintenance inside living cells are now being produced in large quantities and are commercially available for the use in laboratories. Explain the function and use of three types of such enzymes, endonucleases, ligases and polymerases.

Agarose gel electrophoresis

- This is a simple technique commonly used in laboratories to separate DNA molecules according to their sizes. Discuss the basic methodology and the principles underlying this technique.

DNA Blotting

- This is a technique used to transfer the DNA from gel medium onto filter papers or membranes after gel electrophoresis.

DNA Probes, hybridization

- DNA probes are specially labeled DNA molecules which are used to identify other DNA molecules with same or very similar base sequences after hybridization. This is useful in fingerprinting and gene identification. Process of hybridization involves denaturation of DNA.

DNA Finger printing

- Finger printing or DNA typing is widely used now in identifying people, their relatives, criminals etc. This is based on the genetic variability found in some loci among individuals. Discuss the main steps in this methodology.

Recombinant DNA technology

Joining DNA molecules obtained from different species to make functional single molecules is the basis on which genetic engineering is based. This technology was first developed with *E.coli* bacterium. Hybrid DNA molecules with parts coming from different organisms joined together are called recombinant DNA. Knowledge of the following is necessary for an understanding of the technology.

Bacterial plasmids and viral genomes

- Bacteria have circular DNA molecules as chromosomes, much smaller than eukaryotic chromosomes. This DNA is not condensed with histones and bacteria do not have nuclear membranes. Plasmids also have circular DNA molecules much smaller than chromosomes. They carry a few genes, often for antibiotic resistance, which are useful in tracking plasmids. Viral genomes are similar except that they are infectious. DNA can be extracted quite easily from bacterial plasmid or viral. DNA can be separated either by centrifugation or by gel electrophoresis.

Recombinant DNA vectors

- Plasmids and viral genomes are used as carriers of foreign genes into bacteria. The gene of interest, or piece of DNA, is isolated from an extract of DNA from the donor organism. This involves cutting DNA with restriction enzymes, separating the pieces in agarose gels and identifying the piece of interest with a probe. Ligation of this into plasmid or viral genomes is done with restriction enzymes and DNA ligase enzymes.

Transformation of bacteria

- Introducing external DNA molecules or genes into bacterial cells is termed bacterial transformation. In case of *E.coli*, there are methods by which the cells can be made competent to absorb DNA. After transformation, they are grown in Petri dishes to form colonies in selective media. Successfully transformed colonies are identified, often using antibiotic resistant marker genes carried by the vector.

Gene cloning

- Incorporating external genes into host cells by transformation and culturing the transformed cells is called gene cloning. Often the purpose of cloning is to amplify, or to multiply, the cloned gene, but the purpose can also be to produce and extract a protein made by the cloned gene in the host.

Competency 11.2.0 : Gets updated on Gene technology

Competency Level 11.2.2 : Updates on the applications of gene technology

Number of Periods : 03

Learning Outcomes : The student should be able to;

- describe the genetically modified organisms
- explain the use of genetically modified organisms in medicine, agriculture and industry
- discuss possible social problems concerning the use of GM organisms

Suggested Learning-Teaching Process :

- Provide students with some examples of the pictures of genetically modified organisms
- Ask them to gather information on genetically modified organisms in the fields of agriculture, medicine and industry
- Prepare them for an attractive presentation
- Elaborate the subject content according to a appropriate sequence

Guidelines :

Genetically Modified Organisms and their uses

- Many bacteria, plants and animals carrying genes of other organisms have been made using recombinant DNA technology for various purposes. At first bacterial species carrying genes of other microorganisms, plants and animals or human genes were used to obtain useful proteins made by the introduced genes. Producing such proteins in large quantities and purifying them is easier when bacteria are used as the host. Soon afterwards techniques were developed to use eukaryotic organisms like yeast, animals and plants as the host organisms. They are commonly known as genetically modified organisms. At present many genetically modified organisms are used in agriculture, medicine and industry in large scales.

In Agriculture

- Many crop plants with useful characters introduced from other species are used in agriculture. Examples are Corn , Soya, Cotton,Canola varieties carrying genes from the bacterium *Bacillus thuringiensis* to make these plants resistant to insect attacks. Same crops made weedicide resistant with genes from *Agrobacterium*, *tumifaciens* ,Golden rice made rich with beta carotene by genes from the bacterium *Erwinia*. Papaya resistant to ringspot virus.

In Medicine

- Many proteins which are used in clinics for treatment of disorders and diseases are now made using GM organisms. Some examples are human insulin, human growth hormone, antigrowth hormone, blood clotting factors, interferon, hepatitis B antigens etc.

In Industry

- Enzymes and other products used in industries are also made using GM organisms. Examples are enzymes like invertase, chymosin, amylase, pectinase and food additives like glutamate used in food industries.

Social problems concerning the use of GM organisms

Use of GM organisms, especially as agricultural crops, has not received support from some people in many countries and objections have been made. Objections are based mainly on ethical, medical and environmental reasons. Some measures have already been taken by scientists to minimize the risks of using GM organisms in the fields. Discuss possible problems and solutions.

UNIT 12 – Environmental Biology

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.1 : **Engages in an analysis of the biosphere through different organizational levels.**

Number of Periods : **03**

Learning Outcomes : The student should be able to;

- Explain the importance of studying environmental science
- Construct basic characteristics of the levels of organization of organisms in the environment
- List the major abiotic components and state the main characteristics of each of them

Suggested Learning-Teaching Process :

- Let the students build up the organizational levels of the environment
- With the aid of suitable diagrams discuss the nature of the earth

Guidelines :

- **Importance of the knowledge in principles of environmental science.**
- At present mankind is faced with many environmental issues which are growing in size and complexity day by day, threatening survival of all life forms on earth.
- The teacher lists out some of the environmental issues faced by man today. It is important to study these issues in order to make effective suggestions, to take remedial actions.
- **Organizational levels of the environment and the basic characteristics.**
- Concepts of individual organism, population, community, ecosystem, biosphere.
- Teacher should explain the characteristics of a population, community, ecosystem and biosphere.

- Individual organism ; One member of a given species. Individual organisms interact with environment for most of its needs.
- Population ;   A group of individuals of the same species which live interacting with each other in a defined area in a given time. E.g; Elephant population in Yala National Park in 2009.

  A population has features such as growth rate, density, intraspecific competition etc.

- Community

  Populations of different species in a particular area interacting with each other E.g, Animal community of Yala National Park.

  Interactions among populations include predatory, herbivorous and symbiotic relationships.

- Ecosystem

  The functional / dynamic unit comprising all living organisms in a community and the abiotic environment which interact with each other. Eg; a forest

- Biosphere

  The large functional system comprising all ecosystems on earth

- Earth
  - Three layers can be observed in a cross section of the earth; core, mantle and crust. (see annex)

    Crust or the outermost layer is made up of different types of rocks.

    Lithosphere is composed of the crust and the upper portion of the mantle, to a depth of about 100 km.

    Hydrosphere is the oceans and the freshwater bodies. About 70% of the earth's surface is covered by water. Fresh water is only 3% of all water found on earth.

    Atmosphere can be divided into four sections depending on its temperature. From the bottom up they are; Troposphere, Stratosphere, Mesosphere and Thermosphere.

The water vapor and microscopic particles are found only in the troposphere, which is very important to the weather. The O_3 layer is found within stratosphere. The O_3 layer absorbs the UV radiation from the sun. The temperature and pressure changes in these layers and the relative heights of each of them from the earth surface should be indicated.

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.2 : **Investigates the components and activities of ecosystems**

Number of Periods : **05**

Learning Outcomes : The students should be able to;

- describe the components of ecosystems
- discuss the relationships between abiotic and biotic components
- construct food chains and food webs in a given ecosystem

Suggested Learning-Teaching Process :

- Use flow charts and suitable diagrams to show different types of ecosystems, i.e. terrestrial, fresh water and marine ecosystems
- Describe the characteristics of ecosystems
- Let the students build up food chains and food webs which are functioning in above types of ecosystems.
- Let the students construct ecological pyramids using different ecosystems.

Guidelines :

- Structure and functions of ecosystems.
  - Components of ecosystems
    All ecosystems are composed of two main components; Abiotic (non living) and Biotic (living)
  - Abiotic components
  - Many important physical and chemical properties of the major components air, substratum, and water influence living systems
    E.g; light, temperature, rainfall, salinity, pH

- Biotic component
- The major biotic components of an ecosystem are
    - Primary producers
    - Consumers (primary and secondary)
    - Detrivores including decomposers
- The biotic components of an ecosystem are interconnected on the basis of feeding and energy transfer relationships
- Ecological niche is the role that an organism plays in the environment / ecosystem
- Energy flow through an ecosystem
  Sun is the primary energy source. Autotrophs form the food source or potential chemical energy supply for all other organisms in the ecosystem.
- Primary production is the amount of light energy converted to chemical energy within a given period by the primary producers.
- Primary productivity is the rate of production. The amount of light energy converted to chemical energy by a unit area within a unit time by the primary producers.
- Gross primary productivity (GPP) is the total amount of light energy converted to chemical energy by a unit area within a unit time by the primary producers (includes respiratory energy). Given by KJ m^{-2} yr^{-1} or g m^{-2} yr^{-1}
- Net primary productivity (NPP) is the amount of biomass produced by primary producers by a unit area within a unit time [excludes respiratory energy(R)]. Given by KJ m^{-2} yr^{-1} or g m^{-2} yr^{-1}
- GPP = NPP + R
  The energy is transferred through a series of organisms in an ecosystem in a single direction (unidirectional path)
- Food chain is a sequence of feeding relationships through which the energy flows in the ecosystem / community
  Trophic level is a step of a food chain through which energy of an ecosystem / community is transferred
- Food web: In an ecosystem/ community food chains are interconnected at different trophic levels and form a food web.

- As there is a loss of energy from each trophic level to another, a food chain will not contain more than 4 or 5 links.
- The proportion of energy that flows from the lower trophic level to the next in general is only about 10%. Therefore, about 90% is lost.
- Ecological pyramids

  Graphical / diagrammatical representation of feeding relationships of an ecosystem. Three types; Pyramids of energy, Pyramids of biomass, Pyramids of numbers
- Pyramids of numbers and of biomass may be inverted. Pyramids of energy are never inverted
- Cycling of elements in nature by ecosystems.

  The teacher will explain what biogeochemical cycles are and explain their importance.

  The teacher should describe the Carbon, Nitrogen, Phosphorus and hydrological cycles with the aid of suitable diagrams.

Competency 12.1.0 : Engages in a biological analysis on relationships between organisms and their environment

Competency Level 12.1.3 : Investigates the main biomes of the world.

Number of Periods : 04

Learning Outcomes : The students should be able to **;**

- list major biomes in the world
- describe their distribution in the world
- distinguish different biomes using their major characteristic features

Suggested Learning-Teaching Process :

- Use of visual aids to show the distribution of biomes in the world
- Students identify characteristics of different types of biomes using visual aids
- Highlight the general features of biomes

Guidelines :

- **Biomes**
- Biomes are widely spread major ecosystems of the world that are classified according to the predominant vegetation and, characterized by regional climatic conditions and adaptations of organisms to that particular environment.
- There are eight major terrestrial biomes and several minor biomes.
- Eight major terrestrial biomes of the world are
  - Tropical forest
  - Savanna
  - Deserts
  - Chaparral
  - Temperate grassland
  - Temperate broadleaf forest
  - Taiga (Corniferous forest)
  - Tundra
- Distribution and major characteristics of major terrestrial biomes should be explained

Competency 12.1.0 : Engages in a biological analysis on relationships between organisms and their environment

Competency Level 12.1.4 : Utilizes the knowledge on ecosystems of Sri Lanka to contribute to their sustainable usage.

Number of Periods : 08

Learning Outcomes : The students should be able to **;**

- list the different types of ecosystems in Sri Lanka
- elaborate characteristics features
- identify the locations of each type of ecosystem.

Suggested Learning-Teaching Process :

- Use visual aids to show ecosystems in Sri Lanka
- Let the students identify the characteristic features of different ecosystems
- Highlight the important features which help to distinguish major types of ecosystems in Sri Lanka
- Make an elaboration based on sustainable usage of ecosystems

Guidelines :

- **Eco systems in Sri Lanka**
    - Following ecosystems in Sri Lanka should be used in the teaching learning process.

      Forests
        - Tropical rain forests
        - Dry mixed evergreen forests
        - Montane forests
        - Thorn forests/shrubs

      Grasslands
        - Savannas
        - Patana

Inland wet lands

- Rivers and streams
- Reservoirs, Lakes
- Marshes and swamps
- Villus

Coastal ecosystems

- Lagoons and estuaries
- Mangroves
- Coral reefs
- Sea shore
- Sea grass beds

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.5 : **Utilizes the knowledge of Biodiversity for conservation**

Number of Periods : **08**

Learning Outcomes : The students should be able to;

- Define biodiversity, ecosystem diversity, species diversity and genetic diversity
- Elaborate knowledge and understanding of biodiversity being the outcome of the evolution and expansion of organisms over a period of over 3.5 billion years.
- Discuss extinction as a natural process, the rate of which has been greatly increased by human activity
- Define IUCN categories with examples
- Highlight the need of conservation of biodiversity in national level and global level

Suggested Learning-Teaching Process :

- Let the students identify the morphospecies in surrounding environment
- Use a powerpoint presentation to show the origin of life & biodiversity evolution which can be prepared using internet
- Highlight the importance of conservation of biodiversity

Guidelines :

- **Biodiversity**

  Biodiversity is the variability among living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part of. This includes diversity within species, between species and of ecosystems.

- **Genetic diversity**

  Genetic diversity is the genetic variability within a single species of organisms that permit the organisms to adapt to changes in the environment

- **Species diversity**

  The species diversity is a measure of the diversity within an ecological community that incorporates both the number of species in a community and their relative abundances.

  Genetic diversity forms the ultimate pool from which species diversity arises.

  Organisms of a single species have numerous features in common, differ from other organisms in one or more characters and can interbreed or potentially interbreed under natural conditions and produce fertile offspring.

  Estimates of numbers of species in all major taxa indicate that there may be as many as 30 million species of animals and plants at present.

- **Ecosystem diversity**

  Ecosystem diversity is the variety of habitats, living communities and ecological processes in the living world.

- **Origin of Biodiversity, evolution and extinction**

  - Origin of the earth

    The earth was formed about 4.5 billion years ago. Initially there were no oceans, no continents, and no living matter.

    At the beginning the earth was a sphere of molten rock with violent volcanic activity. As the earth cooled, less volatile metals condensed and formed the earth's core. Then lighter Silica rocks formed the earth's crust. The original atmosphere would have consisted of hydrogen, nitrogen, carbon dioxide, water vapour, hydrogen sulfide, ammonia and methane. There was no oxygen in the atmosphere and it was a reducing atmosphere.

- Origin of life

  Theories of origin of life

  1. Theory of creation

     All living species were created as they are by a supernatural God. This belief was spread by some religions mainly Christianity.

  2. Theory of spontaneous generation

     Life may arise from non-living matter spontaneously at any time. The theory stated that animals like worms, insects and rats are generated from dirt under appropriate conditions.

  3. Cosmozoic theory

     Life came to this planet from outer space. Even today, some scientists believe that living organisms may be common in other planets, outside our solar system and that living organisms came to earth with some meteorites which fell on earth, or with some alien space vehicles.

  4. Theory of biochemical evolution

     Organic molecules were generated in the early atmosphere due to electrical discharges and solar radiation from inorganic gases. These substances dissolved in the ocean water gave rise to first life forms.

     Alexander Oparin (1923) and J.B.S. Haldane were the first to formulate this theory. Stanly Miller (1953) obtained experimental evidence for this theory by simulation of conditions of primitive earth in flasks.

     Organic compounds like hydrocarbons, amino acids may have formed in the oceans from simpler organic molecules. The energy for these reactions was probably derived from the ample solar radiation, lightning from intensive electrical storms, violent volcanic eruptions and heat from radioactive decay.

     The primitive ocean would have been a "Primordial Soup" containing abundant organic molecules. This organic soup may have contained amino acids, nitrogenous bases, simple sugars and nucleiotides. These molecules aggregated and became surrounded by a lipid layer. These complexes would have evolved into the primitive cells. These cells would have acquired most of the characters of life such as growth and self replication. The first formed organisms are believed to be heterotrophic, anaerobic prokaryotes and were living around 3.5 billion years ago.

- **Evolution of biodiversity**

  The history of the earth is divided for convenience, into four eras and 11 periods.

  The four eras are; Archaeozoic, Palaeozoic, Mesozoic and Cenozoic.

- During the Precambrian period of Archeozoic era, the only kinds of organisms in existence were bacteria and protists. Photosynthetic organisms appeared and diversified during the period 2.7 – 0.7 billion years ago. The earliest photosynthetic organisms lacked pathways for the production of oxygen. As a result of increasing oxygen in the atmosphere its ionization to form the O_3 layer took place.
- The eukaryotes first appeared 1.0-1.5 billion years ago. This means that life on earth was consisted only of prokaryotes, for two billion years since it first appeared.
- Protists had diversified and all major invertebrate phyla had appeared by 0.7 billion years ago.
- Single celled eukaryotes evolved from bacteria. Oldest multicellular forms of metazoan groups evolved in the sea. Such as cnidarians (corals & sea anemones) some annelids and early arthropods.
- Diversification of life in the oceans took place during the period from 700 million years ago to the present day.
- The origin of the vertebrates and the increase in the number of mollusks, trilobites and crustaceans occurred around 500 million years ago.
- Colonization of land by plants took place about 480 million years ago and diversification on land has continued from that time to the present day.
- Colonization of land by animals took place about 420 million years ago and diversification has taken place from that time to the present day.

- The first vertebrates to move on to land were amphibians. They retained the ability to move between land & water. Amphibians originated from lobed finned fish. Eg; *Latimeria*
- Later the reptiles appeared from amphibians. Reptiles are fully adapted to land life. They have developed special physiological and structural features for this purpose.
- It was at this same time that the earliest mosses and ferns flourished.
- Birds appeared from reptiles. Many birds have wide distribution because of their ability to fly.
- Insects first appeared in the carboniferous period and increased their diversity. Huge rain forests comprising tree ferns, club mosses and early gymnosperms were widespread during the carboniferous period. These forests formed many of the great coal deposits that are utilized today.
- During the Permian (280 million years ago), conifers appeared.
- Adaptive radiation of reptiles giving rise to the dinosaurs in the Triassic. Dinosaurs dominated the earth during Mesozoic era, reaching the peak in the cretaceous.
- The early mammals also appeared in the Triassic, but for millions of years, they remained a minor group.
- The cretaceous is marked by the dominance of the flowering plants and the origin of modern fish and placental mammals.
- Flowering plants widely spread and flourished by adaptive radiation..
- Tertiary period produced many species of mammals by adaptive radiation.
- Man is a recent species, modern man having appeared about 500,000 years ago.
- **Extinction of species**
- Existing species have to make room for new species either by changing themselves or by becoming extinct. Therefore natural extinction has to be recognized as part of the evolutionary process.
- The rate of evolution has been generally higher than that of extinction. Therefore there has been an increase in Biodiversity over time.
- Extinction is the elimination of the last member of a species from the earth.

- Catastrophic episodes of mass extinction in the history of Biodiversity.
    - Extinction of trilobites - late Permian (About 200 million years ago)
    - Extinction of ammonites - late Cretaceous (About 65 million years ago)
    - Extinction of dinosaurs - late Cretaceous (About 65 million years ago)
- With the growth of human population and civilization, mankind has greatly increased the rate of extinction.
- The earth today is dominated by humans and no ecosystem on earth's surface is free from human influence.
- In general it is estimated that about 5-10% of the species may face extinction within the next 30 years.
- The growth of the human population and growth in the resource base used by man is maintained by a number of human involvements such as agriculture, industry, forestry, transport, urbanization etc.
- These activities alter ecosystem functioning resulting in loss of biodiversity.
- The major causes for the loss of biodiversity due to man's influence are;
- Habitat loss and fragmentation: The extensive clearance of forests for agriculture, commerce and industry and human settlements alter biogeochemical cycles and affects the species. This has resulted in the erosion of biodiversity.
- Invasive species: Invasive species is a non-native species which has the ability to spread beyond its introduction site and become established in new locations where it may cause a deleterious effect on local biodiversity. Non-native invasive species can often cause significant changes to ecosystems, upset the ecological balance and cause economic harm. Introduction of species which may be invasive can be intentional or accidental.

  Following are some examples from Sri Lanka.

  Lantana camara – Lantana – Gandapana(S) – Nayunni(T)

  Mimosa pigra – Giant sleeping plant –Yoda nidikumba(S) – Radshatha thottalsurungi(T)

Eichornia crassipes – Water hyacinth – Japan jabara(S) – Kula valai(T)

Chitala chitala – Clown knife fish – Mannawa(S)

Parthenium hysterophorus – Parthenium – Congress weed

– Kangres kalai(T)

- Over exploitation of plant and animal species: Many species of animals and plants are heavily exploited primarily for food by man. E.g. Crocodiles and pythons are exploited for their skin. Elephants are exploited for ivory. Medicinal plants are exploited for pharmaceutical industry.
- Pollution.
  Pollution of water, soil and air affects the functioning of ecosystems and reduce or eliminate sensitive species.
- Global climatic change.
  Human caused increases in green house gases in the atmosphere are likely to cause a global temperature rise. Considerable changes could occur in ecosystems causing loss of species that cannot readily adapt to changes in the climate.
- Genetic erosion resulting from agriculture.
  Modern agriculture uses fewer varieties of plants and animals giving high yields. This lead to the loss of genetic diversity. Habitat loss, together with the displacement of traditional breeds result in the loss of genetic resources, or in genetic erosion.
- **Biodiversity Hotspots.**
  The areas with a high concentration of endemic species facing exceptional levels of threat have been described by Myers in 1988 as biodiversity hot spots.

Among these is the fragmented rainforests of Southwest of Sri Lanka. As a whole, Sri Lanka has a high degree of endemism. Sri Lanka together with Western Ghats of India is one of the major biodiversity hot spots in South Asian region. There are 25 biodiversity hotspots in the world.

- **Endemic Species.**

  An endemic species is a species that is confined to a particular area or country, and not found growing naturally anywhere else in the world.

  Two plant species endemic to Sri Lanka are

  Dipterocarpus zeylanicus – Hora(S) – Ennai(T)

  Garcinia quaesita – Goraka(S) – Gorakappuli(T)

  Two animal species endemic to Sri Lanka are

  Puntius nigrofasciatus – Black ruby barb – Bulath hapaya(S) – Veddiyan(T)

  Loris tardigradus - Slender loris –Unahapuluwa(S) – Thevangu(T)

- **Indigenous Species (Native Species)**

  A plant or animal species that occurs at a place within it's historically known natural range and that forms part of the natural biological diversity of a place. These are species, which arrived and inhabited an area naturally, without deliberate assistance from man. It is a species that originally inhabited a particular geographic area.

  Examples for Sri Lankan indigenous species are *Ophicephalus striatus* – Snake head – Lula(S) – Viral(T) and *Caryota urens*–Kitul(S) – Thippilipanai(T)

- **Exotic Species**

  A species that has been introduced from another geographic region to an area outside its natural range. *Oreochromis mossambicus* – Tilapia(S) – Japan meen(T) and *Hevea brasiliensis* – Rubber(S) – Rupper(T) are two exotic species introduced to Sri Lanka

- **Migratory Species.**

  Migration refers to the act of moving from one place to another in a manner that is seasonally determined and predictable. Migration takes place so that organisms can avoid unfavourable environmental conditions that limit breeding.

  Eg; Indian flycatcher – Sudu redi hora(S) – Inthian eepidipan(T)
  Indian Pitta – Avichchiya(S) – Aarumani kuruvi(T)
  Barn swallow – Wehilihiniya(S) - Malaikuruvi (T)

- **Relict Species**

  The remnants of a once widespread species, which are now found in very restricted or isolated areas.

Eg :- The Tuatara is an example which lives only on a few small islands off New Zealand.

Ichthyophis glutinosus is an ancient legless amphibian with a worm like body form.

Lingula sp. found in Tambalagamuwa Bay in Trincomalee is another example.

- **Flagship Species**

  Flagship species is a species chosen to represent an environmental cause, such as an ecosystem in need of conservation. Those species are chosen for their vulnerability, attractiveness or distinctiveness in order to engender support and acknowledgement from the public at large. Thus, the concept of a flagship species is that the publicity given to few key species, will help the conservation of entire ecosystem and all species contained therein.

  E.g.,The Bengal tiger of India

  The Giant panda of China

  Blue magpie of Sri Lanka – Lanka Kahibella(S) – Neelavudal perumkuyil(T)

- **Keystone species**

  These are species that play a very important role in the stability and functioning of a system. If that species is removed the system tends to collapse.

  E.g., In the African savanna the larger herbivores, especially the elephants destroy trees, making room for the grass species. Without these animals, much of the savanna may turn in to woodland.

  Students should be asked to name some keystone species in some ecosystems in Sri Lanka.

- **Different categories of threatened organisms according to the IUCN Red DATA Book**.

  - **Extinct (EX)**

    A taxon is extinct where there is no reasonable doubt that the last individual of that taxon has died. Examples: Dodo (Lived in Mauritius), Wooly Mammoth (Lived in North America), Southern shrub toad (Dakunudiga panduru mediya) lived in Sri Lanka

- **Extinct in the wild (EW)**

  A taxon is extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside its past range. Examples: Giant tortoise of Seychelles, *Alphonsea hortensis* (A plant of family Annonaceae) of Sri Lanka

- **Critically Endangered (CR)**

  A taxon is critically endangered when the best available evidence indicates that it is facing an extremely high risk of extinction in the wild. Examples; *Macrognathus aral* – Lesser spiny eel – Batakola theliya(S) – Kuraimull vilangu(T)

  Dermochelys coreacea – Leather back turtle – Dara kesbewa(S) – Vari amai(T)

- **Endangered (EN)**

  A taxon is endangered when the best available evidence indicates that it is facing a very high risk of extinction in the wild. Examples, *Caretta caretta* – Loggerhead turtle – Olugedi kesbewa (S) – Perunthalai amai(T), *Melursus ursinus* –Sloth bear- Wahala(S)-Sempukardi (T)

- **Vulnerable (VU)**

  A taxon is vulnerable when the best available evidence indicates that it is facing a high risk of extinction in the wild. Example, *Elephas maximus* – Asian elephant

- **Near threatened (NT)**

  A taxon is near threatened when it does not qualify for critically endangered, endangered, or vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future. Example, *Melanochelus trijuga* – Rock terrapin – Gal ippa(S) – Kal amai(T)

- **Least concern (LC)**

  A taxon is of least concern when it does not quality for critically endangered, endangered, vulnerable or near threatened. Widespread and abundant taxa are included in this category.

Example. *Crocodylus palustris* – Marsh crocodile – Hala kimbula(S) – Seththu muthalai(T)

- **Data Deficient (DD)**

  A taxon is data deficient when there is inadequate information to make a direct, or indirect assessment of its risk of extinction based on its distribution and/ or population status. A taxon in this category may be well studied, and its biology well known, but appropriate data on abundance and / or distribution are lacking. Example *Mystus keletius* – Yellow catfish – Path ankuttu(S) – Manchal keliru(T)

- **Not evaluated (NE)**

  A taxon is not evaluated when it is not yet been evaluated against the criteria used to include in the categories of threatened species. Examples, *Oecophyla smaragdina* – Tailor ant – Dimiya(S) – Musuru(T)

  Chloroxylon swietenia – Satin wood – Burutha(S) – Muthirai(T)

- **Need for Conservation.**

  A principle goal of conservation activity is to ensure the long term survival of as many species as possible. Species that are in danger of extinction have to be specially protected and steps should be taken to ensure their continued reproduction and survival. Conservation can be done in two ways.

  In-Situ conservation. The species is protected and its reproduction facilitated in its natural habitat. Basically a large enough population and adequate, appropriate, habitat space has to be ensured.

  Eg. Protected areas, Traditional home gardens, Sanctuaries, National Parks, Re-introduction of species into the natural habitat. The teacher will give more examples.

  Ex-Situ Conservation. The species is taken out of its natural habitats in to specially created equal situations where its survival and reproduction are ensured.

  Eg **:** Botanical gardens, Zoological gardens, Field gene banks, Captive breeding, Genetic Resource Centers. The teacher will give more examples.

- **Main features of the conventions and Acts related to conservation of Biodiversity.**

- CITES - Convention on International Trade in Endangered species of wild fauna and flora. (Effective from 1975)

  The aim of CITES is to ensure that international trade in specimens of wild animals and plants does not threaten their survival. According to this, the export of some species requires the prior permission and presentation of an export permit. An export permit shall be granted only if export of that species will not be detrimental to its survival. Some examples from Sri Lanka are *Loris tardigradus* – Slender Loris - Unahapuluwa(S) – Thevangu(T), Otter – Diya balla(S) – Neer naai(T) and Sri Lankan leopard – Kotiya(S) – Siruththaipuli(T)
- Biodiversity Convention (1992)

  Its objectives are the conservation of biodiversity, sustainable use of its components, and the fair and equitable sharing of benefits arising from the use of genetic resources.
- RAMSAR Convention (1971)

  RAMSAR convention is the Convention on conservation of wetlands of international importance, especially as waterfowl habitats. There are five RAMSAR sites in Sri Lanka. They are Bunadala National Park, Madu Ganga sanctuary and Annaiwilundawa tanks sanctuary, Vankalai Sactuary , Kumana wet land cluster.
- Fauna and Flora protection Act

  Fauna and flora protection ordinance which is an ordinance to provide for the protection of the fauna and flora of Sri Lanka was enacted in 1937. This was amended by Fauna and Flora Protection Act in 1993. It makes provision for the establishment of national reserves and sanctuaries and also deals with related matters.

  The teacher should list different types of national reserves in Sri Lanka and give examples.

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.6 : **Contributes to maintain the quality of the environment by controlling the factors affecting environmental degradation.**

Number of Period : **03**

Learning outcomes : The students should be able to;

- Explain the concept of pollution
- Tabulate the pollutants of air, water and soil and indicate their sources
- Explain the impacts of air, water and soil pollution.

Suggested learning – Teaching Process:

- Project work - Collect articles, photographs, posters etc. to reflect the impact of human activities on environment throughout the process of human civilization and make presentations.
- Organize and participate at a campaign/ working program to uplift or improve the quality of degraded environment in the locality.
- With the aid of suitable diagrams explain the factors affecting environmental degradation.

Guidelines :

- Introduce the concept of pollution -

  When material and energy is present in a particular environment in potentially harmful amounts, it is said that pollution has occurred.
- Define the concept of pollution.

  Release in to the environment of substances or energy in such quantities and for such duration that they cause harm to people or other organisms or the environment. Pollution can affect all aspects of environment, man-made and natural ecosystems, abiotic and biotic components.

- Air pollution

  Deterioration of the quality of air by releasing substances or energy in such quantities which prevent smooth/ balanced functioning of natural processes and produce undesirable environmental and health effects. Indicate main sources of the following air pollutants. Sulphur dioxide, Nitrogen Oxides, Carbon monoxide, Hydrocarbons, Particulate matter, Chlorofluorocarbon, Carbon dioxide, Ozone

  Adverse impacts of some air pollutants

Pollutant	Impacts
Carbon monoxide	Decrease in oxygen carrying capacity of blood. Impaired perception of stimuli,slows reflexes, impaired vision, drowsiness, decreased muscular coordination and nausea. Exposure to carbon monoxide over a long period at high concentrations can cause death.
Sulphur dioxide	Acute, chronic asthma, bronchitis and emphysema, some association with lung cancer. Causes acid rain. Teacher should explain the impacts of acid rain.
Nitrogen Oxides	Similar effects as of sulphur dioxide. In addition reduce the oxygen carrying capacity of the blood and cause acute pulmonary oedema. i.e. accumulation of fluid in the lung. Produce photochemical smog. Teacher should explain the impacts of photochemical smog.
Hydrocarbons	Produce photochemical smog. Causes eye irritations. drowsiness. Some can be carcinogenic. Some are associated with lung diseases.
Chlorofluorocarbon	Harmless at ground level. But at the level of atmosphere destroy the ozone layer. Teacher should explain the impacts of destruction of ozone layer.

Excess carbon dioxide	Green house effect and global warming. Teacher should explain the impacts of global warming.
Ozone	Damage to animals and harm patients suffering from respiratory disease. Coughing, Choking, impaired lung function, Reduce resistance to pneumonia, Aggravate asthma
Particulate matter	Respiratory problems (Asthma), Some can be carcinogenic, Cut off solar radiation reaching earth surface.

Water pollutants, their major sources and their impacts :

Nitrates and Phosphates
Pathogenic organisms
Oil
Heavy metals; Lead, Mercury, Cadmium, Arsenic, Pesticides
Non-degradable material (polythene)

- Teacher should indicate the major sources of these and explain their impacts.

Soil Pollutants, their sources and impacts

Pesticides
Chlorinated hydrocarbons (DDT, Aldrin, Endrin etc)
Polychlorinated biphenyls
Heavy metals (Pb, Hg, Cd, As)
Radioactive Material
Polythene and plastics

- Teacher should explain the impacts of these pollutants

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.7 : **Gets updated on the global environmental problems.**

Number of Periods : **05**

Learning outcomes : The students should be able to;

- list major global environmental issues
- describe the contributory factors for global warming , depletion of the Ozone layer, acid rains and their impacts

Suggested Learning – Teaching Process:

- Project work
- Make a presentation on global scale environment issues preferably with aid of multimedia material.

Guidelines:

Global environmental problems

- Global warming - The average temperature of the atmosphere is increasing
  Contributory factors - Green house effect. In the atmosphere gases such as CO_2, oxides of nitrogen, Methane, water vapor and Ozone prevent a part of the radiation that reaches the earth's surface being radiated back in to space. CO_2 is the principal green house gas
- Impacts of global warming
  Increase in volume of the ocean leading to gradual rise in sea level.
  In the longer term rising temperature can cause the melting of glaciers and polar ice caps contributing further to sea level rise.
  Changes in pattern of atmospheric flow. Wind patterns, climatic factors will change and rainfall pattern may alter.
  Affect to the agricultural production, composition of vegetation and its distribution can be changed. May alter limits of forests, grass lands and deserts.
  Increase of drought conditions, Increase irrigation demand
  Increase of flood may result in loss of habitats, extinction of certain species
  Increase of forest fires may change in vegetation patterns

Expansion of water may cause beach erosion and disruption of coastal fisheries

Affect human population and health through increased deaths by heat diseases

Increase of migration may cause spread of tropical diseases to temperate areas

- Depletion of the Ozone layer.

  The stratospheric ozone layer is a very effective screen which prevents a major part of the ultra-violet radiation coming from the sun from reaching the surface of the earth. It plays a very important part in the maintenance of life on earth.

  Contributory factors: Release of chlorofluorocarbon compounds
- Impact of Ozone depletion.

  Increased risk of cataracts and skin cancer in people (UV radiation is a mutagenic agent).

  Lowering crop yields through interference with photosynthesis
- Desertification

  (Explain the contributory factors and the impacts)
- Acid rain

  (Explain the contributory factors)

  Impacts of acid rain

  Corrode metals,

  Erode limestone/ buildings

  Increase up take of heavy metals from soil by plants

  Reduce soil organisms responsible for N_2 fixation

  Decrease photosynthesis due to yellowing/ scorching of leaves

  Decrease the abundance of aquatic organisms due to decrease in pH

  Decrease soil fertility

Competency 12.1.0 : **Engages in a biological analysis on relationships between organisms and their environment**

Competency Level 12.1.8 : **Contributes to sustainable usage of environmental resources by getting enlightened on the environmental related protocols and acts**

Number of Periods : 03

Learning outcomes : The students should be able to;

- Demonstrate the knowledge and understanding of national legislations, and global agreements.
- Discuss the importance of sustainable use of resources

Suggested Learning – Teaching Process :

- With the aid of suitable publications, motivate the student to read about the importance of conservation
- Let the students build up list of environmental resources.
- Highlight and discuss the importance of sustainable use of environmental resources.

Guidelines:

Main Conventions, Protocols and Parliamentary Acts contributing to environmental conservation.

- Basel convention

  Convention on the control of trans boundary movement of hazardous wastes and their disposal.

  This aims to protect human health and the environment against the adverse effects which may result from the generation and management of hazardous wastes which may be toxic, poisonous, explosive, corrosive or infectious.
- Marpol convention

  International convention for the prevention of pollution by ships.
- Montreal protocol (1987) on substances that deplete the ozone layer.

  The teacher will explain what the Montreal Protocol is.

- Kyoto protocol

  The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climatic change. The major feature of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries and the European community for reducing green house gas (GHS) emissions. These amount to an average of five per cent against 1990 levels over the five year period 2008-2012.
- National environmental act

  Under the provisions of this Act, the Central Environmental Authority (CEA) as established in 1980. The CEA has wide powers to regulate pollution by issuing environmental licenses and evaluate environmental impacts of development projects through assessment schemes.

Need for the sustainable use of environmental resources

- Natural resources are sources of material and energy found naturally which are of use in everyday life and for economic development.
- Natural resources may be

  living or nonliving

  Renewable or nonrenewable

  May or may not be recycled.

  Exhaustible or nonexhaustible

  Give examples for each.
- Natural resources should be used rationally. Giving suitable examples, explain what are the effects of over-exploitation of natural resources.
- Methods of reducing unwise utilization of natural resources should be explained.
- Sustainable utilization and sustainable development, their meanings, importance and examples should be discussed.

Unit 13 - Microbiology

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities**

Competency Level 13.1.1 : **Explores the diversity and nature of microorganisms**

Number of Periods : 07

Learning Outcomes : The students should be able to;

- understand the nature of microbial world.
- describe the taxonomic diversity of microorganisms.
- describe the diversity of the nutritional & physiological processes of microorganisms.
- elaborate the morphological & reproductive characteristics of micro-organisms.
- conduct laboratory tests to identify major morphological types of microorganisms.
- Prepare simple culture media (NA/ PDA), inoculate with a sample of toddy / yoghurt and stain bacteria found in toddy / yoghurt.

Suggested Learning-Teaching Process :

- Provide students with specimens, prepared slides, pictures of microorganisms.
- Provide students with printed or electronic literature on bacteria, virus and fungus.
- Ask the students to collect information on general characteristic features of above mentioned microorganisms.

- Prepare them for a presentation.
- Make an elaboration according to appropriate sequence.

Guidelines:

- Microbiology concerns the study of organisms that are too small to be clearly observed by the naked eye.
- Microorganisms include
  - Bacteria and Cyanobacteria
  - Viruses
  - Fungi
  - Protozoa and
  - Unicellular algae and filamentous algae
- In general microorganisms are less than 0.1mm in size and cannot be seen with the naked eye.

- The units of measurement of size of microorganisms are;

  Micrometers (μm)

  Nanometers (nm)

  [1μm $= 10^{-6}$m & 1nm $= 10^{-9}$m]

  E.g.;

  Bacteria = 0.25-5μm

  Cyanobacteria = 1μm

  Yeast = 5-10μm

  Filamentous fungi = 5μm

  Viruses = 20-300 nm

- Microorganisms show a high diversity of habitats, microorganisms are found in the biosphere unlike animals or plants. They are found in soil, air, water and atmosphere up to about height of 6 km. They cover the body surfaces of plants, animals and human beings. They live in the genitourinary system, respiratory tract and alimentary canal in man and animals. They are also found in extreme environments like hot water springs, salternes, extremely acidic surroundings and in hydrocarbons like petrol, kerosene and diesel.

- Microorganisms show a diversity of nutritional types.

  E.g.; Four nutritional types can be seen among microorganisms. The classification is based on their sources of carbon and energy.

Nutritional Type	**Source of Energy**	**Source of Carbon**	**Example**
a) Chemoautotrophs	Inorganic chemicals	CO_2	*Nitrobactor* *Nitrosomonas*
b) Chemoheterotrophs	Organic chemicals	Organic Carbon	Most bacteria Fungi, protozoa
c) Photoautotrophs	Light	CO_2	Cyanobacteria Purple sulphur & Green sulphur bacteria
d) Photoheterotrophs	Light	Organic Carbon	Purple non sulphur bacteria

- Microorganisms show a diversity on their relation to oxygen.

  E.g.; According to the relation to oxygen microorganisms can be divided into four physiological groups.

  E.g.;

  a) Aerobic microorganisms - *Acetobacter*
  b) Facultative anaerobic microorganisms - *Saccharomyces*
  c) Obligate anaerobic microorganisms - *Clostridium*
  d) Micro aerophilic microorganisms - *Lactobacillus*

- Some microorganisms are able to fix atmospheric N_2. They show a diversity in this N_2 fixation also.

  E.g.,

  - Some can fix N_2 by making symbiotic relation with other organisms – *Rhizobium* with legume roots
  - Some can fix N_2 as free living organisms - *Azotobacter*

- The rates of growth and reproduction of microorganisms are high. By virtue of their small size, micro-organisms show a high surface area/ volume ratio. This means that surface area available for absorption of nutrients from the environment is large. Flow of materials in and flow of waste material out becomes rapid in a favourable environment because of this, their rate of metabolic process is very high. Therefore, their average generation time (time required for doubling of the population) is relatively low.

Organism	Generation time (hours)
❖ *E. coli*	0.35
❖ *Clostridium botulinum*	0.58
❖ *Anabaena cylindrica*	10.6
❖ *Acantha amoeba*	11
❖ *Saccharomyces cerevisiae*	2

- Different morphological forms of bacteria and their arrangements
  - The most obvious structural feature of bacteria is their shape
  - There are three basic shapes
    - ❖ Rod shape
    - ❖ Spherical
    - ❖ Spiral shape
  - Rod shaped cells are called bacillus
  - Spherical shaped cells are called coccus
  - Spiral shaped cells are called spirillum

- Different forms of arrangement of coccus bacteria
    - Coccus
    - Diplococcus
    - Streptococcus
    - Staphylococcus
    - Tetrads
    - Sarcinae

- Different forms of arrangement of Bacillus bacteria.
    - Diplobacillus
    - Streptobacillus

- Different forms of arrangement of spiral bacteria.
    - Vibrio
    - Spirillum
    - Spirochete

Cyanobacteria

- Explain that most of the bluish green patches seen on moist surfaces, particularly plastered walls of toilets, cement floors and soil contain some species of cyanobacteria.
- Cyanobacteria are widespread in soil, fresh water and marine environments. Some grow in hot springs and are thermophilic.
- Some live in association with fungi (lichens) and higher plants.
- Cyanobacteria exhibit a great variety of shapes and arrangements, unicellular to long multicellular filaments.
- They do not have flagellated cells, but filamentous species show gliding movement.
- Explain the processes and functions of heterocyst in some cyanobacteria, functions of akinete, which are thick walled resting spores resistant to drought and high temperature.

  Reproduction is only by asexual methods, simple cell division or fragmentation.

Structure of viruses

- Viruses are neither prokaryotes nor eukaryotes and do not show any cellular organization.
- They range in size from 20nm-300nm & they can be observed only by the use of electron microscope.
- Viruses are composed of a central core of nucleic acid and surrounded by a protein coat called the capsid, which is made up of a fixed number of protein molecules called capsomeres.
- The nucleic acid may be DNA or RNA depending on the type of virus
- Most viruses that infect plants have RNA. Very few also have DNA. Animal viruses include DNA (*Herpes simplex*) or RNA (influenza, rabies virus, retrovirus - HIV) bacterial virus either include DNA or RNA.
- Protein coats of the viruses give them a characteristic symmetry. On this basis two morphological types are recognized. They are
    - ❖ Icosahedral
    - ❖ Helical
- Some virus have pollyphospholipid coats,
  E.g., Retro viruses – virus posses an enzyme called reverse transcriptase which transcribes their RNA to DNA (E.g., HIV)
- Many viruses contain within the capsid one or more enzymes that are released into the host cell after the virus is uncoated. The most common enzymes are polymerases & they help in the replication of nucleic acids of viruses.
- A wide variety of lipid components have also been found in viruses
  E.g., phospholipids, glycolipids & fatty acids.
- Some viral envelopes contain with spikes made up of glycoprotein.
- Nature of viruses.
    - ❖ Viruses are obligate parasites. They can live and reproduce only within a metabolizing host cell using protein synthesizing and energy generating system of the cell.

- ❖ Viruses are widely distributed in nature and also they can infect other microorganisms
- ❖ Since viruses are obligate parasites, cultivation of viruses requires living cells

  E.g., :- chick embryo
- ❖ Some viruses have complex structures

  E.g., :- bacteriophage
- ❖ Reproduction of viruses

  The lytic cycle of a bacteriophage
- ❖ The life cycles of plant viruses or animal viruses are similar. Plant viruses enter plant cells through surface wounds or insects feeding on plant sap

Prions

- Nature of prions :-
  - ❖ Prions are proteinaceous infectious particles
  - ❖ Smaller than viruses
  - ❖ Pathogens that could exist and replicate without nucleic acids. They can replicate with the help of mammal’s gene that encodes the prion protein.
  - ❖ They have been linked to a group of fatal degenerative brain diseases that have been identified in birds and mammals. These diseases are called Transmissible Spongiform Encephalopathies (TSEs), because the infected brain appears to develop holes becoming somewhat sponge like .

    Eg :- Creutzfeldt Jakob disease (CJO) in humans, mad cow disease in cattle.
  - ❖ Some TSE infections can be transmitted from cow to human. Human to human transmission has been associated with tissue and organ transplants and transfusion with contaminated blood.

- Fungi
    - ❖ General characteristics of fungi
    - ❖ Classification of fungi

  Refer 3rd Unit

- Explain that moulds growing on damp organic matter, bread, leather, decaying vegetables are fungi.
- Fungi are the major decomposers on earth, most fungi are Saprotrophes which obtain nutrition by decomposing dead organic matter.
- Some fungi attack living plants and animals causing diseases.
- Explain the general characteristics of fungi
  - Non photosynthetic, non motile eukaryotic organisms
  - The fungal body consists of a mass of fine tubular branching threads known as hyphae. Collectively they form a mycelium. Hyphae may be septate or aseptate.
- Some are unicellular – *Saccharomyces*
- Rigid cell wall made up of chitin
- Heterotrophic absorptive nutrition – absorb materials directly from outside the body, mainly after digestion by extracellular enzymes, produced by the fungus.
- Fungi may be saprotrophic, parasitic or mutualistic (Lichens and *Mycorrihza*)
- Food is stored as glycogen and not as starch .
- Reproduction by means of spores.
- Explain that the fungal classification is primarily based on
  1. Characteristics of sexual reproduction, sexual spores, fruiting bodies and asexual reproduction.
  2. Morphological features of vegetative mycelium.
- *Mucor, Aspergillus, Penicillium, Agaricus, Allomyces, Rhizopus, Saccharomyces* belong to the following major groups.

  Phylum- Chytridiomycota – *Allomyces*

  Phylum- Zygomycota – *Mucor, Rhizopus*

  Phylum- Ascomycota – *Saccharomyces, Aspergillus,Penicillium*

  Phylum- Basidiomycota – *Agaricus*

- **Culturing microorganism in the laboratory**
    - Explain why microorganisms have to be cultured in the laboratory in order to study them. For example, microorganisms in the soil cannot be studied by examining a soil sample in the field. It is necessary to bring a sample and first culture them in culture media.
    - Culture media contain necessary nutrients for growth of microorganisms .Nutrient agar and potato dextrose agar are two general media ,commonly used to grow bacteria and fungi, respectively.

Nutrient Agar		**Potato dextrose agar**	
Peptone	10g	Potato	200g
Meat extract (beef)	10g	Glucose	20g
Sodium chloride	05g	Agar	15g
Agar	15g	distilled water	1000ml
Distilled water	1000ml	Final pH	5.6
Final pH	7.2		

- All glassware, culture media and liquid nutrient solutions used in microbiological work should be sterilized.
  Explain the principles underlying major methods /techniques used in sterilization of materials and controlling microorganisms, in different situations and their practical application.

Moist heat
- Sterilization
- Steam under pressure 15 lb/sq. inch, 121 ^{0}C for 15 min.
- Using an autoclave /pressure cooker
- Culture media

Pasteurization
High temperature short time method-161^0 F (71.7 ^{0}C) for 15 seconds
Low temperature – holding method-145^0 F (62.8 ^{0}C) for 30 min.
E.g.; milk, wine, beer
Boiling (100 ^{0}C) instruments used for minor surgery , scalpels, glass hypodermic syringes

Dry heat
Hot air oven,160 ^{0}C for 1-2 hours. Glassware, Petri dishes , pipettes
Flaming the inoculating loop in open flame

Filtration
Thermolablile liquids and water are sterilized by this method
Membrane filters (0.45 µm) size filter.

Practical:
- Identification of different types of micro-organisms and observation of bacteria and fungi
- Preparation of a simple culture medium (NA) and inoculation with a sample of toddy/yoghurt
- Staining of bacteria found in toddy or yoghurt using a simple stain

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities.**

Competency Level 13.1.2 : **Explores the concepts, principles relevant to infectious diseases.**

Number of Periods : **08**

Learning Outcomes : The student should be able to;

- explain the concepts in relation to disease.
- describe the characteristics of the pathogens to cause a disease .
- explain virulence factors .
- state the portals of entry of pathogens into the human body.

Suggested Learning-Teaching Process :

- Ask the students to do a survey on disease with the help of hospital authorities.
- Help the students to list out infectious disease and non infectious disease .
- Facilitate students to extract important points on infectious disease .
- Make an elaboration to highlight important points .

Guidelines

- Microorganisms and diseases
  - Disease is a structural and/or functional disorder of the body which results in the development of discernible signs called symptoms.
  - Microbial diseases are quite heterogeneous. They can affect any organ and thus can produce many different symptoms. Hence, they are related only by their common cause, pathogenic organisms.

- The nature, distribution and function of the normal micro biota living in human body

  - A wide variety of microorganisms occur on and in the human body as normal micro biota.

  - The healthy human body is inhabited by a large number of micro-organisms. ($1x10^{14}$ bacterial cells while the body it self contains only $1x10^{13}$ cells)

  - Most of these organisms are generally harmless and live as commensals, or even beneficial. E.g.; some enable certain mammals to digest plant materials

  - The human body is constantly being invaded by microorganisms. Particularly bacteria and viruses, but also certain protozoa and fungi which includes yeasts.

  - Some of the microbes occur on the skin, but most enter the body through its openings and live on the inner surfaces including mucous membranes of nose, throat, upper respiratory tract and intestinal tract. They may enter genitourinary tract also.

  - Internal organs and tissues of the healthy human body are usually free of microorganisms.

  - While most normal micro biota are commensals, some may be opportunistic pathogens. They may cause infection, if there is tissue injury or if the general resistance of the body is lowered due to reasons such as exhaustion, prolonged use of antibiotics, immune suppressive drugs or narcotics.

- Concepts in relation to diseases

  Disease (infections disease) - A physiologically impaired state resulting from microbial infection, microbial products or microbial activity.

  Pathogenecity- The ability of microorganisms to cause disease in the host on infection. Growth of microorganisms within host tissues is termed infections.

  Pathogen – Organisms capable of causing disease

  Host – Organisms on or in which parasitic organisms live

  Parasite – Organisms that live on the body or in the tissue of another living organism, the host from which they obtain nutrients

- Disease occurrence as expressions of ecological relationship between the host and the parasite

  - Microorganisms occur naturally in association with surface tissues of healthy individuals and also occur everywhere in the environment. Some of them are harmless, but some are potential pathogens.

  - Micro-organisms are everywhere and if they are potential pathogens, people do not suffer from diseases all the time in their life time. By the way some pathogens can initiate infections and cause diseases in some people and not in others.

  - Therefore occurrence of disease depends on some properties of pathogen and some properties of host.

- Intrinsic properties of microorganisms (pathogens)

  - Virulence factors

    Virulence decides the degree of pathogenicity. Some micro-organisms are highly virulent (chicken pox virus) some are less virulent.
    The relationship between pathogen and host is dynamic and varies depending on the; “dose of infecting micro-organisms”/ Virulence or virulence factors /host resistance.

$$\text{Infectious disease} \int \frac{\text{Microbial virulence x dose}}{\text{Host resistance (defence)}}$$

Virulence factors (virulence) enhance the pathogenicity and allow the microorganisms to invade and colonize human tissues and disrupt normal body functions. All virulent organisms possess one or more special properties that contribute to their ability to cause disease.

a) Invasiveness

Ability to invade human cells and tissues and to multiply within the tissues. To establish a host-parasite relationship with humans, a pathogen must be able to colonize a surface or invade a tissue of the host. Several extracellular enzymes produced by pathogens contribute to invasiveness.

E.g.; Phospholipase – destroy animal cell membranes

Lecithinase – hydrolyses the lecithin component of the lipid in the cell membrane.

Hyaluronidase – destroys body tissues by attacking the hyaluronic acid cementing substances between cells.

b) Toxigenicity

Ability of microorganisms to produce biochemicals known as toxins that disrupt the normal functions of cells.

These are proteins or lipopolysaccharides that produce specific harmful effects on the host, thus are called biological poisons. They may be,

- Endotoxins - thermo stable toxins which are part of the microbial cell.

  E.g., Lipopolysaccharides of the cell walls of *Salmonella typhi*

- Exotoxins – thermo labile protein toxins, being inactivated by boiling.

  Exotoxins are classified into three types

1)Neurotoxins – interfere with normal transmission of nerve impulses

E.g., toxin produced by *Clostridium tetani*

2)Enterotoxins – stimulates cells of the gastrointestinal tract in an abnormal way

E.g., Toxin produced by *Vibrio cholerae*

3)Cytotoxins – kill host cells by enzymatic attack

E.g., Toxin produced by *Corynobacterium diphtheria*

- Portals of entry of pathogens into the human body.

  Every infectious disease is transmitted to humans from its reservoir by a characteristic mode of transmission.

  - Gastrointestinal tract
  - Respiratory tract
  - Genito urinary tract
  - Wounds on skin

Practical:

Practice techniques for sterilization of water, culture media, glassware heat labile substances and inoculating needles

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities**

Competency Level 13.1.3 : **Explores the defense mechanism of the human body**

Number of Periods : **05**

Learning Outcomes : The student should be able to;

- describe the defense systems of the human body against microbial infection
- elaborate non specific defense mechanisms in human body
- elaborate the specific defense mechanism in human body
- describe active & passive immunity

Suggested Learning-Teaching Process :

- Arrange a group discussion or seminar with the medical officer of health, public health inspector and nurses on the defense mechanism of the human body.
- Ask the students to get ready for the presentation on what they studied.
- Encourage students to present the findings to the whole class.
- Make an elaboration according to appropriate sequence

Guidelines

Defense mechanism of the human body

- The properties of healthy host to prevent the entry and establishment of potential pathogens.
- The human body has defenses against microbial infections. These defense mechanisms are two types.

a) Non-specific defences

b) Specific defences.

a) Non-specific defenses

These are natural defences present in any normal healthy human that will protect the host from any pathogen, regardless of particular species. Nature of non specific defense seen in the human body.

- Skin and the mucous membrane
- Antimicrobial substances in body fluids
- Phagocytosis
- Inflammatory responses

❖ Skin act as a physical barrier, keratinized outer layer serves as an effective barrier to most microorganisms. It is not easily degraded by microbial enzymes. Saline, sweat, sebum and antimicrobial substances produced by skin, prevents the establishment of pathogens.

❖ Mucous membrane of the respiratory tract secretes mucous and microorganisms get trapped in mucous. Ciliated epithelial lining the tract (trachea and bronchi) removes invading microorganisms by beating cilia towards the throat.

❖ Coughing and sneezing help to expel foreign bodies from the respiratory tract.

❖ Some body fluids contain antimicrobial substances, enzymes which prevents undesirable growth of micro – organisms.

❖ E.g. Lysozyme in saliva and tears break down bacterial cell walls.

❖ Lactoferrin present in tears, semen, breast milk and bile.

This chemical binds iron which is an essential growth element for pathogenic organisms and limit growth of pathogens.

❖ Acid in the stomach kills many of the bacteria that come in with the food.

In more extreme cases vomiting and diarrhea expel undesirable bacteria from the gut.

❖ Lactic acid produced by bacteria in the vagina, creating an unfavorable environment for many pathogenic micro organisms

❖ Interferon produced in blood in response to viral infections in eukaryotic cells protect host against viral infections.

❖ Phagocytosis When micro organisms penetrate the body's outer barrier and enter the circulatory system they are subjected to phagocytosis by a variety of cells in blood and lymphatic system.

Eg; Neutrophils
Macrophages

❖ Inflammatory Response Generalized response to infections or tissue damage. Prevents the spread of infection from the original site. Inflammatory response consist of following characteristic features.

a) Reddening of the site of infection

b) Swelling of the site of infection

c) Pain of the site of infection

d) Elevated temperature of the site of infection

- Specific defense mechanism

The specific defense system or development of specific immunity, comes into operation when foreign organisms virus, bacteria, fungi, etc. or foreign substance such as pollens, chemicals enters the body of host. Specific immune response initiates the production of antibodies as response to an invading organism or substance known as antigen. Specific antibodies combine with the antigen and eliminate an invading organisms preventing infection. This type of immunity is referred to as acquired immunity.

- Antibodies are immunoglobulins (proteins) found in blood.
- HIV destroys the immune system and as a result the host is susceptible to any other infection and finally dies.
- Types of acquired immunity
  - Naturally acquired active immunity
  - Naturally acquired passive immunity
  - Artificially acquired active immunity
  - Artificially acquired passive immunity
- Active immunity occurs when an organism produced its own antibodies
- Passive immunity is the result of antibodies being passed into an individual in some way, rather than being produced by the individual itself.
- Naturally acquired active immunity

This immunity is acquired as a result of natural infections such as measles, mumps or chicken pox. Once the body has started to produce specific antibodies in response to a disease causing agent (antigen) host may be resisted to another infection of same antigen

- Naturally acquired passive immunity

When antibodies pass across from the mother to her foetus across through placenta or are passed to the new born baby through breast milk, the baby is protected from some infectious diseases until its own immune system is fully functional.

- Artificially acquired active immunity

  Attenuated microbial cells are used in vaccines to protect some diseases

  E.g. Polio vaccine

  B.C.G. Vaccine

  These microbial cells are antigens. When injected through vaccines, they produce specific antibodies which can protect against the specific pathogens.

- Artificially acquired passive immunity

  Passive immunity may be acquired artificially by the injection of antibodies from another individual. Readymade antibodies are administered when some infection agents are thought to have accidentally entered the body.

  Eg; Antitetanus vaccine

  Antirabies vaccine

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities**

Competency Level 13.1.4 : **Explores the methods of controlling microbial diseases/ infections.**

Number of Periods : **04**

Learning Outcomes : The student should be able to;

- describe the role of disinfectants and antiseptics in controlling microbial diseases.
- differentiate between disinfectants and antiseptics
- state the role of antibiotics in controlling microbial diseases.
- describe briefly the mode of action of some common antibiotics.

Suggested Learning-Teaching Process :

- Arrange a group discussion or seminar with the medical officer of health, public health inspector and nurses on the methods of controlling microbial diseases/ infections
- Ask the students for a presentation
- Based on ;
  - Use of disinfectants
  - Use of antiseptics
  - Immunization
  - Facilitate them for an attractive presentation
  - Make an elaboration according to an appropriate sequence

Guidelines:

- Let the students explore the methods of controlling microbial diseases

  Most microorganisms are potential pathogens and controlling micro organisms in the home environment is essential
- Use of disinfectants

  Disinfectants are chemicals used to destroy or reduce microbial populations in inanimate environments like toilet floors etc. these chemicals are micro biostatic or microbicidal depending on concentration
  E.g., phenols, lysols, chlorine compound
- Use of antiseptics

  These are chemicals which are used mainly on skin to reduce microbial populations
  E.g., Alcohol
- Immunization

  Artificially active and passive immunization methods are practiced, for certain diseases on a wide scale all over the world, as a preventive measure.

- **Curative methods of microbial diseases**
  - Antibiotics

    Use of chemical compounds in the treatment of disease is known as chemotherapy
    Antibiotics and other drugs are widely used chemical compounds used in the control of microbial infections.
    Antibiotics which are chemical compounds naturally produced by micro organisms or synthesized which are inhibitory to other micro organisms
    E.g.;
    - Penicillin – inhibition of the synthesis of bacterial cell wall

- Synthetic Ciprofloxacin – inhibition of the synthesis of bacterial DNA
- Polymyxin – inhibition of the permeability of bacterial cell membrane
- Erythromycin – inhibition of synthesis of bacterial protein
- Ketoconazole / Clotrimazole – inhibition of synthesis of fungal cell membrane

(These antibiotics should be taken in time until we develop our own immunity)

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities**

Competency Level 13.1.5 : **Investigates the use of microorganisms in industry and agriculture**

Number of Periods : **05**

Learning Outcomes : The students should be able to;

- explain the advantages of employing microbes in industries
- describe the commercially used microbial processes
- describe the commercially used microbial products
- elaborate the uses of genetically modified microorganisms for commercial purposes.

Suggested Learning-Teaching Process :

- Arrange a field trip to factories where the microorganisms are used such as brewery, milk products etc.
- Provide web resources or printed matter on the uses of microorganisms in industry and agriculture
- Ask the students to prepare a chart of products and its relevant microorganisms
- Help them to present it for the whole class
- Make an elaboration to cover the subject content

Guidelines:

- Uses of microorganisms in industry and agriculture
- Historical background of using microorganisms and their functions in different products
- Microorganisms have been exploited for uses long before the discovery of them. As early as 6000BC Babylonian and Sumarian civilizations used yeast to make alcohol.
- The large scale production of economically important materials using microorganisms and their metabolic processes have been the basis of industrial microbiology. Such fundamental applications of micro-organisms and their products for the benefits of the mankind is one aspect of current biotechnology. Application of technology has improved and expanded the scope of microbiologically based industries.
- Use of microorganisms in commercial products that are useful for humans

  (1) Microbial cells

  (2) Their metabolic process

  (3) End products
- Basic principles of metabolic process of microorganisms for product formation.
- From the stand point of industrial microbiology microorganisms can be considered as miniature chemical factories. They have this capacity to convert raw material (nutrients or substrate) into endproducts.

Microorganisms + Substrate

↓

Products + Waste materials & Residues

↓ Purification of products

Products

- Microorganisms used in industries are
  - Bacteria
  - Fungi
  - Algae
  - Viruses

- Advantages of using microbial processes over chemical processes
- Micro-organisms convert cheap raw materials into useful products rapidly by virtue of their;

  High growth rate

  Metabolic versatility and ability to use many different materials or substrate
- Many of the chemical conversions need high temperature, pressure, energy and are labor intensive if performed under conventional industrial methods
- There are thousands of commercially important products made by using microorganisms and their metabolic processes. These may be placed into several groups.
  - ❖ Microbial cells, are used as the end product
  - ❖ Microbial metabolic products are used as the end product

- ❖ Microbial metabolic processes are used as the end product
- ❖ Genetically modified microorganisms are used to obtain end product

- **Commercial usage of microbial cells**
  - ❖ Microbial cells used as food supplements

    E.g., Yeast and Algae are cultivated in large scale as food supplements rich in proteins (single cell protein) , *Spirulina*
  - ❖ Microbial cells are commercially produced to use in active immunization against various diseases.

    E.g., Hepatitis bacteria
  - ❖ Microorganisms or their sexual reproductive structures are used as food.

    E.g.; the mushroom *Pleurotus, Agaricus & Lentinus*

- **Commercially used microbial products.**
- Alcoholic beverages

Ethyl alcohol, wine, beer and toddy are products formed by alcoholic fermentation of carbohydrate substrates by yeast *Saccharomyces cerevisiae*

•

$$C_6H_{12}O_6 \xrightarrow{\text{Yeast}} 2C_2H_5OH + 2CO_2$$

- Explain briefly the commercial production of ethyl alcohol, toddy, wine, beer,whisky and arrack indicating the various starting materials used in the process.
- Explain the role of alcoholic fermentation in bread making.

- Production of vinegar :

  Involves 2 steps ;

  (a) Fermentation of carbohydrates to produce ethanol

  (b) Oxidative conversion of ethanol to acetic acid

$$C_2H_5OH + O_2 \longrightarrow CH_3COOH + H_2O$$

- Indicate the different raw materials which can be used in vinegar production
- Explain the role of *Saccharomyces cerevisiae*, *Acetobacter* and *Gluconobacter* in the production of vinegar
- The conversion of ethyl alcohol to acetic acid is an aerobic process.

Production of lactic acid and the fermented milk products.

- Commercial lactic acid production use dairy waste products from cheese and butter industry and employs *Lactobacillus bulgaricus*.
- Commercial production of curd and yoghurt involves lactic acid fermentation by lactic acid bacteria *L. bulgaricus* and *Streptococcus lactis*

Production of Enzymes, Antibiotics

- Commercial production of certain antibiotics and enzymes are examples of industries based on processes of microbial synthesis.
- Many industrial products such as antibiotics, enzymes, amino acids, organic acids are produced by various microorganisms
- Give some examples of the products and the microorganisms involved

Antibiotics

Penicillin	-	*Penicillium notatum*
		Penicillium chrysogenum
Streptomycin	-	*Streptomyces griseus*
Tetracycline	-	*Streptomyces aureofaciens*

Enzymes

Amylase	-	*Aspergillus niger*
	-	*Aspergillus oryzae*
	-	*Bacillus subtilis*
Cellulase	-	*Aspergillus niger*
Glucose oxidase	-	*Aspergillus niger*
Invertase	-	*Saccharomyces cerevisiae*
Lipase	-	*Rhizopus spp*
Protease	-	*Aspergillus oryzae*

Production of Vaccines

- Commercial production is done of variety of microbial antigens used in active immunization against various diseases. Some of them are genetically engineered vaccines. E.g. Hepatitis B vaccine
- Commercial production of various antibody preparations used for passive immunization. E.g. Antitoxins against tetanus, botulism toxin and immunoglobulin against rabies

Biofertilizer , Biopesticides ,Inoculation of Rhizobium

- Certain microorganisms are produced commercially and used directly as bioinsecticides. Similarly *Rhizobium* inoculants are produced and applied to increase nitrogen content of agricultural soils.
- Explain that pesticides and nitrogen fertilizers are used very widely in modern agriculture and widespread use of chemical pesticides has already created many pollution problems. Similarly addition of chemically synthesized nitrogenous fertilizers is environmentally unfriendly and also expensive.
- New microbiological technology has provided alternative pesticides known as biopesticides or insecticides which consists of microbial preparations. Specifically affecting pests. E.g. *Bacillus thuringiensis* an endospore forming bacterium which is pathogenic for many insect larvae. Protein crystals produced by this bacterium are toxic to larvae and when ingested will dissolve and cause destruction of tissues of the guts of larvae.

- **Commercially used microbial processes.**

- Compositing
- The practice of adding plant residues, organic manure to increase plant productivity and composting depend on the activity of microorganisms

- The addition of plant residues and organic matter in the form of animal dung to soil as fertilizer , utilizes ability of microorganisms to decompose and release nutrients

- Composting is the decomposition of organic matter by a mixed population of microorganisms in warm moist aerobic environments

- Addition of any of the above to soil exploits the activities of the natural microbial population in soil.

Biogas production

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of biofuel. The composition of biogas varies depending upon the origin of the anaerobic digestion process.

Typical composition of biogas is Methane, Carbon dioxide ,Nitrogen, Hydrogen and Hydrogen sulfide

Extraction of metals like copper

- Autotrophic bacteria such as *Thiobacillus ferroxidans, Thiobacillus thiooxidans* are used in the recovering of copper from low grade ores, which contain iron and sulfide.
- These organisms produce sulfuric acid , produce Fe^{3+} and cause oxidation of the ore and immobilization of copper as $CuSO_4$
- This process is called microbial leaching and solution of $CuSO_4$ is electrolyzed to obtain copper.

Retting

- Traditional methods of obtaining coir fiber by retting process are brought about by populations of heterogeneous microorganisms
- Explain that the basis of obtaining various kinds of plant fibers , leaf fibers , stem fibers is based on the microbial action (enzymes , pectinases mainly) is known as retting.
- Retting refers to the process of loosening the fibers from woody stem or other plant material. In this process, plant materials are immersed in water for varing lengths of time.
- A heterogeneous group of both aerobic and anaerobic bacteria participate in this process.

Removal of environmental pollution, Bio-remediation

- Environmental applications of microbial activity present a new technology which aims at removing pollution and pollutants by enhancing biodegradation. It is called bioremediation.

- This process utilizes the ability of micro-organisms to degrade and remove wastes and it is called bioremediation.

- Bioremediation is defined as a natural or managed process in which micro organisms catalyze action on pollutants and remedy or eliminate environmental pollutants.

- It is used currently to ,

    - Decrease organic waste content in aquatic environments

    - Accelerate waste water decomposition in industrial food processing and chemical plants

    - Remove oil spills from aquatic environments

    - Accelerate the composting process.

    - Removing toxic metals, chromium, lead, mercury from metal industry wastes

- **Using genetically modified microorganisms for commercial purposes**

    - Hormones, Vaccines, Insulin.

    - Insulin and human growth hormones are produced commercially, by genetically engineered microorganisms
    - Explain that production of therapeutic drugs to treat diseases is the most modern application of microbial technology

- Human insulin if produced by conventional method is expensive. This products now produced using a genetically engineered bacterium *E. coli* cheaply
- Human growth hormone is another pharmaceutical product made more effectively by genetically engineered bacterium. Previously it was obtained in small quantities by extracting from pituitary glands of animals.

Competency 13.1.0 : **Uses diversity, functions and impacts of microorganisms for the success of human activities**

Competency Level 13.1.6 : **Uses the functions of soil microorganisms to maintain the agricultural activities at optimum level.**

Number of Periods : **05**

Learning Outcomes : The student should be able to;

- describe the nature , distribution and processes of soil microbes.
- explain the natural role of microorganisms as decomposers in recycling of minerals
- elaborate the specific role of microorganisms in nitrogen cycle and carbon cycle
- describe the interactions of soil microorganisms relevant to plant growth

Suggested Learning-Teaching Process :

- Provide the students with the literature on soil microbes
- Ask the students to collect information on the nature, distribution and processes of soil microbes
- Facilitate the students to prepare a booklet on the findings
- Ask the students to present their findings and make an elaboration

Guidelines

- Soil sustains a large population of microorganisms and provides an adequate physical and chemical environment for their existence.

- Nature & distribution of soil microorganisms

  Man is almost entirely dependent upon plants as a source of food. Most plants are rooted in soil, from which they obtain essential mineral nutrients. These originate from dead plant and animal remains and rock minerals. The release of nutrients from these sources is brought about by physical, chemical and biological processes. But it is generally considered that soil microorganisms play the most important role in releasing nutrients.

- Soil contains a diversity of microorganisms fungi, bacteria, algae and viruses belonging to different genera and species. The relative proportions of different groups are influenced by the soil environment.

- Soil population in a fertile agricultural soil

Type	**Number per gram of soil**
Bacteria	2,500,000,000
Acitinomycetes	700,000
Fungi	400,000
Algae	50,000
Protozoa	30,000

- Chemical and physical environment of soil as a healthy medium for growth of microorganisms

- Soil provides an adequate physical and chemical environment for growth of microorganisms in terms of space and nutrients which include minerals, decomposing organic materials, water, gases such as CO_2, O_2 and N_2.

- The distribution of microorganisms vary with the depth of the soil. More micro organisms are found in surface layers than in deeper layers. Explain the reasons for such a distribution.

Depth (cm)	*Aerobic bacteria	Anaerobic bacteria	Actinomycetes	Fungi	Algae
3-8	7800	1950	2080	119	25
20-25	1800	379	245	50	5
35-40	472	98	49	14	0.5
65-75	10	1	5	6	0.1
135-145	1	0.4	-	3	-

* Organisms/ gram of soil x 10^3

- Role of microorganisms in cyclic process of minerals
- In decomposition of plant and animal material extracellular enzymes of bacteria and fungi break down complex organic material into simple inorganic materials (minerals) CO_2 and H_2O.
- This process is called mineralization and is the major process by which plant nutrients are made available.
- Decomposition

  (a) Helps to remove plant and animal debris from the earth's surface allowing other organisms to live

  (b) Recycle minerals which are found in limited quantities on the earth.
- Explain the role of microorganisms in the biochemical transformation of nitrogen and nitrogenous compounds in the nitrogen cycle of nature.
  - Proteolysis
  - Amino acid degradation (ammonification)
  - Nitrification
  - Denitrification
  - Nitrogen fixation

- Interactions of soil microorganisms relevant to plant growth
- Microorganisms are distributed freely in the soil and those associated with root surfaces/ root regions exert various effects on plant growth
- Microorganisms are involved in the formation of stable soil aggregates which are characteristic of good soil structure in fertile soils. Fungal filaments, Actinomycete filaments and polysaccharide gums/ slimes produced by bacteria are involved in soil aggregate formation
- Nitrogen fixation occurs both by symbiotic associations (*Rhizobium* and root nodules) and by non symbiotic organisms (free living bacteria & cyanobacteria)
- Mycorrhizal association of roots of higher plants and fungi affect plant growth accumulating soluble nutrients/ phosphates from soil and transferring them to plants
- Soil microorganisms produce plant growth substances, indole acetic acid, gibberellins, cytokinins
- Soil is also the major reservoir of plant pathogenic microorganisms, which affect and destroy crops.
- Root surfaces / root regions of plants contain dense populations of micro organisms. They are known as Rhizophere bacteria or Rhizobacteria. These bacteria live on various root secretions and many of these bacteria produce growth promoting substances, chemicals that inhibit the growth of plant pathogenic bacteria.

Competency 13.2.0 : **Utilizes the microbilogical concepts and principles to maintain the quality of drinking water and for solid waste management.**

Competency Level 13.2.1 : **Uses the microbial concepts and principles in drinking water & waste water management.**

Number of Periods : **05**

Learning Outcomes : The student should be able to,

- list the diseases transmitted by water
- describe the steps in water treatment in an urban water treatment plant
- explain the effects of discharging waste water into natural water resources
- describe the principles and main steps in purification of industrial waste water
- list out the legal limits in releasing waste water into water bodies according to Sri Lanka standards.

Suggested Learning-Teaching Process :

- Arrange a field trip to urban water treatment plant and industrial waste water plant
- Ask the students to make a report on principles and main steps in purification of;
  1. Urban water
  2. Industrial water

- As a group work ask the students to list the diseases transmitted by water
- Help them to make an attractive presentation
- Elaborate the subject content according to appropriate sequence

Guidelines

Microbiology of drinking water and waste water & solid waste

- Natural sources of drinking water & possible contamination methods.
- Drinking water of most communities and municipalities is obtained from wells, surface sources such as rivers, streams, lakes and that such natural water supplies are likely to be polluted with domestic and industrial wastes. Such wastes may carry pathogenic microorganisms.
- These pathogenic organisms enter the natural waters mainly through human and animal faeces and they may endanger health of consumers.
- The pathogenic organisms that are frequently transmitted through water are those which cause infections in the intestinal tract. E.g. Typhoid and paratyphoid bacteria, Cholera bacteria, Entero viruses, microorganisms causing dysentery.
- The quality of drinking water is ensured through routine testing procedures conducted in Municipal laboratories and laboratories of the water board. The quality is determined on the basis of the presence or absence of coli form bacteria which come through faecal contamination.
- **Steps in water treatment in an urban water treatment plant**
- This operation produces water which is of standard quality and safe for human consumption. There are three main steps. In addition, in some water

treatment plants, river water is allowed to cascade down several steps.This will allow aeration of water.

(a) Sedimentation

(b) Filtration

(c) Disinfection

(a) **Sedimentation –** occurs in large reservoirs where water remains for a holding period during which large particulate matter settles to the bottom. Sedimentation is enhanced by adding alum (Aluminum sulphate) which produces a sticky precipitate. Many microorganisms as well as finely suspended matter are removed in this manner.

(b) **Filtration –** this is done by sand and removes 99% of bacteria

(c) **Disinfection –** water is then disinfected using chlorine. The chlorine dosage must be sufficient to leave a residue of 0.2 – 2.0 mg/l of free chlorine in the water.

- The major concern about drinking water is related to the transmission of disease by pathogens (Typhoid, Cholera etc.) Therefore tests have been developed to determine the safety of water, in terms of its sanitary quality. It is not practical to look for pathogens like *Salmonella, Shigella* or *Vibrio* as during routine analysis because ,

(a) They are present in small numbers (unless there is an epidemic or outbreak of disease)

(b) Will be difficult to detect and also will take time

- Therefore water safety / sanitary quality is tested routinely using a particular indicator organism constantly present in human faeces, Coliform bacteria defined as aerobic or facultative anaerobic, gram negative, non-endospore forming, rod shaped bacteria, which ferment lactose to form gas within 48 hours.

- If coliforms are present it indicates the possibility of having other pathogenic organisms as well because water is contaminated by faecal matter.
- Standard tests for coliforms are being used

- **Waste water**
  - After water has been used in homes (domestic) or industry it becomes waste water.
  - This waste water contains large amounts of organic waste from food and other materials and includes carbohydrates, fats, proteins and micro organisms
  - Adverse effects of discharging large amount of waste water into natural water bodies.

    (a) Dissemination of pathogenic microorganisms

    (b) Water pollution due to accumulation of biodegradable material and their decomposition products

    (c) Decomposition which may consume large amounts of oxygen in water affecting aquatic organisms (high BOD – biological oxygen demand)

    (d) Anaerobic decomposition leading to bad smells
  - It is a legal requirement in most countries that such waste waters are properly treated to a required standard before being discharged into natural waters
  - Principles and main steps in purification of industrial waste water

- Primary treatment
  - Large floating materials screened out
  - Sand removed
  - Oil and grease removed
  - Solid matter settles out in sedimentation tanks
  - Sludge collected and removed (see page 331 in annex)
  - No biological activity is used here
  - Primary treatment removes 25-35% organic matter
- Secondary treatment
  - The liquid flowing out of primary treatment enters the secondary treatment stage
  - During this treatment waste water is aerated to facilitate growth of aerobic bacteria and rapid microbial oxidation. One of two systems used are, activated sludge and tricking filter.
  - In activated sludge vigorous aeration is done mechanically. In tricking filters waste water is slowly sprinkled or sprayed over a bed of rocky material and allowed to trickle. In this process micro organisms grow on the filter bed and oxidize organic matter.
  - In secondary treatment 75-95 % of organic material is oxidized.
  - The liquid flowing through these systems are then disinfected and allowed to flow into natural waters
  - Sludge remaining from both treatments is sent to an anaerobic sludge digester where anaerobic decomposition convert the organic material in the sludge finally to methane and CO_2 (biogas)
  - Digested sludge can be used as fertilizer

Competency 13.2.0 : **Utilizes the microbiological concepts and principles to maintain the quality of drinking water and for solid waste management.**

Competency Level 13.2.2 : **Explores the environmental and sanitary importance of recycling of solid waste matter**

Number of Periods : **02**

Learning Outcomes : The student should be able to;

- describe the nature of solid waste matter
- explain the environmental and hygienic importance in recycling solid waste matter
- describe the techniques used in managing solid waste

Suggested Learning-Teaching Process :

- Provide the hand outs, publications etc. published by central environmental authority
- Write a report based on solid waste matter, environmental and hygienic importance of cycling solid waste matter and the techniques used in managing solid waste
- Ask the students to make a presentation
- Make an elaboration according to appropriate sequence

Guidelines

- Solid waste matter
  - Nature of solid waste matter

- Waste material that are organic in nature, such as plant material, food scraps, paper products, polythene, glass are considered as solid waste.
- Food waste and plant material degrade rapidly.
- Whereas plastics, glasses and paper wastes do not.

* Environmental and hygienic importance in recycling solid waste matter
* Open dumping of solid waste create several environmental problems such as

  - It develops mosquito breeding grounds
  - Produce bad smell due to anaerobic decomposition of waste
  - Methane is a major product of anaerobic decomposition of waste; it is hazardous because it is explosive.
  - Spreading out of insects and rodents
  - Ground water can be contaminated

  Therefore solid waste should be well managed. There are several methods to minimize the problems created with solid waste.

  Separation and recycling

  In most countries all household organic waste such as kitchen scraps, plant cuttings, plastics, glass and papers are collected in separate containers. From these paper products and glass can be recycled for further use.

  Decomposition of organic matter

  Plant material, food scraps and paper products can be recycled using biological composting and digestion processes to decompose the organic matter. Resulting organic material is then recycled as compost for agricultural or landscaping purposes.

  In addition, waste gas from the process (such as methane) can be captured and used for generating electricity.

Sanitary land fills

Sanitary landfills are one of the most popular forms of waste disposal, primarily because they are the least expensive way to dispose of waste. More than four-fifths of municipal solid waste is disposed of in landfills.

A sanitary landfill is an engineered means of disposing of waste. In a sanitary landfill, waste is spread in layers on a piece of property, usually on marginal or sub marginal land. The objective is to spread the layers and then compact them tightly, greatly reducing the volume of the waste. The waste is then covered by soil.

A landfill should not be located in areas with high ground water levels.

Much of the waste in a sanitary landfill will decompose through biological and chemical processes that produce solid, liquid and gaseous products.

Competency 13.3.0 : **Explores the impact of microbes on food.**

Competency Level 13.3.1 : **Contributes to the prevention of diseases that are caused by spoiled food**

Number of Periods : **07**

Learning Outcomes : The student should be able to;

- explain the physical and chemical changes in food spoilage
- describe the effects of food spoilage on human health

Suggested Learning-Teaching Process :

- Provide them with some spoiled food items and ask the students to identify the physical changes
- Ask the students to gather information on the chemical and biological changes in the above spoiled food, factors affecting the food spoilage and food borne infections.
- Provide the opportunity to a presentation on food spoilage
- Make an elaboration according to the subject content

Guidelines

Microbiology of Food

- All food materials used for human consumption are of plant or animal origin.
- Explain that microorganisms inhabit nearly every niche on earth and food supply which are of plant or animal origin is no exception. Food have a natural micro biota and also get contaminated with microorganisms in nature during handling and processing
- Food materials contain nutrients, act as culture media for growth of micro organisms.

- Explain that food materials contain nutrients, the same nutrients are required for the growth of many microorganisms.
- Therefore, food serves as a culture medium such as nutrient broth. Numerous bacteria, yeast, molds will grow in this broth.
- Growth of microorganisms in food changes physical, chemical and biological structures of food making them unfit for consumption. (food spoilage)
- Microorganisms growing in food are heterotrophic bacteria and fungi. During this process they breakdown carbohydrates, proteins and fats to obtain energy and other requirements for their own growth.
- Various extra cellular enzymes, amylase, protease, lipase secreted by micro organisms participate in this process.
- As a result of this, major constituents of food undergo chemical and physical changes.
- Explain the chemical changes take place in food

Putrefaction

$$\text{Protein food} \xrightarrow[\text{Micro organisms}]{\text{Proteolytic}} \text{Amino acids + Amines + Ammonia + } H_2S$$

Fermentation

$$\text{Carbohydrate food} \xrightarrow[\text{Micro organisms}]{\text{Saccharolytic}} \text{Acid + Alcohol + Gases}$$

Rancidity

$$\text{Fatty food} \xrightarrow[\text{Micro organisms}]{\text{Lipolytic}} \text{Fatty acid + Glycerol}$$

- Explain the physical changes that may take place in food.

  Softening of food, pigmentation, ropiness, slime or gum formation (polysaccharide), toxin accumulation.
- In addition, food may contain large populations of active microorganisms which may be pathogenic
- All these make food unsuitable for human consumption
- Various external and internal factors in the food influence spoilage
- Explain how various external and internal factors in food influence spoilage.
- Any factor that influences growth and activity of microorganisms influences food spoilage
- **Internal factors** are those factors that are present in food itself. Explain the effect on following internal factors during spoilage
  - pH
  - moisture content
  - Nutrient content
  - Biological structure

- pH
    - ❖ Most microorganisms grow best at pH values around 7.0 (6.6 – 7.5) and very few grow below 4.0
    - ❖ In general molds, yeast can grow over a wide range of pH from very low – very high (pH 2 - 10)
    - ❖ Bacteria in general grow between pH 5 – 7
    - ❖ Fruits such as limes (pH 1.8 – 2.0), orange (pH3.6 – 4.3), banana (pH 4.5 – 4.7) are likely to be spoiled by molds and yeast
    - ❖ Most sea foods and meats, beef (pH 5.1 – 6.2), chicken (pH 6.2 – 6.4), fish (pH 6.6 – 6.8), milk (pH 6.3 – 6.5) are susceptible to bacterial, mold and yeast spoilage.
- Moisture content
    - ❖ Explain that drying which is the oldest method of preserving food is based on reducing moisture content
    - ❖ High moisture containing food such as meat, fish are spoiled by bacteria
    - ❖ Low moisture containing food such as biscuits, bread are spoiled by molds.
    - ❖ Dried milk powder, flour which contains very low moisture are not easily spoiled by bacteria or molds
    - ❖ Salt and sugar containing foods (available water is low) are generally spoiled by halophillic bacteria (salted foods), osmophillic and xerophillic molds/ yeast (sugary foods).
- Nutrient content
    - ❖ Water, source of energy, nitrogen, vitamins and minerals are essential nutrients for growth of microorganisms

- ❖ Nutrient rich food are easily spoiled by micro organisms

  E.g.; Milk, meat

- Biological structure

  - ❖ The natural covering of some foods protect the food against entry and damage by spoilage organisms

    E.g., outer covering of fruits, shell of egg.

- **External factors** are environmental factors that affect both food and micro organisms

  1.Temperature of storage
  2.Relative humidity of environment
  3.Presence and concentrations of gases in the environment, O_2 and CO_2

  - ❖ Explain that growth of microorganisms is affected by a wide range of temperatures, at low temperature growth is slow and spoilage is slow, at ambient temperature growth is high and spoilage is also high
  - ❖ However even at low temperature (E.g. 4^0C) microbial spoilage occurs by psychrophillic bacteria
  - ❖ Relative humidity (RH) of the storage environment is important because it relates to the availability of moisture which is an important factor for microbial growth spoilage
  - ❖ Low moisture containing food should not be stored in high RH environments because the food will pick moisture and microbial growth will occur.

❖ Food borne diseases

❖ Some microorganisms produce various toxic substances in food which cause food poisoning or food intoxication when consumed

❖ Illness may result from consuming food spoiled by microorganisms

- ❖ Microorganisms grow and multiply in food increasing the numbers of microbial cells, and also produce toxic chemical substances
- ❖ Ingestion of large numbers of microbial cells and their toxic chemicals by any one eating highly contaminated food, may develop disease
- ❖ These diseases/ illnesses are of two kinds

  (a) food borne infections

  (b) food intoxication

  - ❖ In food borne infections the contaminating microorganisms enters the body of the person eating spoiled food, and grow inside the host, multiplying in numbers and also produce toxins which cause symptoms of the characteristic disease

    E.g. *Salmonella typhi* - typhoid fever
    Shigella – dysentery
    Vibrio cholerae – cholera

  - ❖ In food intoxication, spoiled food already contains toxins which have been produced due to microbial growth. Any person who eats such contaminated food containing toxins will develop symptoms of the disease within a short time

    Food poisoning - *Staphylococcus aureus*
    Botulism – *Clostridium botulinum*

  - ❖ In general both types of illnesses are referred to as due to food poisoning

Competency 13.3.0 : **Explores the impact of microbes on food**

Competency Level 13.3.2 : **Utilizes the knowledge on food preservation for successful applications**

Number of Periods : **01**

Learning Outcomes : The student should be able to;

- explain the concept and importance of food preservation
- elaborate the principles of methods in preserving food

Suggested teaching learning process

- Ask the students to collect some different preserved food and by the observation to find out the methods of preservation
- Ask the students to find out the principles underlying these methods
- Facilitate them for a presentation

Make an elaboration on the subject content

Guidelines

- ❖ Preservation of food is an important aspect of everyday life
- ❖ Explain why it is necessary to preserve food
- ❖ Most kinds of food are readily decomposed by microorganisms unless special methods are used for preservation
- ❖ When food production exceeds the demand excess of food may be preserved
- ❖ Principles of methods of food preservation are based on the control of microbial growth & activity using aseptic techniques, heat, low temperature, dehydration, chemicals & radiation

❖ Explain the principles on which food preservation methods are based with suitable examples

  - Prevention of entry of microorganisms into food (aseptic)
  - Prevention of the growth and activity of microorganisms in food
  - Removal or killing of microorganisms in food

❖ Explain how the above principles are applied in the following methods of food preservation

Canning
Aseptic packaging
Drying
Salting
Salting and drying
Addition of sugar
Pasteurization
Smoking
Addition of chemicals
Radiation
Low temperature preservation

Unit 14 Applied Biology

Competency 14.1.0 : **Use biological concepts and principles to promote quality of living**

Competency Level 14.1.1 : **Investigates aquaculture systems to suggest actions for systematic maintenance**

Number of Periods : **08**

Learning Outcomes : The student should be able to;

- describe the methods of aquaculture
- explain the characteristic features of fish that could be cultured
- identifies different species of fish and prawns
- develop an interest in preparing an aquarium

Suggested Learning - Teaching Process:

- Field trips – to see an aquaculture farm and an aquarium
- Use relevant specimens, diagrams to highlight the external features of organisms that are cultured.
- Use audio visual aids as much as possible

Guidelines :

Aquaculture - Culture of young stages of aquatic organisms and obtain yields

❖ **Need of Aquaculture**

The teacher should explain the need for aquaculture considering the increase in human population and the limited food resources from aquatic environment. It should also be pointed out that fish is an important source of protein which can be obtained at a relatively low price through aquaculture, especially for the rural sector. In addition, the need of culture of aquatic plants and ornamental fish for recreational purposes and as foreign exchange earners should also be explained.

- ❖ **Species grown in Sri Lanka**
- Species of shrimps: *Penaeus monodon* (tiger prawn), *Penaeus indicus* (Indian white prawn)
- Species of food fish: *Oreochromis mossambicus* (Mossambique tilapia), *Oreochromis niloticus* (Nile tilapia), *Catla catla* (Catla), *Labeo rohita* (Rohu), *Cirrhinus mrigala* (Mrigal)
- Common aquatic plants: *Cabomba, Ceratophyllum, Vallisneria, Aponogeton, Hydrilla, Pistia*

Students should be able to identify these fish, shrimp and plant species using their external features

❖ **Methods of aquaculture**

- Main aquaculture systems: Intensive
  Semi intensive
  Extensive
- Compare these methods based on stocking density, supplementary feeding, water quality maintenance, harvesting method, yield etc.
- Teacher should explain the desirable features of culturable fish species
- The teacher should explain what monoculture and polyculture are. Advantages of polyculture over monoculture should also be explained. Suitable fish species combinations for polyculture should be given indicating the reasons.

❖ **Environmental Impacts of shrimp culture in Sri Lanka**

- The teacher should explain the environmental impacts of shrimp culture in Sri Lanka

❖ **Ornamental fish culture**

Common species that are used; Guppies, goldfish, carps, gouramies, sword tails, mollies, barbs (Cumings barb, Black ruby barb), angel fish

- Students should be able to identify these species using external features.

- **Maintenance of an aquarium**

  Following factors should be considered;

  Turbidity of water

  Presence of large aquatic plants

  Abundance of Plankton

  Water temperature

  Dissolved O_2 Content

  Salinity

  pH

  General Cleanliness

  Students should be encouraged to maintain an aquarium in their homes or in the school.

  Practical:

  Identification of fish, prawn and aquatic plant species used in aquaculture

Competency 14.1.0 : **Use biological concepts and principles to promote the quality of living**

Competency Level 14.1.2 : **Suggests solutions to overcome the damage caused by insect pests.**

Number of Periods : **08**

Learning Outcomes : The students should be able to;

- identify major insect pests of coconut and paddy
- describe the damage symptoms
- identify infected crop plants
- use appropriate controlling methods

Suggested Learning - Teaching Process:

- Field trips – Coconut Research Institute, Rice Research Institute
- Use of relevant specimens, diagrams to study the external features of the organisms and their damage
- Audiovisual aids

Guidelines for teaching:

- The teacher should explain what a pest is, paying attention to economic injury level and economic threshold level
- External morphological features, stages of the life cycle, nature of the damage, damage symptoms and control measures of the following coconut pests should be explained

    Red weevil

    Black beetle

    Coconut mite

Following description on Coconut mite (*Aceria guerreronis)* can be used in teaching

First reported in Sri Lanka in 1997 from Kalpitiya. At present distributed in many districts .

- **Morphological characteristics that can be used for identification**- minute, around 0.1-0.2 mm in size. It cannot be seen distinctly with the naked eye. they are elongate, wormlike and possess two pairs of legs. They are white and translucent.
- **Life cycle-** Life cycle includes egg, two nymph stages and the adult stage. Each female can lay approximately 30-50 eggs. Eggs are shiny white and globular in shape which hatch into protonymph stage in three days. The next stage is called nymph which subsequently molts into an adult. A coconut mite develops from egg to adult in 7 - 10 days.The protonymphs ,nymphs and adults cause damage. The dispersal of mite is primarily through wind.
- **Nature of damage and damage symptoms**
  - Symptoms could be observed on fruits (of any age).Mostly prevalent in fruits of around 3-7 months
  - Live as clusters under perianth and sucks juice. Therefore, fruit is damaged
  - Initially yellowish white, triangular shaped patches could be observed (below the perianth) which subsequently enlarge and turn brown.
  - Superficial layers of the husk dry and peel off.
  - Development of fruit is obstructed resulting in nuts becoming smaller in size, falling of nuts and deformities in shape. Severe damage to fruits results in shallow eruptions on fruits

- **Control methods**
  - Successful and long term control methods have not been discovered yet. Therefore, measures are taken to minimize the damage and control spreading of the mite

- Cutting and burning infested fruits
- Use suitable chemical methods-Application of burnt engine oil directly on the young fruits of bunches between 2-6 months of age .This can kill the mites on fruits
- Coconut Mite is mostly distributed by wind or through transportation of infested young fruits and raw husks. When harvesting some mites can be present on fruits. Therefore, fruits should be kept for about one month after plucking and then transported. This minimizes the spread of disease to other areas.

- External morphological features, stages of the life cycle, nature of the damage, damage symptoms and control measures of the following pests of paddy should be explained
    - Brown plant hopper
    - Paddy bug
    - Yellow stem borer
- Pest control Methods
    - Traditional Methods
    - Chemical Methods
    - Biological Method
- Integrated Pest Management

Practical:

Study of common insect pests of paddy and coconut in Sri Lanka

Competency 14.1.0	: **Uses biological concepts and principles to promote quality of living**
Competency Level 14.1.3	: **Uses the biological knowledge and understanding in minimizing the damage caused by parasites.**
Number of Periods	: **06**
Learning Outcomes	: The student should be able to; • identify the infective stages of malarial parasite, filarial parasite and hook worm and describe their life cycles. • describe the methods of transmission, symptoms of infection and controlling methods of these parasites.

Suggested Learning - TeachingProcess:

- Provide the students with pictures, photographs of life cycle stages of above parasites
- Allow the students to make presentations on methods of control of these parasites
- Make an elaboration to cover the subject content using audiovisual aids.

Guidelines for teaching:

- With the aid of suitable diagrams describe external morphology of adult stages and lifecycles of parasites and the methods of transmission.
    - Malarial parasite
    - Filarial parasite
    - Hook worm
- Discuss the controlling methods of the parasites using biological knowledge of their life cycles

Practical:

Observation of stages of life cycles and study of data on incidence and distribution of the following parasites in Sri Lanka: malarial parasite, filarial parasite & hook worm

Competency 14.1.0 : **Use biological concepts and principles to promote quality of living**

Competency Level 14.1.4 : **Uses the biological knowledge and understanding in controlling weeds**

Number of Periods : **02**

Learning Outcomes : The students should be able to;

- identify common weeds in her/his environment
- explain what are weeds
- elaborate the characteristic features of weeds
- describe the principles underlying the methods of weed control
- discuss the advantages and disadvantages of different weed control methods

Suggested Learning - Teaching Process:

- Provide the students with samples, pictures, photographs and web resources of weeds.
- Arrange a field trip to nearby estate or paddy field or vegetable garden to identify weeds.
- Ask the students to collect the sample of weeds
- Guide the students to identify weeds
- Ask the students to collect information on
  - The methods of weed control
  - The characteristic features of weeds
- Allow the students to make a presentation
- Make an elaboration to cover the subject content

Guidelines :

- **Weeds:**
  - Weed is a plant growing at a place where it is not desired.
  - Weeds can be described as plants that are competitive, persistent and pernicious and interfere with human activities and as a result it is undesirable.
  - These plants can be either native or exotic.
- Weeds compete with crop plants for nutrients, water, light and space
  - Competition between weeds and crops result in the yield. The quality of the harvested product is also reduced
- Explain the characteristics of weeds
  - Efficient resource usage such as water, light, CO_2 nutrients etc.
  - High vegetative growth. Ex *:Cyperus,Salvinia,Eichhornia* -stolons
  - Early maturation to a seed producing stage. Ex. *Parthenium, Eupatorium,* most paddy weeds
  - Abundant seed production. Ex: *Lantana, Eupatorium,Parthenium*
  - Ability to produce seeds under adverse conditions Ex: *Eupatorium, Parthenium*
  - Long term survival of buried seeds.Ex: *Eupatorium*
  - Efficient seed dispersal.,Ex: *Lantana, Eupatorium ,Cyperus iria, Vernonia*
  - High seed germination rate. Ex: *Lanatana, Eupatorium, Ageratum, Parthenium*
  - Allelopathy(in some)– ability to eliminate competition by producing toxins and preventing the growth of other plants. Ex*; Cyperus rotundus*

(Common names of these weeds should also be given wherever possible)

- Weed control
  - The suppression of a weed to the point that its economic impact is minimized
  - To control the weed, one should know
    - ❖ Information about weed

- ❖ Taxonomy and biogeography
- ❖ Pattern and rate of spread
- ❖ Impact assessment
- ❖ Ecological information
- ❖ Information on control

The methods of weed control can be classified into 4 groups. Discuss every method and mention the advantages and disadvantages of each method.

(1) Physical control method

- Physical removal or destruction of weed. In the paddy fields or vegetable beds weeds are removed by hands and in vast areas machines and apparatus can be used.
- Advantages
  - Removal of weeds completely for a long period.
  - Crop damage is less
  - Not needing professional skills
- Disadvantages
  - Time consuming
  - Labour intensive
  - Not successful for the plants with underground stems

(2) Chemical control method

- Applying weedicides which are chemicals capable of killing or inhibiting the growth of weed.
- Advantages
  - Effective method
  - Reasonable cost
- Disadvantages
  - Have to apply repeatedly to prevent the spread of weeds.
  - Unspecific weedicide may damage the crops too
  - Cause soil and water pollution

(3) Biological control method

- Use of natural enemies to reduce weed population

- Advantages
    - Provide long term control
    - Environment friendly
- Disadvantages
    - Have to select an organism which is host specific
    - Expensive
    - Take a long time period to select a suitable organism

(4) Cultural methods

- Cropping practices and environmental management methods
- Eg; suitable time of planting crops
- Method of planting crops
- Crop density
- Competitive cropping
- Crop rotation
- Stale seed bed
- Changing the crop/weed environment

- Advantage
    - Environmental friendly
- Disadvantage
    - Time consuming

Practical:

Study of different kinds of weeds in a selected area and separation into morpho species

Competency 14.1.0	:	**Use biological concepts and principles to promote the quality of living**
Competency Level 14.1.5	:	**Uses the biological knowledge and understanding to minimize the damage caused by microorganisms in plants**
Number of Periods	:	**02**
Learning Outcomes	:	The students should be able to; • list the plant diseases caused by micro-organisms • describe the preventive measures of those diseases • use the biological knowledge and understanding to minimize the damage caused by micro-organisms

Suggested Learning – Teaching Process :

- Provide the students with pictures of affected plants by wilt, mildew, rot, mosaic and blight.
- Ask the students to gather information about
  - Causative organisms
  - Symptoms
  - Prevention
  - Control methods
- Guide them to make a presentation
- Make an elaboration according to the appropriate sequence.

- **Guidelines:**
  - Plant diseases caused by microorganisms
    - Wilts
      - ❖ Caused by an interference with the normal movement of water within the plant (loss of turgour)

- ❖ Explain the symptoms of wilting
- ❖ Caused by bacteria/ fungi
- ❖ Bacterial wilts by, *Pseudomonas solanacearum* in tobacco.
- ❖ Fungi wilts caused *by Fusarium* species in tomato.

- Mildews
  - Caused by fungi

    Eg; Rubber mildew by *Oidium heavea*
  - Mildew is the development under humid conditions of a white or grey bloom on the leaf/ stem lesions owing to the production of sporangiophores
  - Indicate the common symptoms
- Rots
  - Causative organism is bacteria
  - *Erwinia carotovora* Invade the tissues of living plants and produce soft rot.
  - Indicate the common symptoms

Mosaics

- Causative organism is virus
  - Cause leaf spots or mottling & characterized by the production of yellowish spots or blotches and necrotic spots or blotches on the leaves & sometimes on the blossoms of plants.
  - Example ; in cucumber, plantain, tobacco, papaw

- Blights
  - Causative organism is Bacteria/ Fungi
  - Leaf blight of rice by *Xanthomonas oryzae (*bacteria)
  - Explain the symptoms

    Lleaf blight by *Rhizoctonia* in rice and *Phytophthora infestans* in potatoes

- Prevention of plant diseases caused by microorganisms.
  - Plant disease legislation which prohibits the introduction of plants or plant parts
  - Inspection of this material before it is distributed
  - Elimination of pathogens before planting
- Explain with suitable examples
- Control methods of plant diseases caused by micro organisms
- Explain the methods briefly.
  - Basically two methods
    1) Eradication
    2) Breeding resistant varieties
- Eradication – When the pathogen is established following steps can be taken to control
    1) Removal of diseased plant
    2) Elimination by cultural practices such as crop rotation, pruning, ploughing etc.
    3) Destruction of pathogens using antibiotics, fungicides etc.
- Breeding resistant varieties

Competency 14.1.0 : **Use biological concepts and principles to promote the quality of living**

Competency Level 14.1.6 : **Gets updated in applications of emerging technologies related to biology**

Number of Periods : **04**

Learning Outcomes : The students should be able to ;

- state the applications of nanotechnology in biology
- state what are stem cells are and list their sources
- state the outcomes and applications of human genome project
- state advantages of stem cell therapy and potential uses

Suggested Learning – Teaching Process:

- Ask the students to gather information about
  - Nanotechnology
  - Human Genome Project and
  - Stem cell therapy
- Guide them to make a presentation
- Make an elaboration according to the appropriate sequence.

Guidelines:

❖ **Stem cell therapy**

Stem cells are undifferentiated cells which can renew themselves by mitosis and are capable of differentiating into many kinds of tissue.

Stem cells are of two types embryonic stem cells and adult stem cells.

Embryonic stem cells are obtained from inner cell mass of blastocysts.

Adult stem cells are present in many tissues which can produce new cells and repair damages. Eg. blood, bone marrow, umbilical cord.

Stem cells can now be cultured in culture media *in-vitro* and can be transplanted in embryos or adult organisms to regenerate tissues.
There are ethical concerns of obtaining human embryonic stem cells..
When these cells are placed into a host/host embryo, interaction with the cells around them determine their further development.

- Applications:
    - Produce multiple clones in cattle breeding
    - Repair damaged heart muscles, damaged spinal neurons, treating of Parkinson's disease, diabetes in mice
    - Blood stem cells used to replenish bone marrow of cancer patients
- Advantages
    - Stem cells offer the possibility of replacing damaged or lost human tissues and gene therapy

❖ Introduction to the Human Genome Project

- An international project, to determine the entire sequence of nucleotides in the human genome and to map all the genes of human genome. Can help to diagnose and treat many genetic diseases such as cancer and diabetes etc

- This project originated in 1990 when a group of scientists formed the international Human Genome Sequencing consortium. The goal of this publicly funded effort was to use a clone-by-clone approach to sequence the human genome

- In 2004, the "Finished" sequence was published and announced as the reference sequence in the databases. This sequence now includes 99% of the euchromatic sequence, up from 95%. It has an error rate 1 per 100,000 bases.

- Significance
    - Research on the whole genome (including heterochromatin) can move ahead
    - Genes involved in genetic defects can be recognized
    - DNA sequences can be used as diagnostic tools of genetic defects
    - Some disease such as diabetes that result from defects in more than one gene can be addressed
    - Comparisons with other genomes are already changing our understanding of genome evolution

- **Applications**

- Improved diagnosis of disease
- Earlier detection of genetic predispositions to disease
- Designing of DNA based "custom drugs"
- Gene therapy and control systems for drugs
- Study of human evolution and anthropology

❖ Nanotechnology

Nanotechnology is a process which use minute particles which are measured in nanometres (1 nm=10^{-9}). Smaller particles have very high surface to volume ratio and therefore different physical and chemical properties than bigger particles. Richard Feyman (1959) , a Physicist enlightened the world on nanotechnology.

Nanotechnology can be applied for diagnosis, prevention and treatment in the medical field.

- For prevention
    - Antimicrobial coatings

Antibiotic lotions which acts against harmful microbes such as bacteria and fungi

- Sterilization of the theatres, hospitals and surgical equipment. (eg. Titanium oxide and silver are used to destroy the microbes and prevent the existence of biological fluids in theatres.) Silver nanolotions are also applied in theatres to prevent entry of microbes.
- Nanofilters- Nanoparticles such as silver, TiO_2 filters prevent the entrance of microbes as virus (used to examine SARS – Severe Acute Respiratory Syndrome - patients)

- Diagnosis
  - To measure the blood pressure, body temperature, pulse at home by using a device
- Treatment
  - Pain killers
  - Medicines for Asthma
  - Viva gel for HIV (Can prevent the entry of the virus)
  - Treatment of cancer
    Administration of Chemotherapy drugs by using nanorobots
  - Control diabetes – By a device which is attached to the body required dosage of insulin at required intervals can be released into the body
  - Nanoshells/needles
    A nanoshell is slightly bigger than a Polio virus. Medicines can be entered into these shells and injected into the body. Then these shells are grouped around the carcinogenic cells and by using I.R. the medicine can be dissolved and released towards the carcinogenic cell.
  - Biological robots

Can produce vitamins, hormones and enzymes in treatment of patients. In addition they can absorb toxic substances and turn them into non toxic

- Artificial bones

  Nanocomposites are used to replace broken bones and to fill teeth

SCHOOL BASED ASSESSMENT

Introduction- School Based Assessment

Learning –Teaching and Evaluation are three major components of the process of Education. It is a fact that teachers should know that evaluation is used to assess the progress of learning –teaching process. Moreover, teachers should know that these components influence mutually and develop each other .According to formative assessment (continuous assessment) fundamentals; it should be done while teaching or it is an ongoing process. Formative assessment can be done at the beginning, in the middle, at the end and at any instance of the learning teaching process.

Teachers who expect to assess the progress of learning of the students should use an organized plan. School Based Assessment (SBA) process is not a mere examination method or a testing method. This programme is known as the method of intervening to develop learning in students and teaching of teachers. Furthermore, this process can be used to maximize the student's capacities by identifying their strengths and weaknesses closely.

When implementing SBA programmes, students are directed to exploratory process through Learning Teaching activities and it is expected that teachers should be with the students facilitating, directing and observing the task they are engaged in.

At this juncture students should be assessed continuously and the teacher should confirm whether the skills of the students get developed up to expected level by assessing continuously. Learning teaching process should not only provide proper experiences to the students but also check whether the students have acquired them properly. For this, to happen proper guiding should be given.

Teachers who are engaged in evaluation/assessment would be able to supply guidance in two ways. They are commonly known as feed-back and feed- forward. Teacher's role should be providing Feedback to avoid learning difficulties when the students' weaknesses and inabilities are revealed and provide feed-forward when the abilities and the strengths are identified, to develop such strong skills of the students.

Student should be able to identify what objectives have achieved to which level, leads to success of the Learning Teaching process. Teachers are expected to judge the competency levels students have reached through evaluation and they should communicate information about student progress to parents and other relevant sectors. The best method that can be used to assess is the SBA that provides the opportunity to assess student continuously.

Teachers who have got the above objective in mind will use effective learning, teaching and evaluation methods to make the teaching process and learning process effective. Following are the types of evaluation tools student and, teachers can use. These types were introduced to teachers by the Department of Examinations and National Institute of Education with the new reforms. Therefore, we expect that the teachers in the system know about them well

Types of assessment tools:

1. Assignments	2. Projects
3. Survey	4. Exploration
5. Observation	6. Exhibitions
7. Field trips	8. Short written
9. Structured essays	10. Open book test
11. Creative activities	12. Listening Tests
13. Practical work	14. Speech
15. Self creation	16 Group work
17. Concept maps	18. Double entry journal
19. Wall papers	20. Quizzes
21. Question and answer book	22. Debates
23. Panel discussions	24. Seminars
25. Impromptu speeches	26. Role-plays

Teachers are not expected to use above mentioned activities for all the units and for all the subjects. Teachers should be able to pick and choose the suitable type for the relevant units and for the relevant subjects to assess the progress of the students appropriately. The types of assessment tools are mentioned in Teacher's Instructional Manuals.

If the teachers try to avoid administering the relevant assessment tools in their classes there will be lapses in exhibiting the growth of academic abilities, affective factors and psycho- motor skills in the students

Term 1

Evaluation Plan No.1

1.0 Evaluation : Term I - Evaluation Plan No. 1

2.0 Competency levels covered : 1.1.3.

3.0 Nature of Instrument : Report

4.0 Objectives :

1. To use scientific method in problem solving in their day to day life
2. To develop the observation skills of the students

5.0 Instructions for implementation:

1. Guide the students to select a suitable problem
2. Guide them to use scientific method to solve the problem

Evaluation Plan No.2

1.0 Evaluation : Term 1 - Evaluation Plan No. 2

2.0 Competency levels covered : 2.2.1

3.0 Nature of Instrument : Literature review

4.0 Objectives :

1. To collect information from reliable sources
2. To motivate the students to update their knowledge on microscopy
3. To use systematic ways to present information

5.0 Instructions for implementation:

1. Provide students with authentic resources on microscopic techniques
2. Direct students to present information using formal methods

Evaluation Plan No.3

1.0 Evaluation : Term I - Evaluation Plan No. 3

2.0 Competency levels covered : 2.1.3

3.0 Nature of Instrument : Practical Test

4.0 Objectives :

1. To upgrade the practical skills of students
2. To design experimental methodology on their own

5.0 Instructions for implementation

For teacher:

1. Provide students with different food samples and allow them to find the presence / absence of reducing sugars, non reducing sugars, starch, proteins and lipids

Evaluation Plan No.4

1.0 Evaluation : Term I- Evaluation Plan No. 4

2.0 Competency level : 2.2.3, 2.2.4

3.0 Nature of instrument : Preparation of port folio

4.0 Objectives :

1. To induce the students to collect arrange and store data in a systematic way
2. To develop presentation skills
3. To motivate towards further study of cells and tissues

5.0 Instructions for implementation

: 1) Guide the students to gather relevant information in a logical and formal manner providing relevant sources.

2) Direct students to elaborate on the study of cells and tissues.

Evaluation Plan No.5

1.0	Evaluation	:	Term I- Evaluation Plan No. 5
2.0	Competency levels covered	:	2.2.1, 2.2.2,2.2.3,2.4.3
3.0	Nature of instrument	:	Panel discussion
4.0	Objectives	:	1. To motivate students towards exploring about energy relationships 2. To enhance the ability of sharing knowledge through discussions

5.0 Instructions for implementation

1) Guide the students to inquire on the energy relations that occur in nature providing relevant sources .
2) Guide the students to present energy relations in a variety of illustration techniques.

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Term 2

Evaluation Plan No.1

1.0	Evaluation	:	Term 2 - Evaluation Plan No. 1
2.0	Competency levels covered	:	3.1.6 – 3.1.8
3.0	Nature of instrument	:	Preparation of a field note book
4.0	Objectives	:	1. To use external features to identify organisms 2. To develop scientific drawing skills 3. To classify organisms according to their external characteristic features

5.0 Instructions for implementation

1) Allow students to collect information individually or as a group

2) Field visits can be organized by the school to facilitate this activity

Evaluation Plan No.2

1.0	Evaluation	:	Term 2 - Evaluation Plan No.2
2.0	Competency Levels Covered	:	3.1.6, 3.1.7 & 3.1.8
3.0	Nature of instrument	:	Spot test
4.0	Objectives	:	1. To motivate to find out more about diversity of organisms within kingdom Animalia 2. To develop the skills to identify organisms by using external features

5.0 Instructions for implementation

1) Prepare the questions according to the number of students in the class.
2) Arrange tables with the specimens for each question
3) Instruct students to take the places one by one & answer each question within a minute
4) Ensure that all the students have answered all the questions.

Evaluation Plan No.3

1.0 Evaluation : Term 2 - Evaluation Plan No.3

2.0 Competency levels covered: 4.1.0, 5.1.0, 6.1.0, 7.1.0

3.0 Nature of instrument : Assignment

4.0 Objectives :

1. To develop creative skills
2. To increase the curiosity of the functions of each system
3. To motivate towards collaborative work

Evaluation Plan No.4

1.0 Evaluation : Term 2 - Evaluation Plan No.4

2.0 Competency levels covered : 6.1.1, 6.1.2, 6.1.3,6.1.4,6.1.5,6.1.7

3.0 Nature of instrument : Exhibition

4.0 Objectives :

1. To develop the creative skills
2. To enhance observation and analytical skills
3. To motivate towards collaborative work
4. To develop presentation skills

5.0 Instructions for implementation

1) Allocate topics to groups of students in a suitable way

2) Make the students prepare exhibits on relevant themes

3) Make arrangements to hold the exhibition on an appropriate date.

Evaluation Plan No. 5

1.0	Evaluation	:	Term 2 - Evaluation Plan No.5
2.0	Competency levels covered	:	4.1.2, 5.1.1, 7.1.1, 7.1.2
3.0	Nature of instrument	:	Impromptu speech
4.0	Objectives	:	1. To test the ability of preparedness on relevant subject content 2. To develop the ability of expressing ideas exactly to the point

5.0 Instructions for implementation

1) Prepare a number of themes which cover the content
2) Make lots on each theme
3) Ask each student to take one out of the lot and make an impromptu speech.

Term 3

Evaluation Plan No.1

1.0	Evaluation	:	Term 3 - Evaluation Plan No.1
2.0	Competency levels covered	:	7.1.4, 7.1.5, 7.1.6, 7.1.7, 7.1.9
3.0	Nature of instrument	:	Quiz program
4.0	Objectives	:	1. To evaluate the knowledge on selected subject content 2. To enhance the ability of constructing appropriate verbal answers to a given problem

Evaluation Plan No.2

1.0	Evaluation	:	Term 3 - Evaluation Plan No.2
2.0	Competency levels covered	:	4.1.3, 5.1.2, 8.1.3, 9.1.3
3.0	Nature of instrument	:	Seminars (in groups)
4.0	Objectives	:	1. To motivate students to disseminate information regarding disorders of digestive, respiratory, excretory and skeletal systems to the society 2. To inculcate attitudes regarding preventive measures of disorders 3. To develop the skill of correct usage of audio visual aids

Evaluation Plan No. 3

1.0	Evaluation	:	Term 3 - Evaluation Plan No.3
2.0	Competency levels covered	:	7.1.8
3.0	Nature of instrument	:	Open book test
4.0	Objectives	:	1. To motivate students to find information on endocrine glands 2. To enhance the ability of extracting information from suitable sources

Evaluation Plan No.4

1.0	Evaluation	:	Term 3 - Evaluation Plan No.4
2.0	Competency levels covered	:	All the competency levels for the third term
3.0	Nature of instrument	:	short questions and structured essay questions
4.0	Objectives	:	1. To evaluate the knowledge on coordination, homeostasis, excretion, support & movement 2. To develop the ability of constructing an appropriate written answer to a given question

Evaluation Plan No.5

1.0	Evaluation	:	Term 3 - Evaluation Plan No.5
2.0	Competency levels covered	:	7.1.6, 7.1.7, 7.1.10
3.0	Nature of instrument	:	Exhibition
4.0	Objectives	:	

1. To motivate students to explore about sensory organs/structures
2. To develop the skill of handling different material to make models
3. To develop presentation skills
4. To kindle creative thinking

Grade 13

Term 1

Evaluation Plan No.1

1.0	Evaluation	:	Term 1 - Evaluation Plan No.1
2.0	Competency levels covered	:	10.1.1,10.1.2,10.1.3,10.1.4
3.0	Nature of instrument	:	Quizz program
4.0	Objectives	:	1. To evaluate the knowledge on selected subject content 2. To enhance the ability of constructing appropriate verbal answers to a given problem

Evaluation Plan No.2

1.0	Evaluation	:	Term 1 - Evaluation Plan No.2
2.0	Competency levels covered	:	10.1.5,10.1.6, 10.1.7
3.0	Nature of instrument	:	Seminars (in groups)
4.0	Objectives	:	1. To motivate students to disseminate information regarding reproductive health 2. To inculcate attitudes regarding preventive measures of disorders 3. To develop the skill of correct usage of audio visual aids 4. Direct students to present information using formal methods

Evaluation Plan No.3

1.0 Evaluation : Term I - Evaluation Plan No. 3

2.0 Competency levels covered : 10.1.8,10.1.9,10.1.10,10.1.11,10.1.12

3.0 Nature of Instrument : Open book Test

4.0 Objectives :

1. To motivate students to find information on reproduction of plants
2. To enhance the ability of extracting information from reliable sources

Evaluation Plan No.4

1.0 Evaluation : Term I- Evaluation Plan No. 4

2.0 Competency level : 2.2.3, 2.2.4

3.0 Nature of instrument : Assignment

4.0 Objectives :

1. To develop creative skills
2. To increase curiosity on Genetics

Evaluation Plan No.5

1.0 Evaluation : Term I- Evaluation Plan No. 5

2.0 Competency levels covered : 11.1.1,11.1.2,11.1.3,11.1.4

3.0 Nature of instrument : Panel discussion

4.0 Objectives :

1. To motivate students towards Mendalian genetics and molecular basis of genetics
2. To enhance the ability of sharing knowledge through discussions

5.0 Instructions for implementation

For Teacher :

1) Guide the students to inquire on Mendalian genetics and molecular basis of genetics
2) Guide the students to present the specified content in a variety of illustration techniques

Term 2

Evaluation Plan No.1

1.0 Evaluation : Term 2 - Evaluation Plan No. 1

2.0 Competency levels covered : 11.2.2

3.0 Nature of instrument : Debate

4.0 Objectives :

1. To identify social issues regarding genetically modified organisms
2. To explore current situation regarding genetically modified organisms in Sri Lanka
3. To classify organisms according to their external characteristic features

5.0 Instructions for implementation

For Teacher : 1) Allocate topics to students in a suitable way

2)Allow sufficient time for collecting information

Evaluation Plan No.2

1.0 Evaluation : Term 2 - Evaluation Plan No.2

2.0 Competency Levels covered : 12.1.4, 12.1.5

3.0 Nature of instrument : Field note book

4.0 Objectives :

1. To explore characteristics of ecosystems in Sri Lanka
2. To motivate towards conserving natural resources

5.0 Instructions for implementation

For Teacher : 1) Field visits should be organized by the school to facilitate this activity

2) Allow students to collect information individually or as a group

Evaluation Plan No.3

1.0 Evaluation : Term 2 - Evaluation Plan No.3

2.0 Competency levels covered : 12.1.5,12.1.8

3.0 Nature of instrument : Assignment

4.0 Objectives :

1. To motivate towards conserving biodiversity
2. To motivate towards collaborative work
3. To collect information from reliable sources

Evaluation Plan No.4

1.0 Evaluation : Term 2 - Evaluation Plan No.4

2.0 Competency levels covered : 12.1.1,12.1.2,12.1.3

3.0 Nature of instrument : Impromptu speech

4.0 Objectives :

1. To test the ability of preparedness on relevant subject content
2. To develop the ability of expressing ideas exactly to the point

5.0 Instructions for implementation

For Teacher :

1. Prepare a number of themes which cover the content
2. Make lots on each theme
3. Ask each student to take one out of the lot and make an impromptu speech.

Evaluation Plan No. 5

1.0 Evaluation : Term 2 - Evaluation Plan No.5

2.0 Competency levels covered : 13.1.2

3.0 Nature of instrument : Practical Test

4.0 Objectives :

1. To upgrade practical skills of students
2. To practice different techniques used in sterilization of different substances/material
3. To highlight the importance of maintaining aseptic conditions in sterilization

5.0 Instructions for implementation

For Teacher :

1. Provide students with required material/equipment
2. Allow individual/group work depending on available resources

Term 3

Evaluation Plan No.1

1.0 Evaluation : Term 3 - Evaluation Plan No.1

2.0 Competency levels covered : 13.1.5, 13.3.2, 13.1.6

3.0 Nature of instrument : Literature Review

4.0 Objectives :

1. To collect information from reliable sources
2. To update knowledge on use of microorganisms on industry and agriculture

5.0 Instructions for implementation

For Teacher : 1. Provide students with authentic resources on microscopic techniques

2. Direct students to present information using formal methods

Evaluation Plan No.2

1.0 Evaluation : Term 3 - Evaluation Plan No.2

2.0 Competency levels covered : 14.1.1

3.0 Nature of instrument : Spot Test

4.0 Objectives :

1. To enable students to identify fish and prawn species used in aquaculture
2. To develop skills to identify organisms using external features

6.0 Instructions for implementation

For Teacher : 1) Prepare the questions according to the number of students in the class.

2) Arrange tables with the specimens for each question
3) Instruct students to take the places one by one & answer each question within a minute
4) Ensure that all the students have answered all the questions.

Evaluation Plan No. 3

1.0 Evaluation : Term 3 - Evaluation Plan No.3

2.0 Competency levels covered : 14.1.4

3.0 Nature of instrument : Preparation of a field note book

4.0 Objectives :

1. To use external features to identify organisms
2. To develop scientific drawing skills

5.0 Instructions for implementation

For Teacher : 1) Allow students to collect information individually or as a group

2) Field visits can be organized by the school to facilitate this activity

Evaluation Plan No.4

1.0 Evaluation : Term 3 - Evaluation Plan No.4

2.0 Competency levels covered : 13.2.1, 13.1.3,13.1.4,14.1.5,14.1.6

3.0 Nature of instrument : Quiz Program

4.0 Objectives :

1. To evaluate the knowledge on selected subject content
2. To enhance the ability of constructing appropriate verbal answers to a given problem

Evaluation Plan No.5

1.0 Evaluation : Term 3 - Evaluation Plan No.5

2.0 Competency levels covered : All the competency levels for the third term

3.0 Nature of instrument : Short questions and structure essay questions.

4.0 Objectives : 1. To evaluate knowledge on Microbiology and Applied Biology.
2. To develop ability of constructing an appropriate answer to a written question.

ANNEX

Essential Nutrients in Plants

Element	Principal Form in Which Element is Absorbed	Examples of Important Functions
Macronutrients		
C	CO_2	Major component of organic molecules
O	O_2, H_2O	Major component of organic molecules
H	H_2O	Major component of organic molecules
N	NO_3^-, NH_4^+	Component of amino acids, proteins, nucleotides, nucleic acids, chlorophyll, coenzymes, enzymes
K	K^+	Protein synthesis, operation of stomata
Ca	Ca^{2+}	Component of cell walls, maintenance of membrane structure and permeability , activates some enzymes.
Mg	Mg^{++}	Component of chlorophyll molecule, activates many enzymes.
P	$H_2PO_4^-$, HPO_4^{--}	Component of ADP and ATP, nucleic acids, phospholipids, several coenzymes
S	SO_4^{--}	Components of some amino acids and proteins, coenzyme – A
Micronutrients		
Cl	Cl^-	Osmosis and ionic balance
Fe	Fe^{++}, Fe^{+++}	Chlorophyll synthesis, cytochromes. nitrogenase
Mn	Mn^{++}	Activator of certain enzymes
Zn	Zn^{++}	Activator of many enzymes & activate formation of Chlorophyll
B	BO_3^- or $B_4O_7^{--}$	Possibly involved in Carbohydrate transport , nucleic acid synthesis.
Cu	Cu^{2+}	Activator or component of certain enzymes
Mo	MoO_4^{--}	Nitrogen fixation nitrate reduction

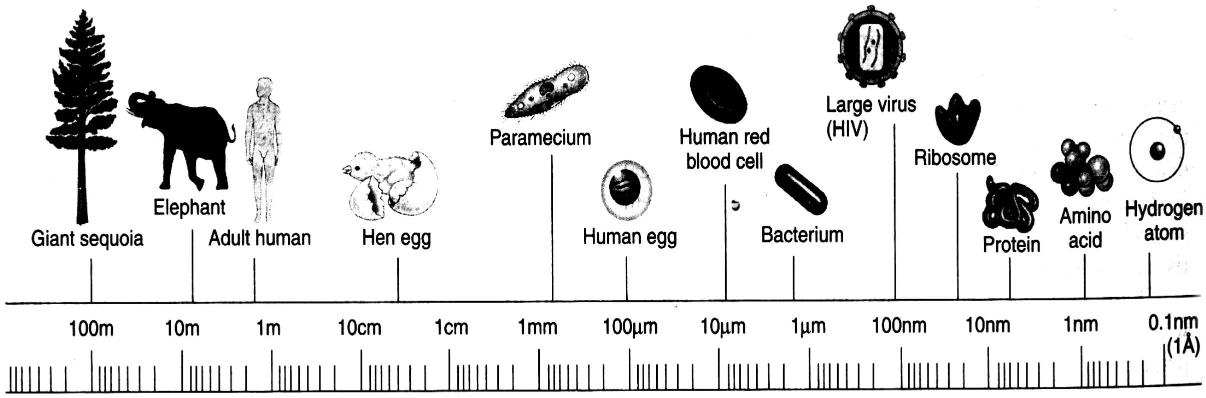
Characteristics of the Eukaryotic Kingdoms

	Protista	Plantae	Fungi	Animalia
Cell type	Eukaryotic	Eukaryotic	Eukaryotic	Eukaryotic
Nuclear Envelope	Present	Present	Present	Present
Transcription and Translation	Occur in different compartments	Occur in different compartments	Occur in different compartments	Occur in different compartments
Histone proteins associated with DNA	Present	Present	Present	Present
Cytoskeleton	Present	Present	Present	Present
Mitochondria	Present in some	Present	Present	Present
Chloroplasts	Present (some forms)	Present	Absent	Absent
Cell wall	Present in some forms , various types	Cellulose and other polysaccharides	Chitin and other noncellulose polysaccharides	Absent
Means of genetic recombination if present	Fertilization and meiosis	Fertilization and meiosis	Fertilization and meiosis	Fertilization and meiosis
Mode of Nutrition	Photosynthetic or heterotrophic or combination of both	Photosynthetic, chlorophyll *a* & *b*	Absorption	Ingestion
Motility	9+2 cilia and flagella; amoeboid, contractile fibrils	None in most forms; 9+2 cilia and flagella in gametes of some forms	Both motile and nonmotile	9+2 cilia and flagella, contractile fibrils
Multicellularity	Absent in most forms	Present in all forms	Present in most forms	Present in all forms
Nervous system	Primitive mechanisms for conducting stimuli in some forms	A few have primitive mechanisms for couducting stimuli	None	Present (except sponges), often complex

Features of the Domains of Life

Feature	Archaea	Bacteria	Eukarya
Amino acid that initiates protein synthesis	Methionine	Formyl - methionine	Methionine
Membrane bounded organells	Absent	Absent	Present
Membrane lipid structure	Branched	Unbranched	Unbranched
Nuclear envelope	Absent	Absent	Present
Number of different RNA polymerases	Several	One	Several
Peptidoglycan in cell wall	Absent	Present	Absent
Response to the antibiotics Streptomycin & Chloramphenicol	Growth not inhibited	Growth inhibited	Growth not inhibited

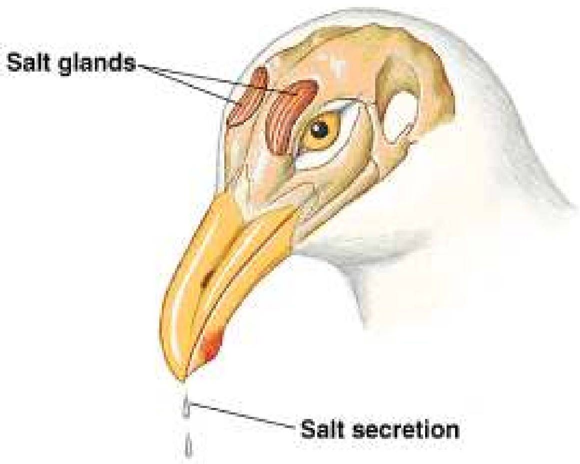
Size of cells



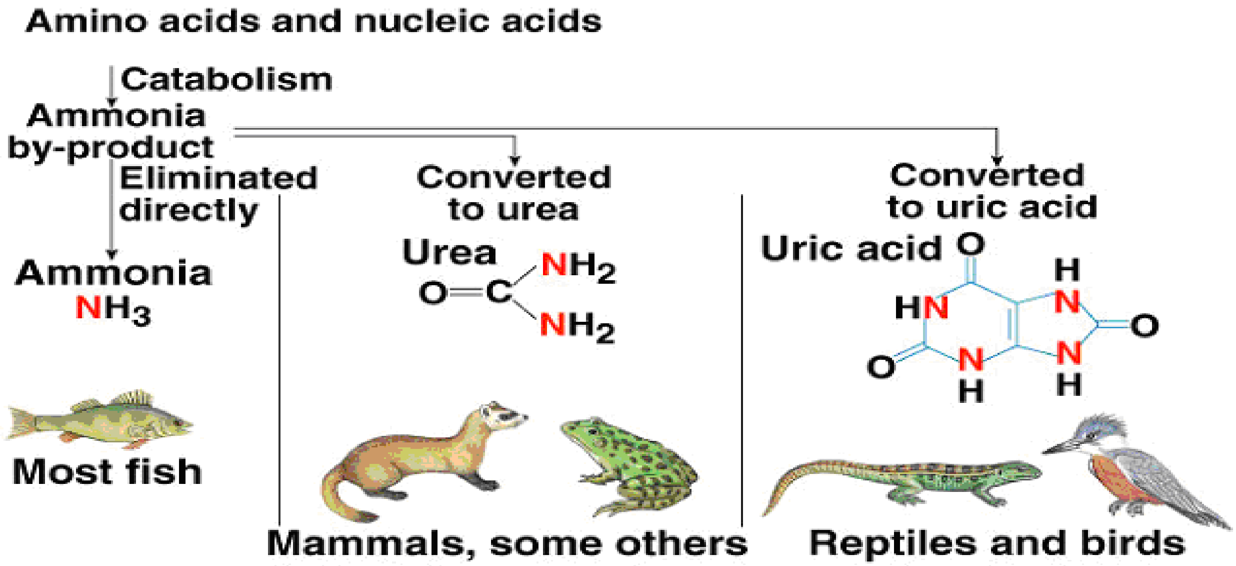
ELECTRON MICROSCOPE

HUMAN EYE

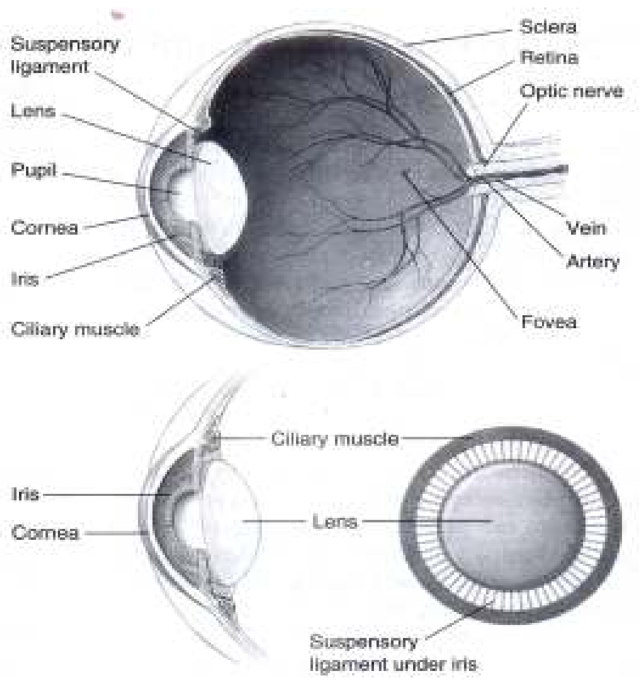
LIGHT MICROSCOPE



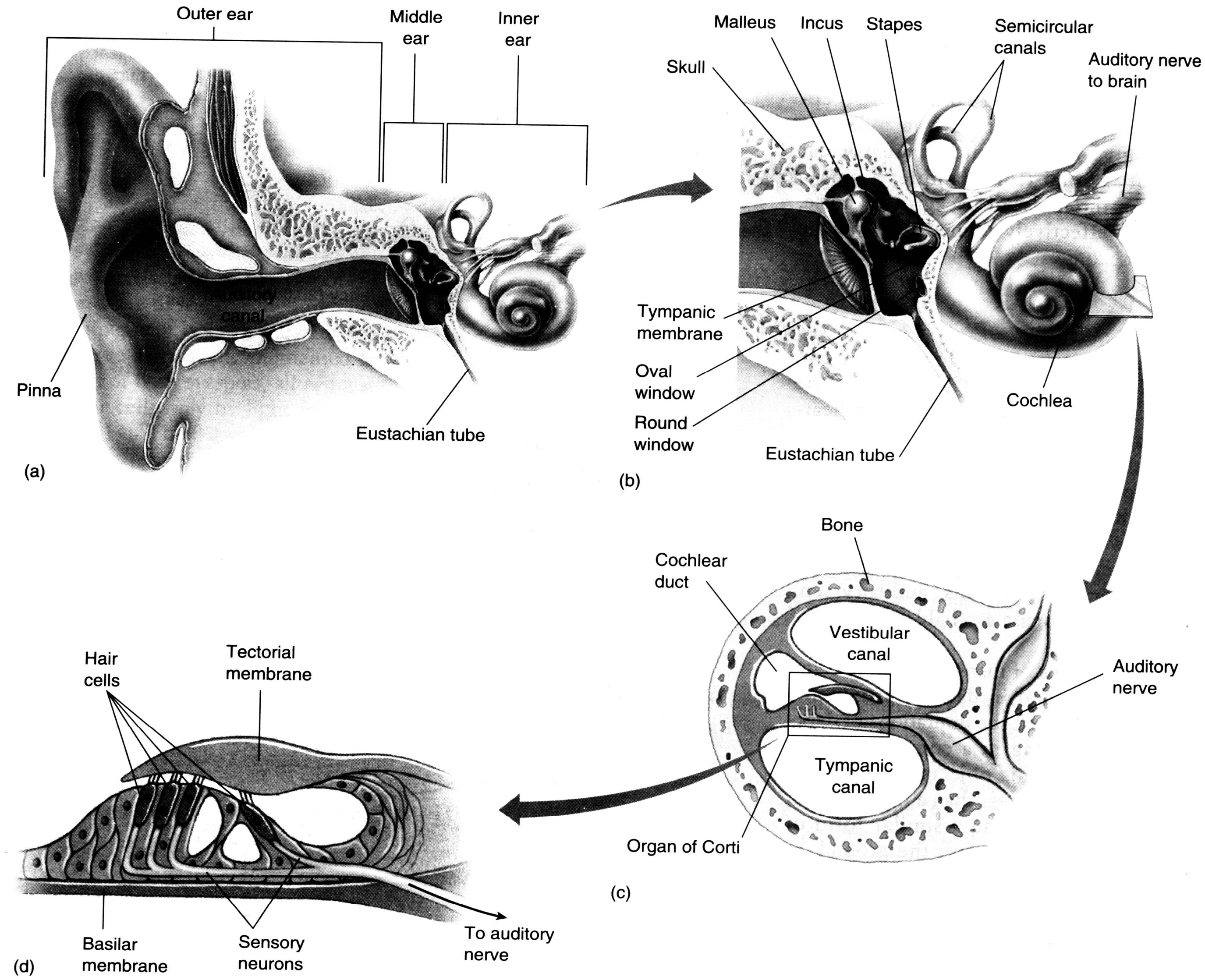
Salt glands



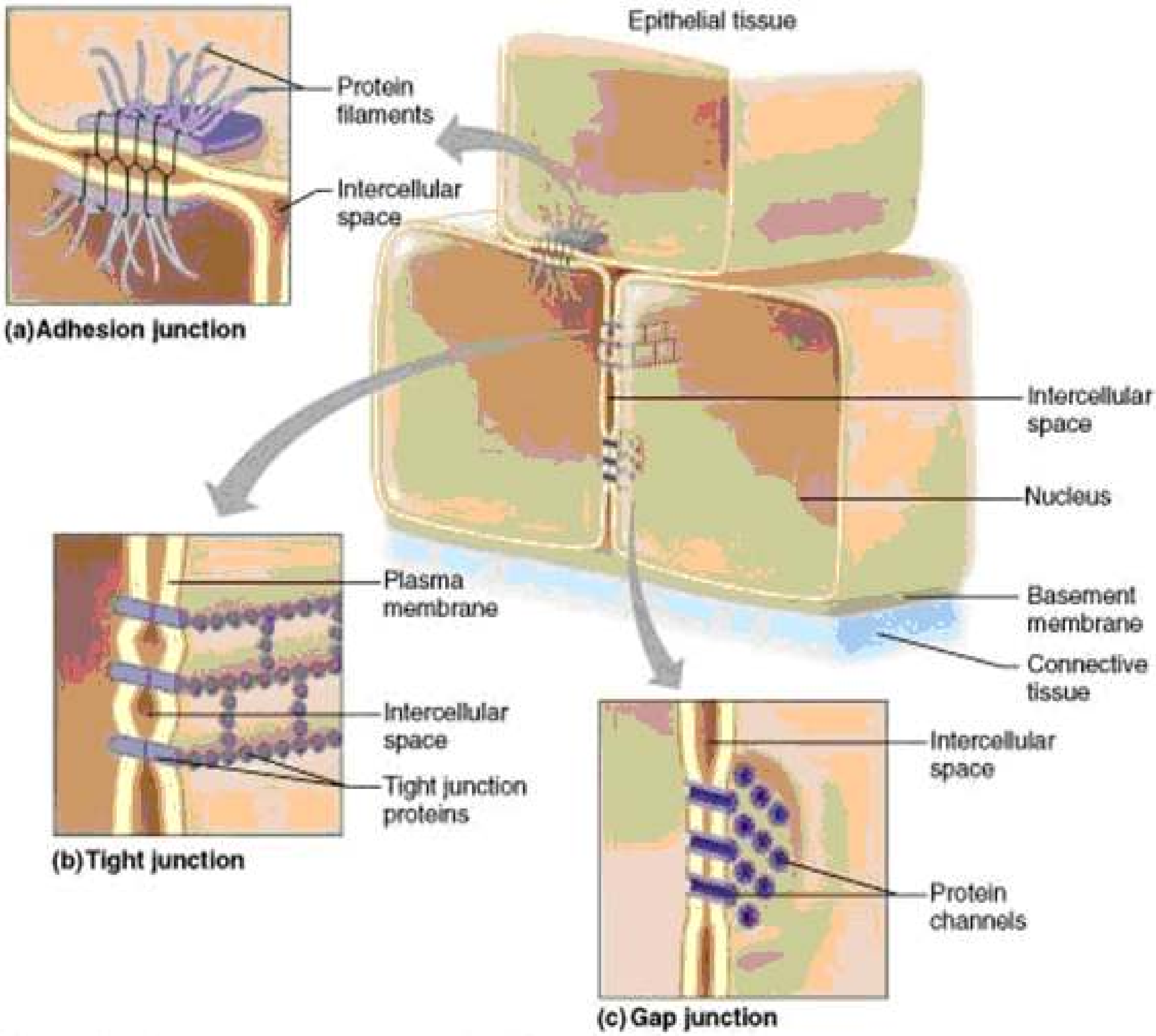
Nitrogenous wastes



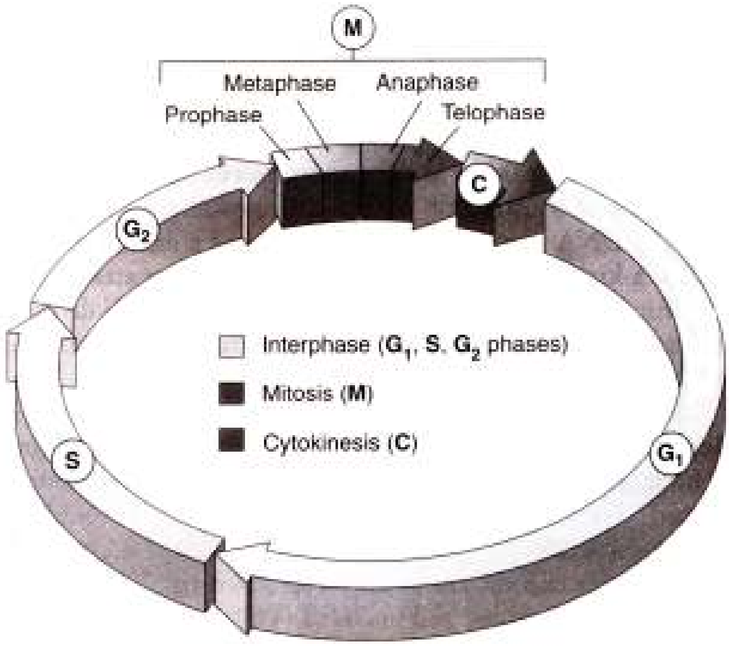
Structure of human eye



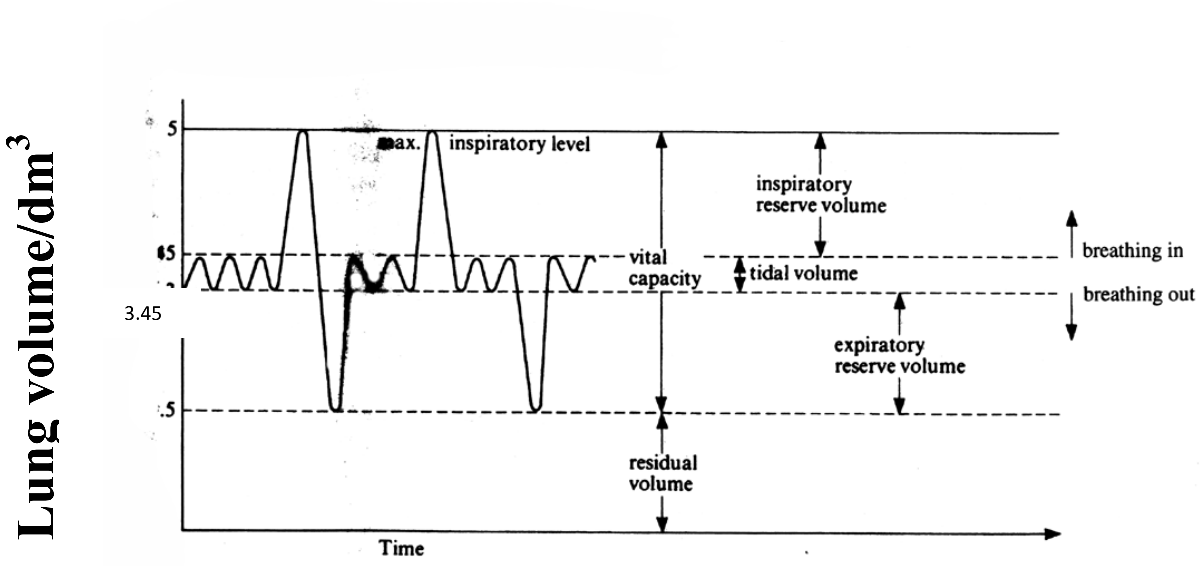
Structure of human ear



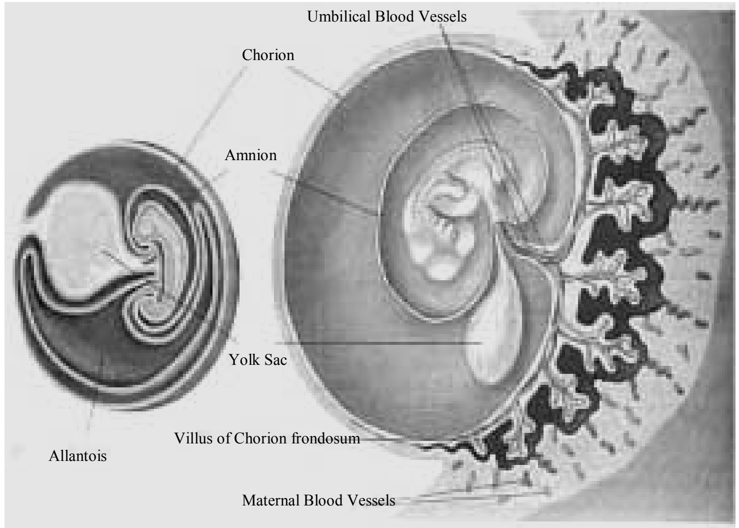
Cell Junctions



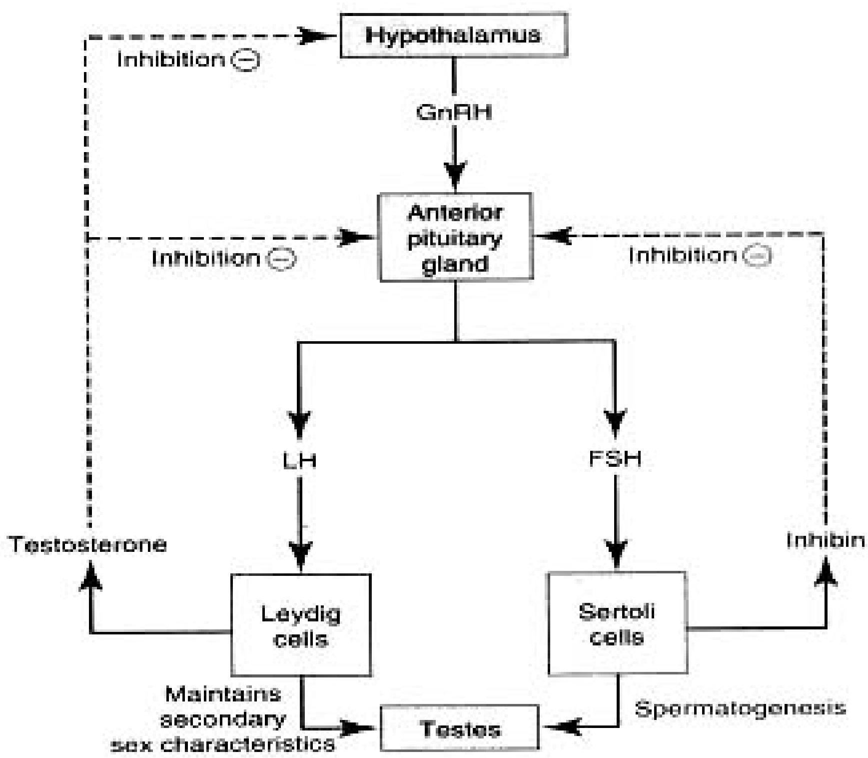
Cell Cycle



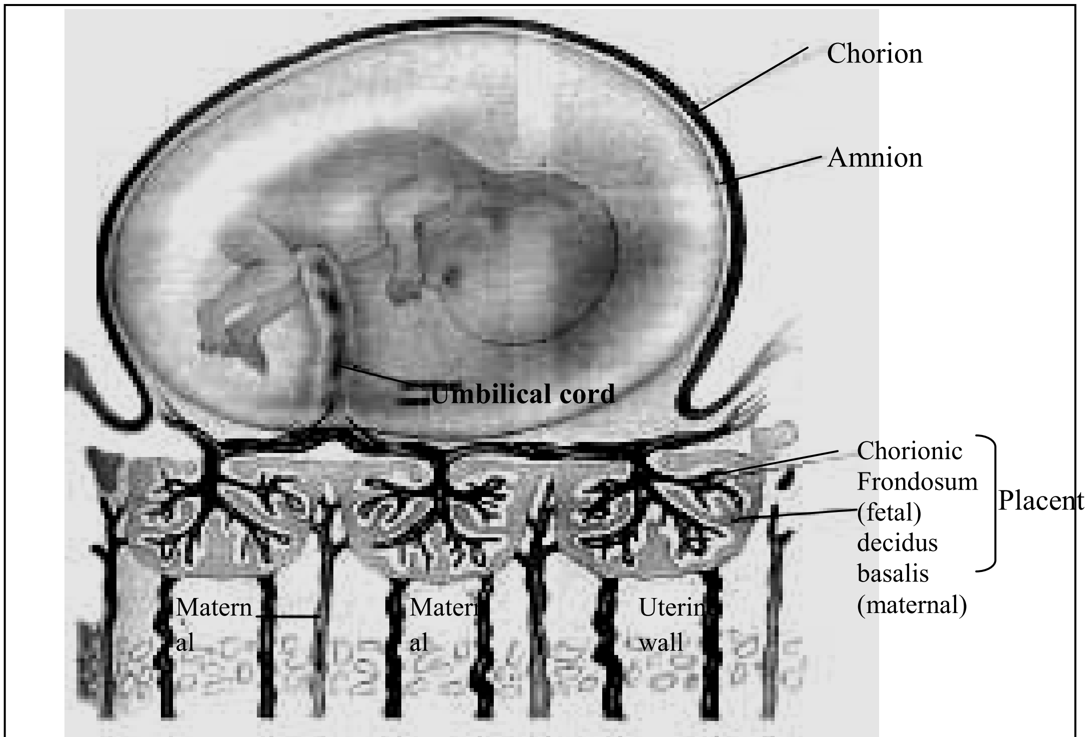
Lung volumes and lung capacities



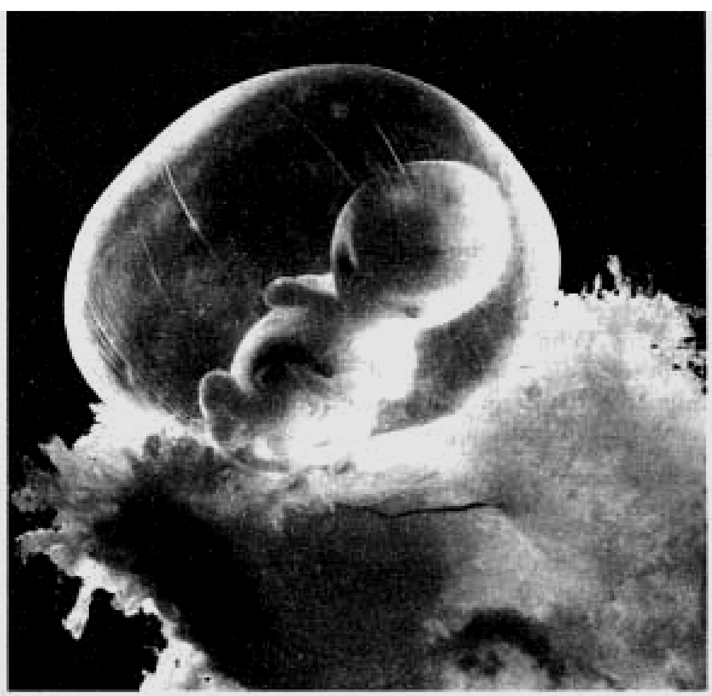
The extra embryonic membrances



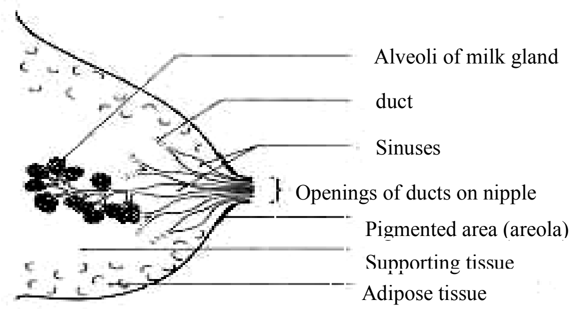
Hormonal interactions between the tests and anterior pituitary. LH stimulates the Leydig cells to secrete testosterone and FSH stimulates the Sertoli cells of the seminiferous tubules to secrete inhibin. Testesterone and inhibin. in turn , exert negative feedback inhibition on the secretion of LH and FSH respectively.



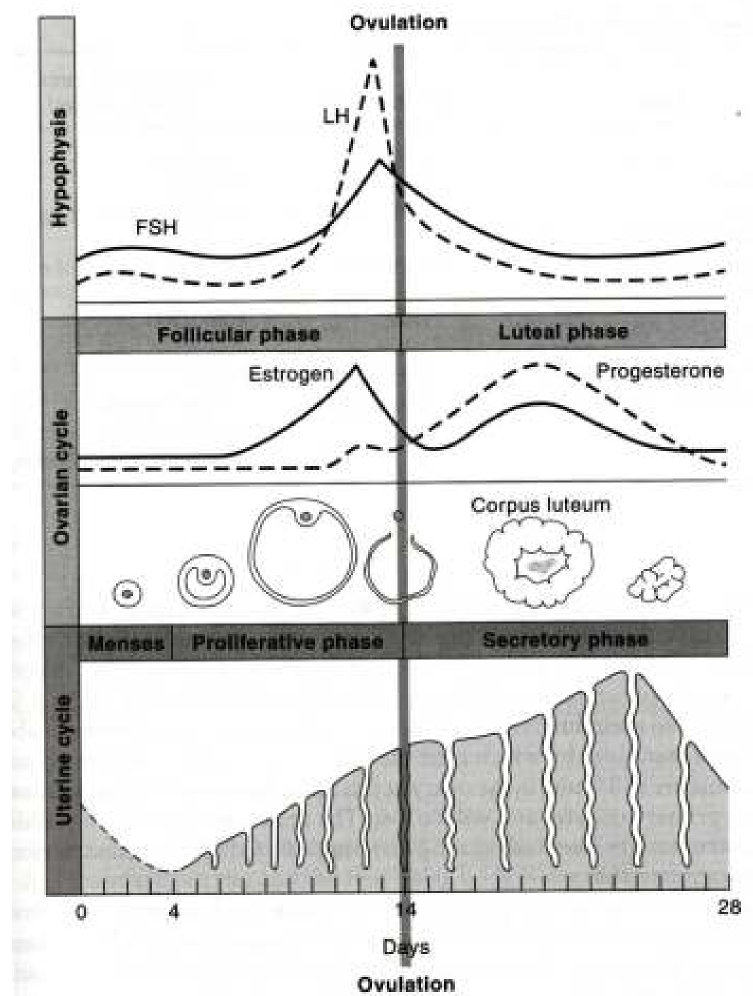
Structure of Placenta



Placenta and embryo at seven weeks.



The human female breast showing the milk glands where milk is secreted and the ducts and sinuses carrying milk to the nipple



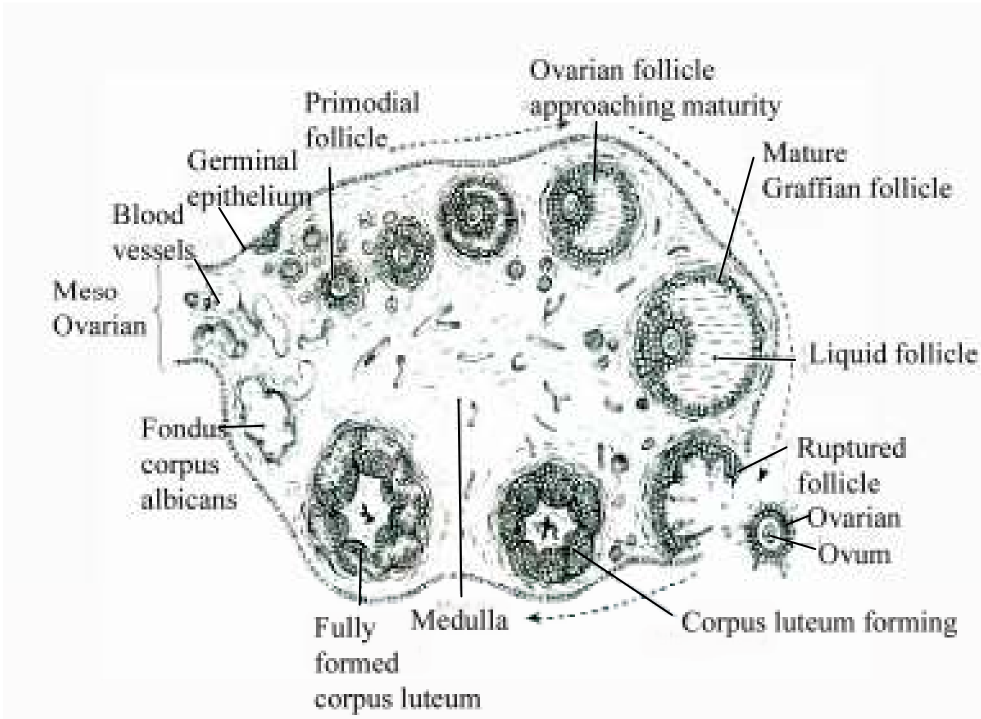
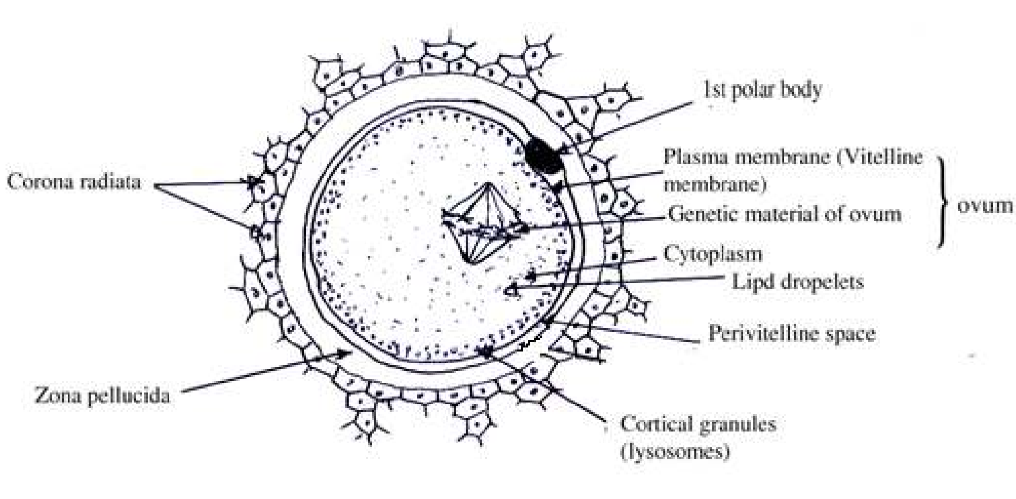


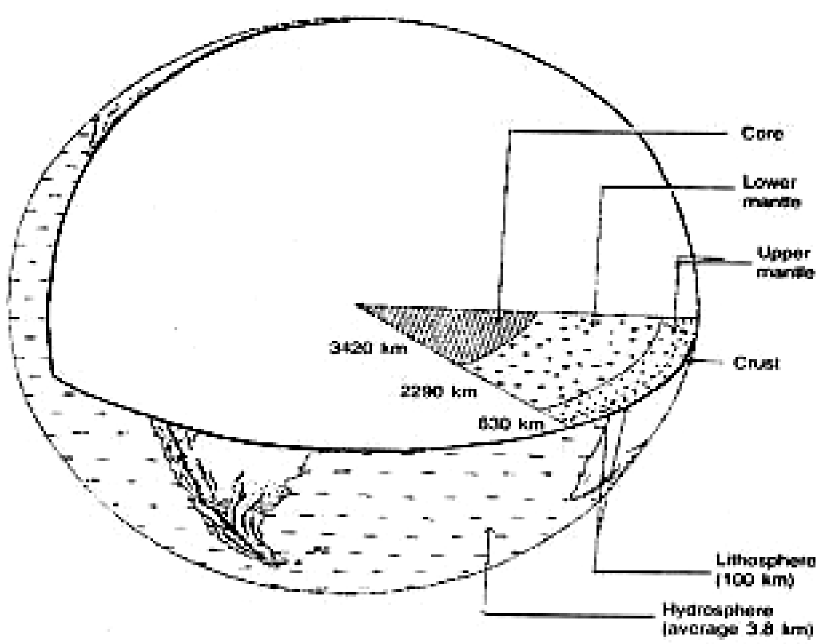
Diagram of a section of an ovary showing the stages of development of one ovarian follicle



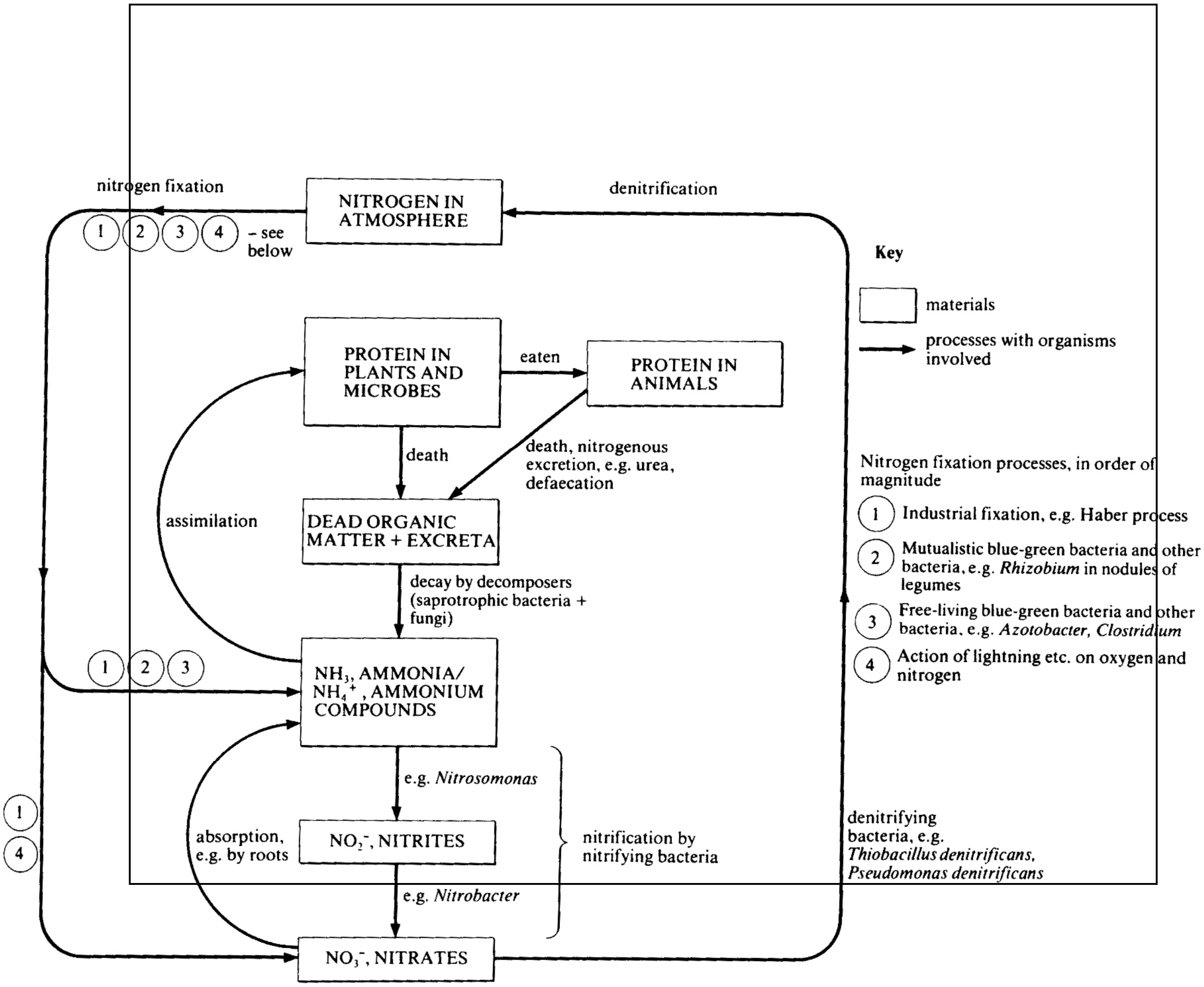
Structure of secondary ocyte

The hormones secreted by the placenta during pregnancy and their functions.

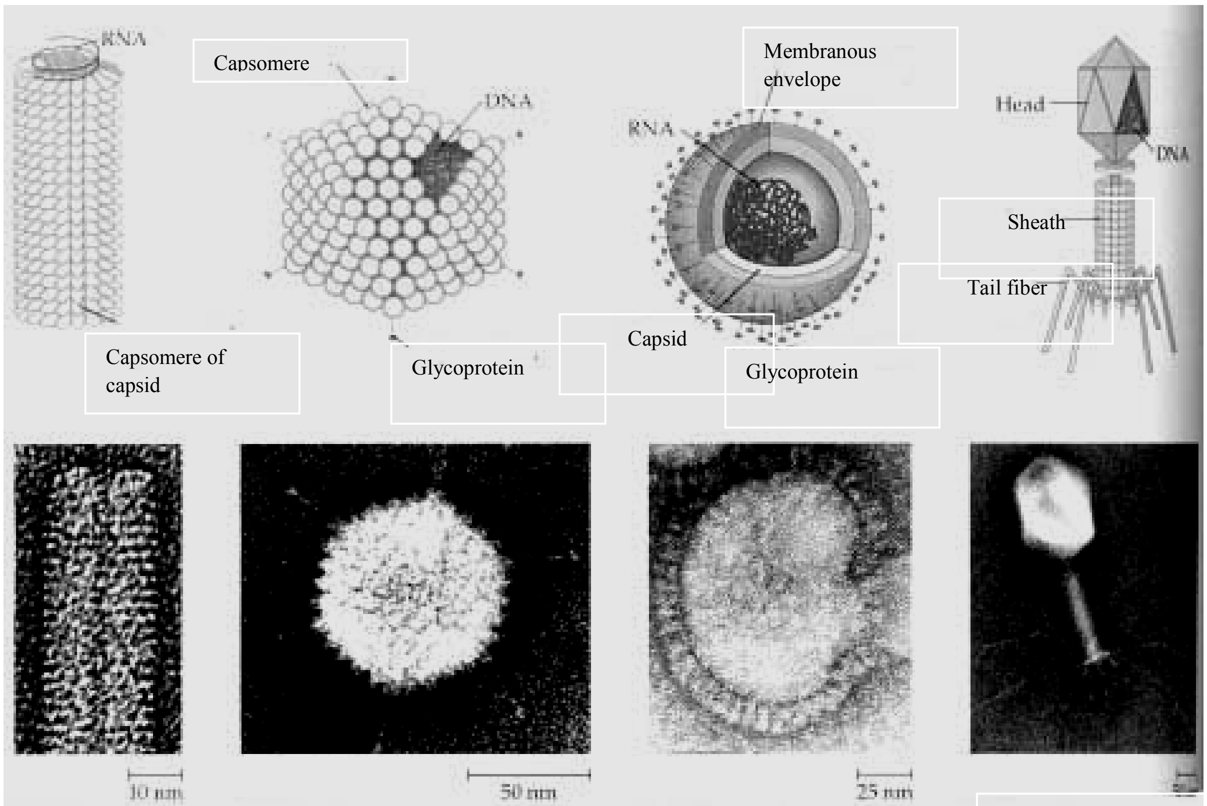
Oestrogen	*Progesterone*	*Human placental lactogen (HPL)*	*Chorionic gonadotrophin (CG)*
Stimulates development of duct system of breasts	Stimulates development of milk glands in breasts ready for lactation	Stimulates growth and development of breasts in preparation for lactation	Maintains activity of the corpus luteum up to 3 months of pregnan- until the placenta takes over, level then declines
Inhibits FSH release	Inhibits FSH release	Needed before oestrogen and progesterone can have their effects on the breasts (hence oestrogen and progesterone do not stimulate breast development during a normal menstrual cycle)	
Inhibits prolactin release and therefore inhibits lactation (see lactation)	Inhibits prolactin release and therefore inhibits lactation (see lactation)		
Stimulates growth of uterus, particularly muscle	Inhibits contraction of myometrium (relaxes muscle and helps to prevent miscarriage)		
Increases sensitivity of myometrium to oxytocin (see birth)	Maintains lining of uterus		



INTERNAL STRUCTURE OF THE EARTH



Nitrogen cycle. 79% by volume of the atmosphere is nitrogen. This is the main nitrogen reservoir.

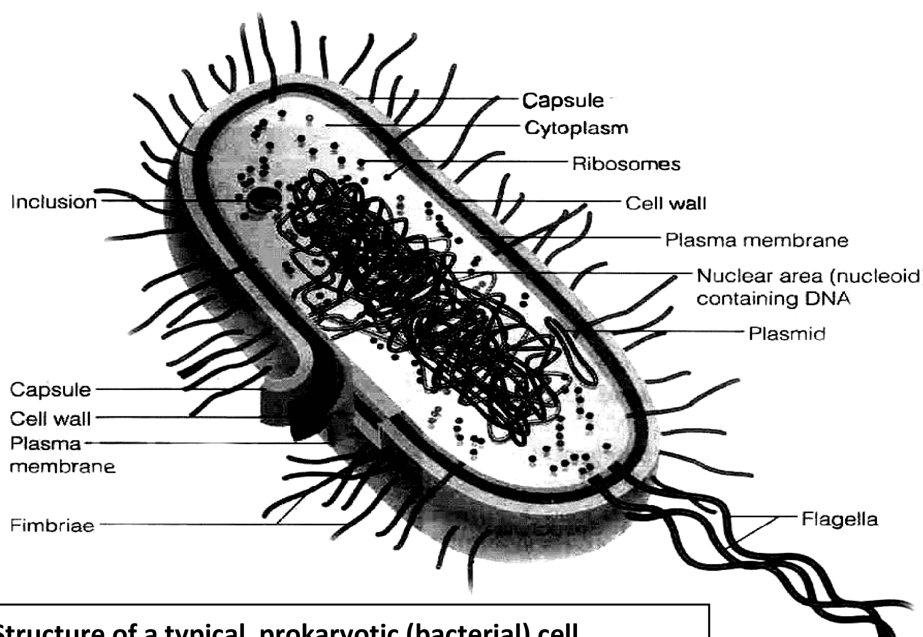


d) Tobacco mesaio

c) Adeno virus

b) Influenza virus

a) T-even bacteriophage



Structure of a typical prokaryotic (bacterial) cell

Representative sources of Antibiotic	
MICROOGANISM	**ANTIBIOTIC**
Gram-Positive Rods	
Bacillus subtilis	*Bacitracin*
Bacillus polymyxa	*Polymyxin*
Actinomycetes	
Streptomyces nodosus	*Amphotericin B*
Streptomyces venezuelae	*Chloramphenicol*
Streptomyces aureofaciens	*Chlortetracycline (Aureomycin) and Tetracycline*
Streptomyces erythraeus	*Erythromycin*
Streptomyces fradiae	*Neomycin*
Streptomyces noursei	*Nystatin*
Streptomyces griseus	*Streptomycin*
Micromonospora purpurea	*Gentamicin*
Fungi	
Cephalosporium	*Cephalothin*
Penicillium griseofulvum	*Griseofulvin*
Penicillium notatum	*Penicillin*

Types of acquired immunity	
TYPE OF IMMUNITY	**HOW ACQUIRED**
Naturally acquired active immunity	Antigens enter the body naturally; antibodies and specialized lymphocytes are produced
Naturally acquired passive immunity (placental and milk transfer)	Fetus or baby receives antibodies from an immunized mother
Artificially acquired active immunity	Prepared antigens in vaccines are introduced into susceptible individual, who produces antibodies and specialized lymphocytes
Artificially acquired passive immunity	Immune serum is injected into susceptible individual, who receives preformed antibodies

Summary of predominant normal flora found according to body site			
Body Site	**Microorganism**	**Body site**	**Microorganisms**
Skin	*Staphylococcus epidermidis,* *S. aureus* *Propioniactierum acnes* *Diphtheroids* *Candida Spp.* *Pityrosporum spp.*	Gastrointestinal tract Stomach	*Lactobacillus spp.* *Yeasts (Candida spp.)*
		Small intestine	*Enterococci* *Lactoacilli* *Corynebacteria* *Candida albicans* *Bacteroides spp.* *Escherichia coli*
Eye	*Staphylococcus epidermidis,* *S. aureus* *Corynebacterium spp.* *Streptococcus pneumoniae*	Large intestine	*>300 bacterial species found including:* *Escherichia coli* *Proteus spp.* *Klebsiella spp.* *Enterobacter spp.* *Bacteroides fragilis,* *B. melaninogenicus* *B. Oralis* *Fusobacterium spp.* *Bifidobacterium spp.* *Eubacterium spp.* *Lactobacillus spp.* *Clostridum perfringens* *Trichomonas hominis* *Entamoeba, Endolimax, and lodamoeba spp.*
Upper respiratory tract	*Staphylococcus epidermidis,* *S. aureus* *Streptococcus pneumoniae* *Corynebacterium spp.* *Neisseria spp.* *Branhamella spp.* *Haemophilus spp.* *Micrococcus spp.*		
Tongue and buccal mucosa	*Streptococcus salivarius,* *Streptococc*us spp. Neisseria spp. Veillonella spp. Actinomyces spp. Lactoacillus spp. Yeasts (candida spp.)	Genitourinary tract	*Staphylococcus epidermidis* *Streptococcus faecalis* *Corynebacteria* *Neisseria spp.* *E. coli* *Lactobacilli* *Enterococci* *Candida albicans* *Clostridium spp.* *Peptostreptococci* *Trichomonas vaginalis*
Teeth and gingival crevices	Bacteroides spp. Fusobacterium spp. Streptococcus mutans, Streptococcus spp. Actinomyces spp. Lactobacillus spp. Porphyromonas gingivalis Prevotella spp. Spirochetes (Treponema denticola) Wolinella spp. Selenomonas spp. Trichomonas tenax		

Some protein toxins produced by microorganisms that cause disease in humans

Microorganism	**Toxin**	**Disease**	**Action**
Clostridium botulinum	Several Neurotoxins	Botulism	Paralysis, blocks neural transmission
Clostridium perfringens	α-Toxin	Gas gangrene	Lecithinase
	γ-Toxin		Collagenase
	θ-Toxin		Hemolysin
Clostridium tetani	Neurotoxin (tetanospasm)	Tetanus	Spastic paralysis interferes with motor neurons
	Tetanolysin		Hemolytic
			Cardioxtoxin
Corynebacterium diphtheriae	Diphtheria toxin	Diphtheria	Blocks protein synthesis at level of translation
Streptococcus pyogenes	Streptolysin O	Scarlet fever	Hemolysin
	Streptolysin S		Hemolysin
	Erythrogenic		Causes rash of scarlet fever
Shigella dysenteriae	Neurotoxin	Bacterial dysentery	Hemorrhage, paralysis
Staphylococcus aureus	Enterotoxin	Food poisoning	Intestinal inflammation
Aspergillus flavus	Aflatoxin B_1	Aflatoxicosis	Blocks protein synthesis at level of transcription
Amanita phalloides	$\propto$-Amanitin	Mushroom food poisoning	Blocks protein synthesis at level of transcription

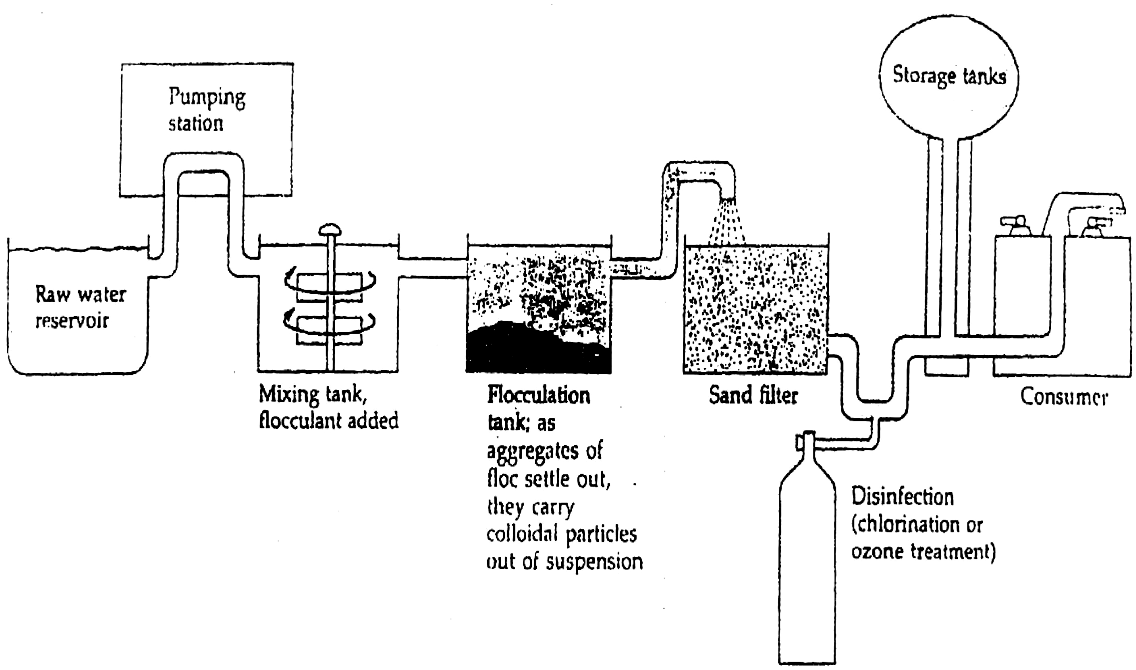
Causative Agents for Some Common Diseases, by Portal of Entry			
PORTAL OF ENTRY	CAUSAINE AGENT	DISEASE	INCUBATION PERIOD
Respiratory tract	*Corynebacterium diphtheriae*	Diphtheria	2–5 days
	Neisseria meningitidis	Meningococcal meningitis	1–7 days
	Streptococcus pneumoniae	Pneumococcal pneumonia	Variable
	Mycobacterium tuberculosis	Tuberculosis	Variable
	Bordetella pertussis	Whooping cough (pertussis)	12–20 days
	Myxovirus	Influenza	18–36 hours
	Paramyxovirus	Measles (rubeola)	11–14 days
	Togavirus	German measles (rubella)	2–3 weeks
	Epstein–Barr virus (herpesvirus)	Infectious mononucleosis	2–6 weeks
	Varicella-zoster virus (herpesvirus)	Chickenpox (varicella)	14–16 days
	Poxvirus	Smallpox (variola)	12 days
	Coccidioides immitis (fungus)	Coccidioidomycosis (primary infection)	1–3 weeks
Gastro intestinal tract	*Histoplasma capsulatum* (fungus)	Histoplasmosis	5–18 days
	Shigella species	Bacillary dysentery (shigellosis)	1–2 days
	Brucella species	Brucellosis (undulant fever)	6–14 days
	Vibrio cholerae	Cholera	1–3 days
	Salmonella enteritidis, Salmonella typhimurium, Salmonella choleraesuis	Salmonellosis	7–22 hours
	Salmonella typhi	Typhoid fever	14 days
	Hepatitis A virus (picornavirus)	Hepatitis A	15–50 days
	Paramyxovirus	Mumps	2–3 weeks
	Poliovirus	Poliomyelitis	4–7 days
Genitourinary tract	*Trichinella spiralis* (helminth)	Trichinosis	2–28 days
	Neisseria gonorrhoeae	Gonorrhea	3–8 days
	Treponema pallidum	Syphilis	9–90 days
Skin or parenteral route	*Clostridium perfringens*	Gas gangrene	1–5 days
	Clostridium tetani	Tetanus	3–21 days
	Leptospira interrogans	Leptospirosis	2–20 days
	Yersinia pestis	Plague	2–6 days
	Rickettsia rickettsii	Rocky Mountain spotted fever	3–12 days
	Hepatitis B virus**	Hepatitis B	6 weeks–6 months
	Rhabdovirus	Rabies	10 days–1 year
	Togavirus	Yellow fever	3–6 days
	Plasmodium species (protozoan)	Malaria	2 weeks

All causative agents are bacteria, unless indicated otherwise. For viruses, only the viral group is given, except where the virus has a name different from the disease it causes. ** These pathogens can also cause disease after entering the body via the gastrointestinal tract.

Diseases caused by Exotoxins		
DISEASE	**BACTERIUM**	**MECHANISM**
Botulism	*Clostridium botulinum*	Neurotoxin prevents transmission of nerve impulses flaccid paralysis results
Tetanus	*Clostridium tetani*	Neurotoxin blocks nerve impulse that permits relaxation of one skeletal muscle while the opposing muscle is contracting
Gas gangrene and food poisoning	*Clostridium perfringens and other species of Clostridium*	One exotoxin (cytotexin) causes massive red blood cell destruction (hemolysis); another exotoxin (enterotoxin) is related to food and causes diarrhea
Diphtheria	*Corynebacterium diphtheriae*	Cytotoxin inhibits protein synthesis, especially in nerve, heart and kidney cells
Scalded skin syndrome, food poisoning, and toxic shock syndrome	*Staphylococcus aureus*	One exotoxin causes skin layers to separate and slough off (scaled skin): another exotoxin (enterotoxin) produces diarrhea and vomiting; still another exotoxin produces symptoms associated with TSS
Cholera	*Vibrio cholerae*	Enterotoxin includes diarrhea
Scarlet lever	*Streptococcus pyogenes*	Cytotoxins cause vasodilation that results in the characterisc rash
Traveler's diarrhea	*Enterotoxigenic Escherichia coli and Shigella spp.*	Enterotoxin causes excessive secretion of ions and water ; diarrhea results

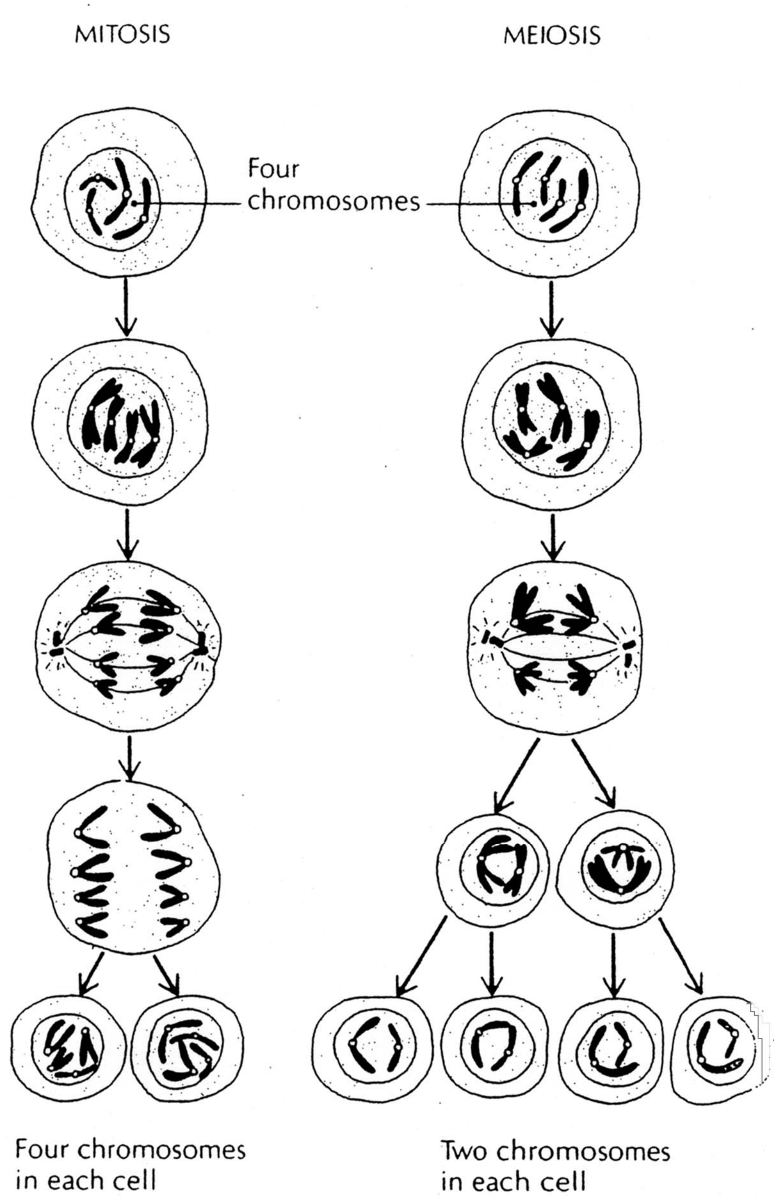
Comparison of selected characteristics of bacterial LPS toxins (Endotoxins) and protein toxins (Exotoxins)

Characteristic	LPS Toxin	Protein Toxin
Chemical composition	LPS- protein complex	Protein
source	Cell walls of Gram-negative bacteria; released upon death and autolysis of the bacteria	Gram-negative and Gram-positive bacteria; excretion products of growing cells or, in some cases, substances released upon autolysis and death of the bacteria
Effects on host	Nonspecific	Generally affects specific tissues
Thermostability	Relatively heat-stable (may resist 120^0C for 1 hour)	Heat-labile; most are inactivated at 60-80^0C
Toxoids	No	Yes
Lethal dose	Large	Small

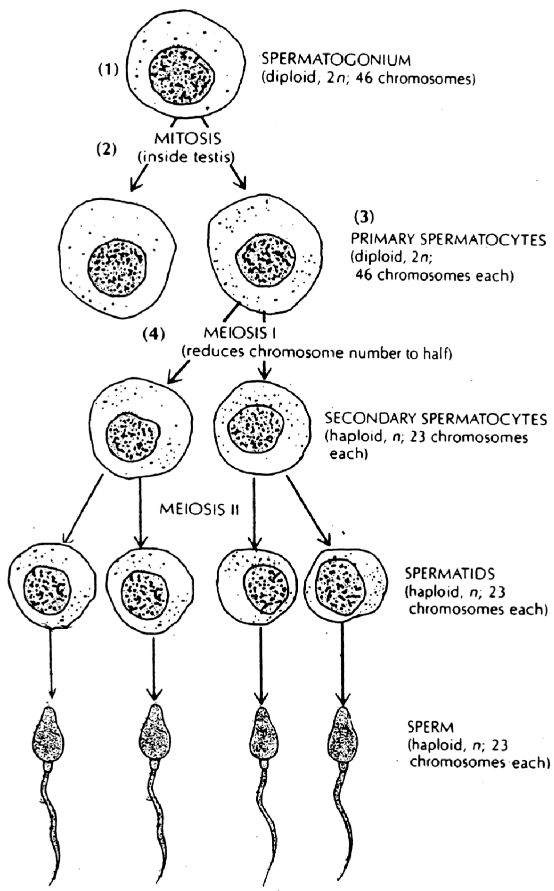


Steps of water treatment in a typical municipal water purification plant.

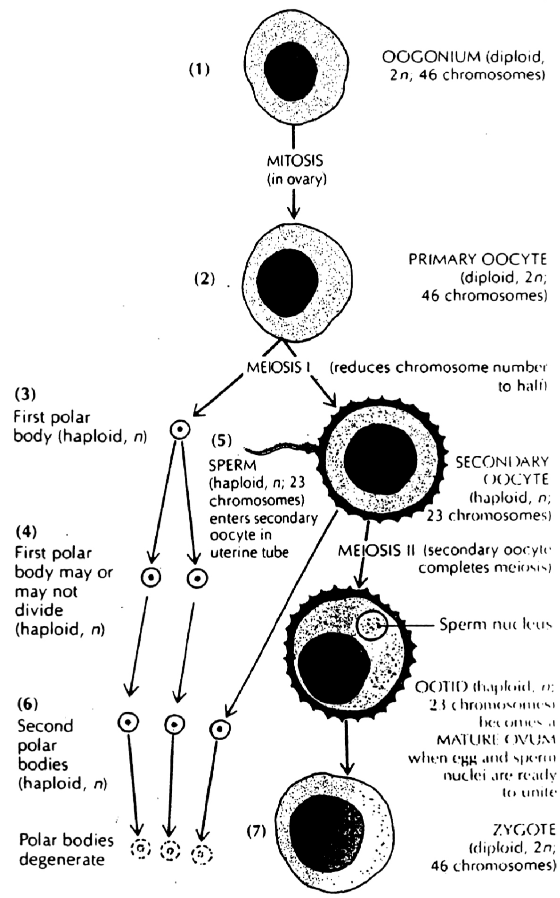
Comparison of mitosis and meiosis. In the simplified example shown here, there are four chromosomes: two long ones (one from the male parent and one from the female parent) and two short ones (one from the male parent and one from the female parent). Mitosis with one division, results in two cells identical to the original one with four chromosomes in each cell. Meiosis, with two divisions, results in four cells different from the original one, with two chromosomes in each cell.

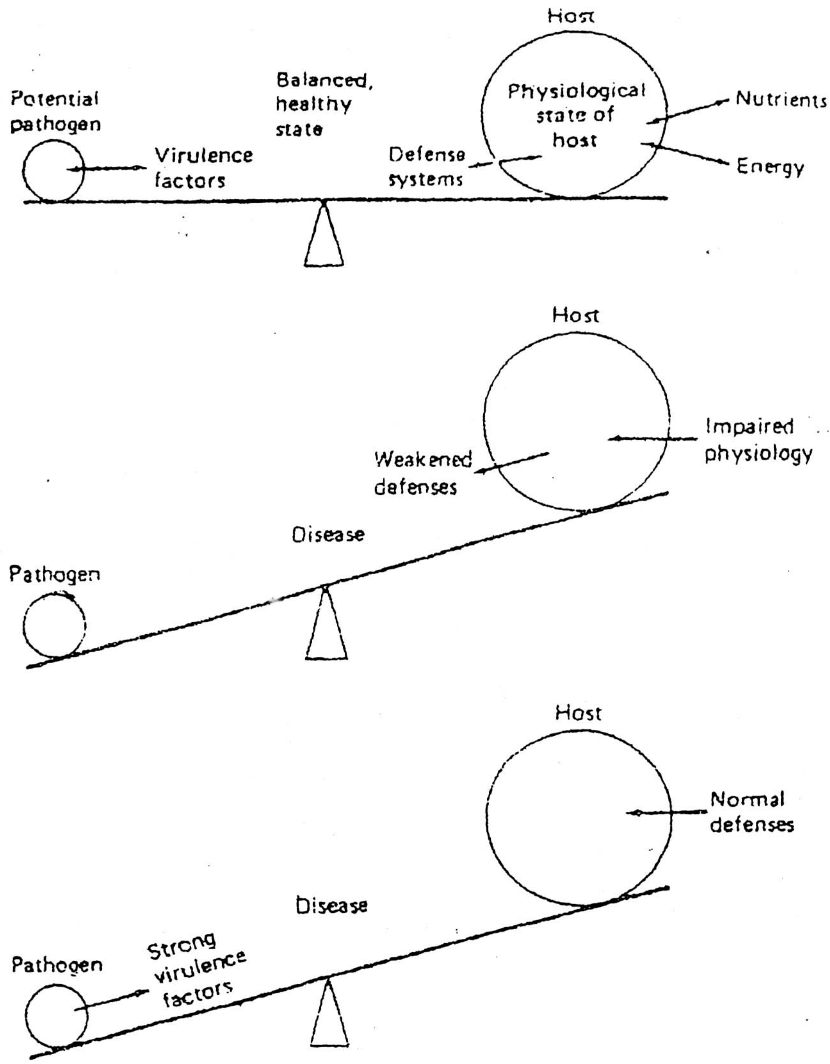


Cellular events in spermatogenesis in the seminiferous tubules.



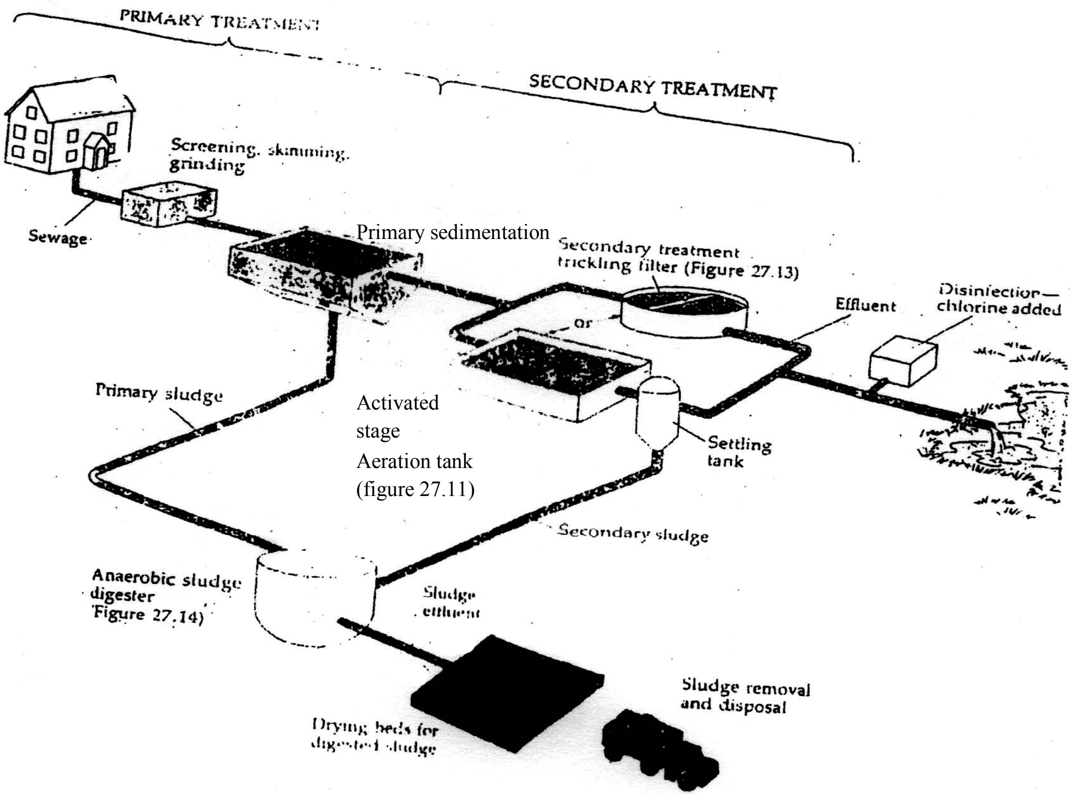
Cellular events in oogenesis in the ovary and uterine tube.



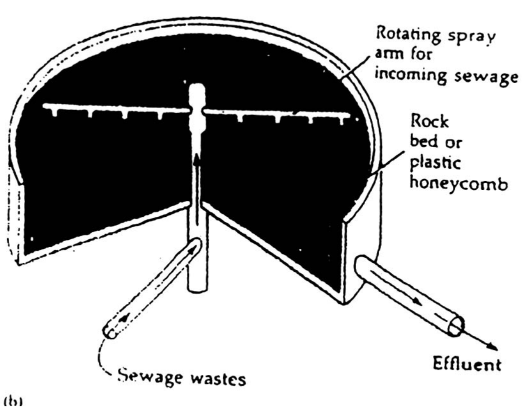


The interaction of a potential pathogen and a human host cell depends upon the intrinsic (virulence) factors of the microbe and the physiological state of the host with the environmental factors determined by that state.

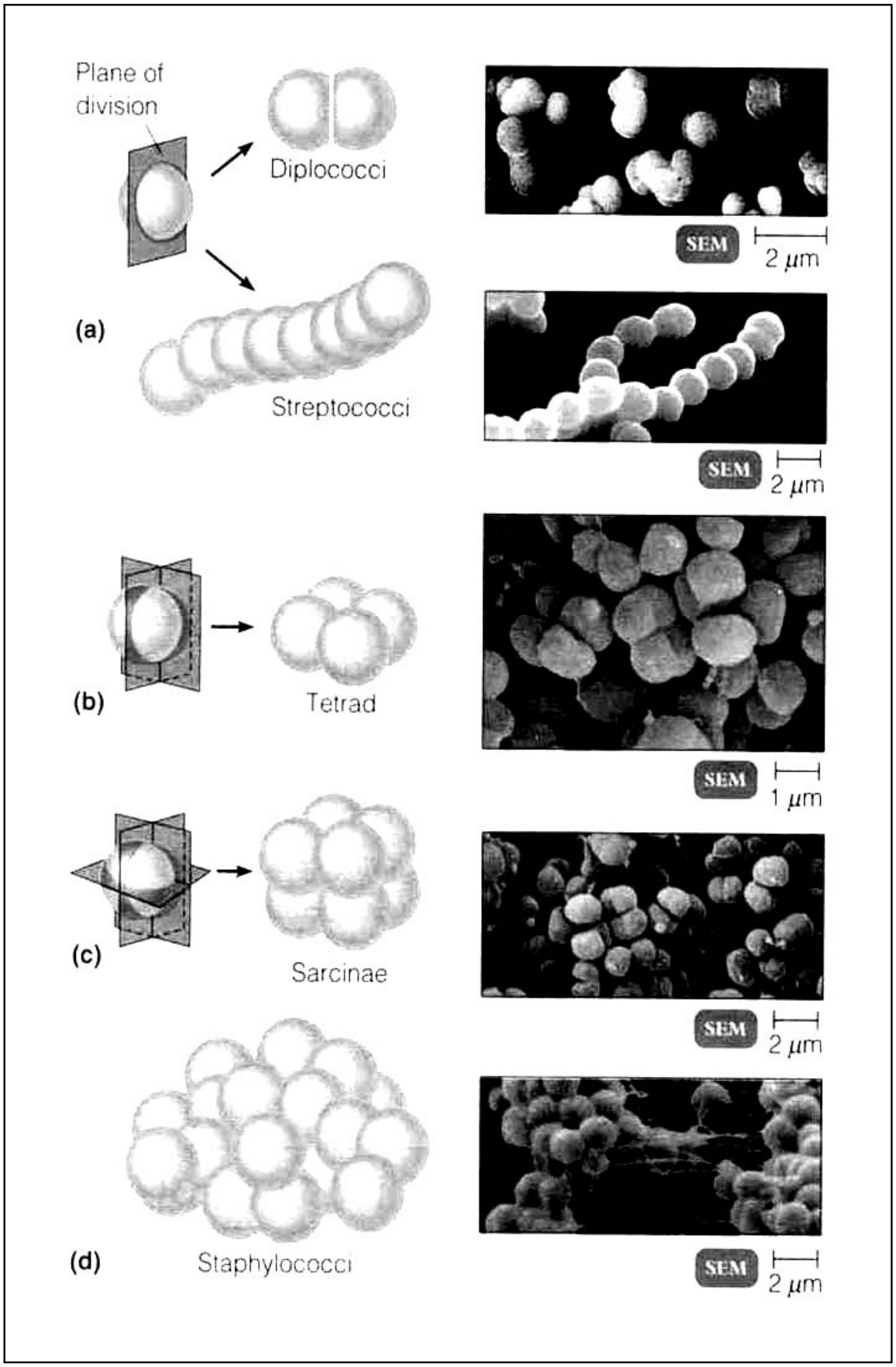
Current Industrial Effluent Discharge Quality Standards				
Parameter	**Units**	**General Effluent standards for discharge to inland surface waters***	**Tolerance limits for effluents discharged to marine coastal areas***	**Tolerance limits for effluents discharged on land for irrigation**
pH Range (at ambient temperature)	-	6.0 to 8.5	6.0 to 8.5	5.5 to 9.0
Temperature of Discharge	^0C	40	45	-
Total suspended solids (TSS) practical doze of	Mg/1	**50	***150	-
a) Total suspended solids	μm	850	-	-
b) Floatable solids	μm	-	3	-
c) Settleable solids	μm	-	850	-
Total dissolved solids (TDS)	mg/1	-	-	2100
Chloride (as Cl)	mg/1	-	-	600
Sulfate (as SO_4)	mg/1	-	-	1000
Sodium Adsorption Ratio (SAR)	-	-	-	10 to 15
Residual Sodium Carbonate	mol/1		-	2.5
Per cent Sodium			-	-
Biochemical Oxygen Demand (5 day, 20^0C)	mg/1	**30	100	250
Chemical Oxygen Demand	mg/1	**250	250	-
Oil and Grease	mg/1	10.0	20	10.0
Ammoniacal Nitrogen	mg/1	50.0	50.0	-
Phenolic Compounds (as phenol)	mg/1	1.0	5.0	-
Colour	Varies	****	****	-
Surfactants	mg/1	-	-	-
Cyanides (as CN)	mg/1	0.2	0.2	-
Sulfides (as S)	mg/1	2.0	5.0	-
Fluorides (as F)	mg/1	2.0	15	-
Total Residual Chlorine	mg/1	1.0	1.0	-
Arsenic	mg/1	0.2	0.2	0.2
Boron	mg/1	-	-	2.0
Cadmium, Total	mg/1	0.1	2.0	2.0
Chromium, Hexavalent	mg/1	-	-	-
Chromium, Total	mg/1	0.1	1.0	1.0
Copper, Total	mg/1	3.0	3.0	-
Lead, Total	mg/1	0.1	1.0	1.0
Mercury, Total	mg/1	0.0005	0.01	0.01
Nickel, Total	mg/1	3.0	5.0	-
Selenium, Total	mg/1	0.05	0.05	-
Zinc, Total	mg/1	5.0	5.0	-
Pesticides	-	Not detectable	-	-
Organo-Phosphorous Compounds (as P)	mg/1	-	1.0	-
Chlorinated Hydrocarbons (as Cl)	mg/1	-	0.02	-
Radioactive Materials				
a) Alpha emitters	μC/ml	10^{-7}	10^{-8}	10^{-9}
b) Beta emitters	μC/ml	10^{-8}	10^{-7}	10^{-8}



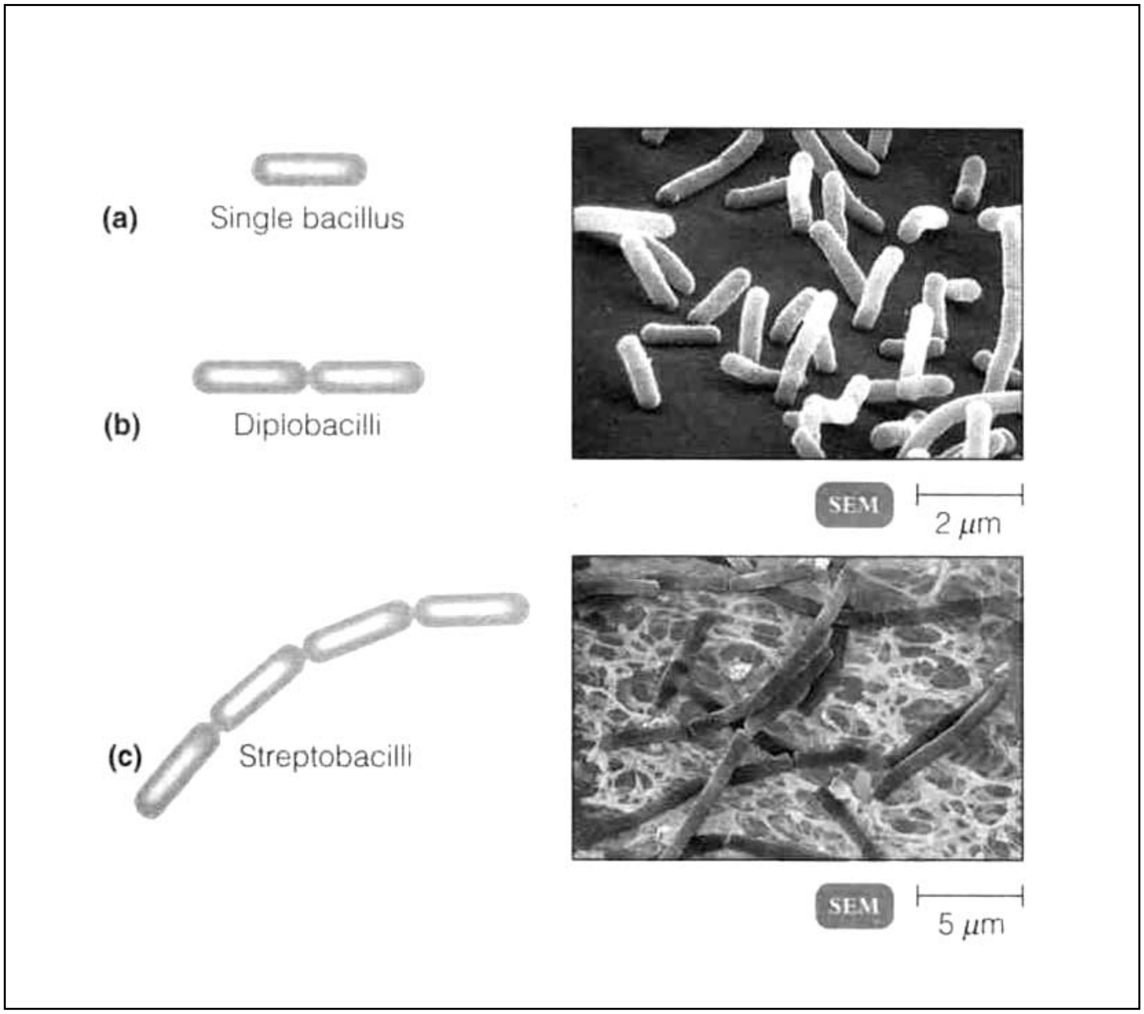
Steps of typical sewage waste treatment. A particular system would use either activated sludge aeration tanks or trickling filters, not both, as shown in this figure. The sludge is disposed of in landfills or agricultural land. Microbial activity occurs aerobically in trickling filters or in activated sludge aeration tanks and anaerobically in the anaerobic sludge digester.

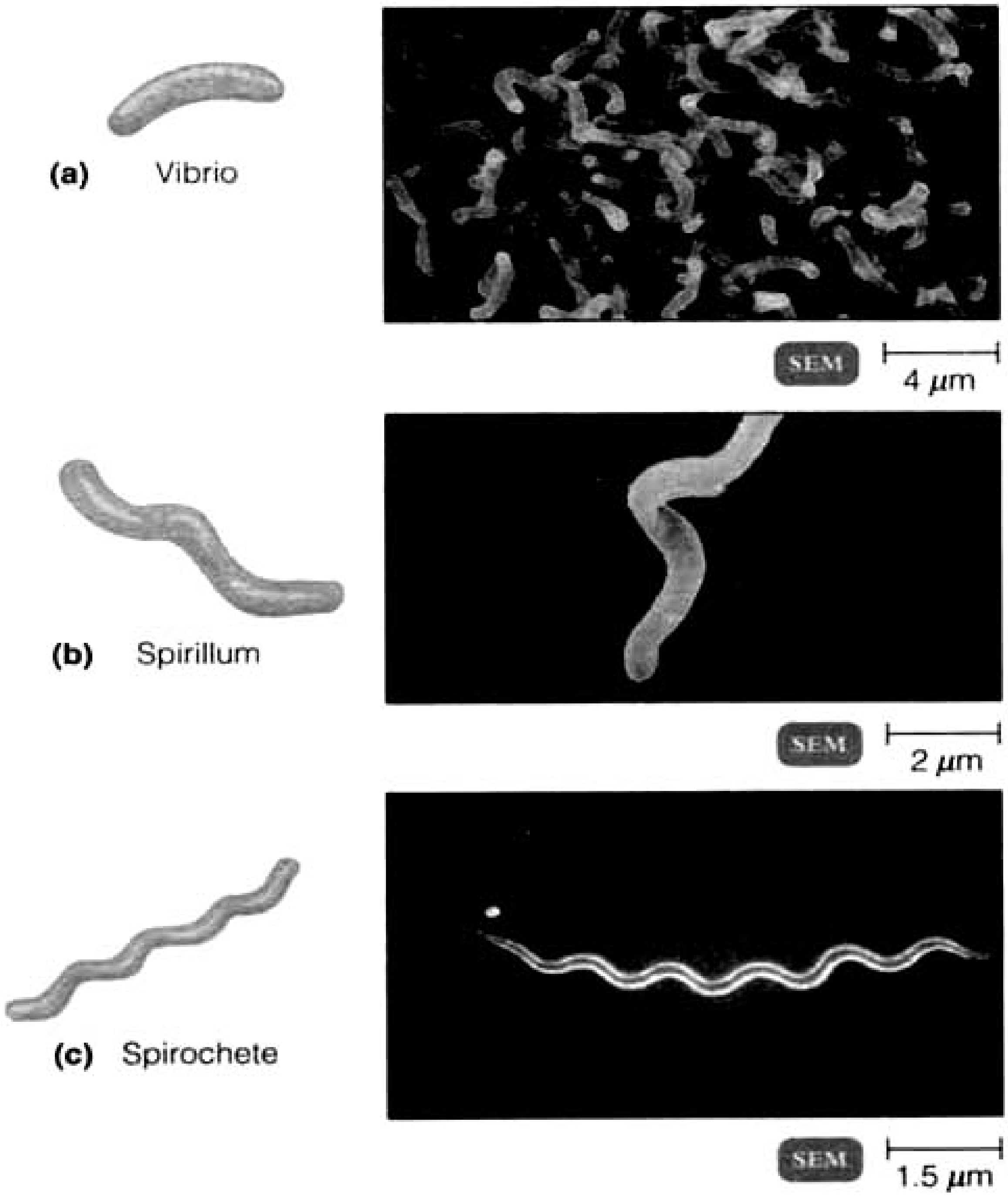


Trickling filter method of secondary treatment. (a) The sewage is sprayed from the system of rotating pipes onto a bed of rocks or plastic honeycomb designed to have a maximum surface area and allow oxygen to penetrate deeply into the bed. Microorganisms grow on the enormous surface area, forming a microbial slime layer that aerobically metabolizes the organic matter in the sewage tricking down through the bed. (b) Diagram of a trickling filter system.



Plane of division
Diplococci
SEM
2 μm
(a)
Streptococci
SEM
2 μm
(b)
Tetrad
SEM
1 μm
(c)
Sarcinae
SEM
2 μm
(d)
Staphylococci
SEM
2 μm


(a)
Single bacillus
(b)
Diplobacilli
SEM
2 μm
(c)
Streptobacilli
SEM
5 μm



(a) Vibrio
SEM
4 μm
(b) Spirillum
SEM
2 μm
(c) Spirochete
SEM
1.5 μm