ZOOLOGY SEMESTER VII (MSc sem I/ honors)
Core Course- I
COURSE TITLE: Phylogeny of Invertebrates and Vertebrates
COURSE CODE:23PS7ZOCC1PIV
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Enlist the salient features of non-chordates 2. Classify and describe non-chordates upto Class level 3. Explain phylogeny and systematics of various Chordates 4. Describe unique characteristics and affinities of Protochordates and Vertebrates. 5. Classify Protochordates and Vertebrates upto order level.		
Module I	**Non-chordate Phylogeny**	**[15L]**
Learning objectives The module is intended to - ● Introduce learner to detailed classification of non chordates ● Discuss salient features of various phyla with examples.		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Classify major phyla of non-chordates upto Class level ● Assign Phylum/Class based on the characteristics of an animal		

1.1	Phylogeny, salient features, classification up to Class level (wherever applicable) of the following phyla 1.1.1 Protista (Protozoa) 1.1.2. Porifera 1.1.3 Coelenterata 1.1.4 Ctenophora 1.1.5 Mollusca 1.1.6 Bryozoa 1.1.7 Brachiopoda 1.1.8 Echinodermata 1.1.9 Chaetognatha 1.1.10 Platyhelminthes and Nemathelminthes 1.1.11 Acanthocephala 1.1.12 Annelida 1.1.13 Sipunculoidea 1.1.14 Arthropoda 1.1.15 Onychophora – Peripatus: A connecting link between Annelida and Arthropoda	 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L

- Invertebrate Zoology by P S Verma (Author), E L Jordon : S Chand; Fifteenth edition
- Biology Of Non-Chordates by Fatik Mandal, PHI Learning; 2nd edition

Module II	**Hemichordate, Protochordate and Chordate Phylogeny**	**[15L]**

Learning objectives

The module is intended to -

- Describe Phylogeny, salient features, classification up to Class of Hemichordate and Protochordate
- Explain Vertebrate ancestry and origin of Vertebrates.
- Describe salient features and phylogeny of Ostracoderms and affinities of Cyclostomes
- Describe features of early tetrapods and lungfishes
- Describe affinities of Aves
- Identify affinities of Aves with other organisms
- Explain different types of flight in organisms
- Describe evolution and various features of Mammals

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss phylogeny, salient features, Classification up to Class of hemichordate and Protochordate
- Elaborate on Vertebrate ancestry and origin of Vertebrates
- Discuss on salient features and phylogeny of Ostracoderms and affinities of Cyclostomes
- Recognize the features of chordates on field
- Relate organisms based on phylogeny
- Analyze and compare different types of flights in animals
- Analyze and compare different types of walking gaits in animals

2.1	Phylogeny, salient features, classification up to Class level (wherever applicable) of the following phyla 2.1.1 Hemichordata and its affinities 2.1.2 Urochordata and its affinities 2.1.3 Cephalochordata and its affinities. 2.1.4 Vertebrate ancestry and origin of Vertebrates. Salient features and phylogeny of Ostracoderms.	 1L 1L 1L 2L
2.2	2.2..1 Affinities of Cyclostomes 2.2.2 Primitive tetrapods and Crossopterygians 2.2.3 Dipnoi - lungfishes who failed to evolve as Amphibians 2.2.4 Warm blooded reptile - Archaeopteryx 2.2.5 Affinities of Aves 2.2.6 Origin of flight 2.2.7 Egg laying Mammals - connecting link between	1L 1L 1L 1L 1L 1L 1L

	mammals and reptiles 2.2.8 Evolution of Mammals 2.2.9 Walking gait in animals	1L 1L 1L

- P.S. Dhami & J.K. Dhami, 1981. Chordate zoology. (R. Chand & Co.).
- R.L.Kotpal, 2000. Modern textbook of zoology, Vertebrates. (Rastogi Publ., Meerut).
- E.L. Jordan & P.S. Verma, 1998. Chordate zoology. (S. Chand & Co.)

ZOOLOGY SEMESTER VII (MSc sem I/ honors)
Core Course- II
COURSE TITLE: Biomolecules and Metabolism
COURSE CODE: 23PS7ZOCC2BMM
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Discuss the properties and classification of carbohydrates, proteins, nucleic acids and lipids 2. Summarize synthesis, conversion and degradation of carbohydrates, proteins lipids and nucleic acids. 3. Sketch and explain the various metabolic pathways of proteins and nucleic acids 4. Recall the integration of major metabolic pathways		
Module I	**Carbohydrates and Lipids**	**[15L]**
Learning objectives The module is intended to - ● Introduce the properties of biomolecules (carbohydrates and lipids) along with their biological functions. ● Categorise various biomolecules and explain their roles in metabolism. ● Explain the regulation of major metabolic pathways.		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Describe properties and functions of biomolecules (carbohydrates and lipids) ● Discuss the synthesis and role of major biomolecules. ● Recall the reaction sequences of various metabolic pathways. ● Explain the significance of major metabolic pathways.		
Module 1		**15L**

1.1	Carbohydrates 1.1.1 Classification: mono-, oligo- and poly-saccharides. 1.1.2 Monosaccharides 1.1.3 Oligosaccharides 1.1.4 Polysaccharides- homo- and hetero-polysaccharides. 1.1.5 Biological functions of carbohydrates.	3L
1.2	Carbohydrate Metabolism 1.2.1 Glycolysis Reaction sequence, flow of carbon, Conversion of pyruvate to lactate and Acetyl coenzyme-A, significance of pyruvate lactate interconversion, aerobic and anaerobic glycolysis and energetic of glycolysis. Regulation of glycolysis 1.2.2 Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate, lactate. Regulation of gluconeogenesis 1.2.3 Glycogen metabolism: Glycogenesis, Glycogenolysis. Regulation of the two pathways. 1.2.4 Significance of following pathways: Hexose monophosphate shunt as a multifunctional pathway; Uronic Acid Pathway; Glyoxylate cycle.	2L 1L 1L 1L
1.3	Lipids 1.3.1 Classification: simple and complex lipids 1.3.2 Fatty acids 1.3.3 Acylglycerols 1.3.4 Complex lipids 1.3.5 Glycolipids 1.3.6 Biological functions of lipids.	3 L
1.4	Lipid Metabolism 1.4.1 Dynamics of body lipids, mobilisation of fats, regulation of hormone sensitive TG lipase, fate of glycerol and free fatty acids. 1.4.2 Fatty acid metabolism: Oxidation of even-carbon and odd- carbon atom fatty acid, oxidation of unsaturated fatty acids,biosynthesis of fatty acids including desaturation, metabolism of phospholipids, cholesterol and alcohol.	2L 2L

References

- Biochemistry by U.Satyanarayana and U.Chakrapani published by Elsevier and co-published with Books and Allied, Fourth Edition, 2013.

- APA. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.)

Module II	**Proteins and Nucleic acids**	**15L**

Learning objectives

The module is intended to -

- Introduce the properties of biomolecules (proteins and nucleic acids) along with their biological functions.
- Interpret the regulation of various metabolic pathways.
- Explain the process of energy demand and supply through metabolism.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain the functions and classification of proteins and nucleic acids
- Understand the process of synthesis, conversion and degradation of these biomolecules.
- Discuss the roles of various types of complex biomolecules.
- Sketch various metabolic cycles.
- Summarise the process of metabolism by integrating major metabolic pathways.

Module II	**Title**	**15L**
2.1	Proteins 2.1.1 Amino acids: structure and classification 2.1.2 Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate proteins haemoglobin, cytochromes, myoglobin; bonds involved in protein organization. 2.1.3 Properties of proteins: classification, denaturation and protein folding. 2.1.4 Biological functions of proteins. Biologically important peptides: glutathione, octa-, nona and deca-peptides. Glycoproteins, Lipoproteins	 1L 1L 1L 1L
2.2	Protein Metabolism 2.2.1 Metabolism of amino acids: Amino acid pool, transamination; oxidative and nonoxidative deamination; metabolism of	 2L

	branched chain amino acids; fate of carbon skeleton of amino acids. 2.2.2 Metabolism of ammonia: Urea cycle	 2L
2.3	Nucleic acids 2.3.1 Types, Components, Structure of DNA 2.3.2 Structure, types and functions of RNA	 2L 1L
2.4	Metabolism of Nucleic acids 2.4.1 Synthesis of ribonucleotides- a brief idea of de novo pathway and salvation pathway 2.4.2 Conversion of ribonucleotides to deoxyribonucleotides 2.4.3 Degradation of nucleotides 2.4.4 Integration of Metabolism, Energy demand and supply: Integration of major metabolic pathways of energy metabolism, intermediary metabolism; organ specialisation and metabolic integration. Metabolism in starvation	 1L 1L 1L 1L

References

● Biochemistry by U.Satyanarayana and U.Chakrapani published by Elsevier and co-published with Books and Allied, Fourth Edition, 2013.
● APA. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.)

ZOOLOGY SEMESTER VII
Core Course- III
COURSE TITLE: Evolution and Developmental Biology
COURSE CODE 23PS7ZOCC3EDB
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe evolutionary stages, trends and causes of Horse, Elephant and Human evolution 2. Analyze molecular data for phylogenetic analysis. 3. Explain the concept in development biology 4. Describe the vulva formation in *C. elegans*, limb development in vertebrates, concepts of regeneration and distinguish between the types of regeneration, role of stem cells and metamorphosis in insects.

Module I	**Evolution**	**15L**

Learning objectives

The module is intended to -

- Understand theories of evolution and concepts related to evolution
- Understand concepts related to molecular evolution

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Describe process of evolution of Horse, Elephant and Human
- Define concepts in Molecular Phylogeny

Module 1		**15L**
1.1	Extinct bird order - Archaeopterigyformes	1L
1.2	Evolution of Horse	2L

1.3	Evolution of Elephant	2L
1.4	Human Evolution, evolutionary adaptations in human lineages	2L
1.5	Human Migration	1L
1.6	Molecular Evolution 1.5.1 Patterns and modes of nucleotide substitutions 1.5.1.1 Nucleotide substitutions in DNA 1.5.1.2 Rate of substitution and variation in evolutionary rate between genes 1.5.1.3 Housekeeping genes and pseudogenes 1.5.1.4 Molecular clock 1.5.1.5 Single nucleotide polymorphism and Copy number variation 1.5.2 Molecular Phylogeny 1.5.2.1 Reading Phylogenetic tree and it's reconstruction methods 1.5.2.2 Horizontal gene transfer 1.5.2.3 Acquisition and origin of new functions 1.5.2.4 Multigene families 1.5.2.5 Gene duplication and conversion	4L 3L

References

CNVs

- https://www.nature.com/scitable/ebooks/genetic-variation-and-evolution-16553748/126455448/

Molecular clock

- https://www.nature.com/scitable/topicpage/the-molecular-clock-and-estimating-species-divergence-41971/
- http://www.nature.com/scitable/topicpage/origins-of-new-genes-and-pseudogenes-835

Origin of new genes and pseudogenes

- https://www.nature.com/scitable/topicpage/evolutionary-adaptation-in-the-human-lineage-12397/
- http://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956
- http://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956

Module II	**Developmental Biology**	**15L**

Learning objectives

The module is intended to -

- Explain the concepts of developmental biology.
- Discuss organogenesis
- Explain metamorphosis and the hormonal regulation involved.
- Explain the role of stem cells in development.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss cell aggregation and cell differentiation
- Enlist the genes and their role in axis formation in drosophila and in organogenesis.
- Explain the concepts of organogenesis, metamorphosis, regeneration, aging and stem cells.

Subtopic	**Title**	**15L**
2.1	Basic concepts of Developmental Biology – cell fate, competence, commitment, trans differentiation and differentiation, dedifferentiation, cell specification	2L
2.2	Cell aggregation and differentiation in Dictyostelium	1L
2.3	Morphogenesis and cell adhesion- Differential cell affinity, cadherins and cell adhesion.	1L
2.4	2.4.1 Axis formation and pattern formation: *Drosophila* and *Xenopus*. 2.4.2 Sea Urchin fertilization and early development	3L
2.5	Organogenesis 2.5.1 Vulva formation in *Caenorhabditis elegans* 2.5.2 Limb development in tetrapods	2L

2.6	Metamorphosis (a) Amphibian metamorphosis (b) Hormonal control of insect metamorphosis (c) Programmed cell death	2L
2.7	Regeneration (a) Regeneration in Hydra (b) Regeneration of Salamander limbs	2L
2.8	Aging: Senescence, life span and causes of aging	1L
2.9	Stem cell and their role in development	1L

References

- DEVELOPMENTAL BIOLOGY, 11TH EDITION 2016 S. F. Gilbert, M. J. F. Barres
- Korzh, V. (2005). Boris Balinsky: transition from embryology to developmental biology. *BioEssays*, *27*(9), 970-977

ZOOLOGY SEMESTER VII (MSc sem I/ honors)
Core Course- IV
COURSE TITLE: Instrumentation
COURSE CODE 23PS7ZOCC4INT
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Understand various instruments and techniques 2. The working and principle of instruments 3. Know their application in industries		
Module I	**Microtomy, Microscopy, Radioactivity and Separation Techniques**	**15L**
Learning objectives The module is intended to - ● Understand the principle, working and application of various instruments and techniques in different industries ● Know the different types of Microscope and Microtome that are used in industries ● The concept of Radioactivity and its principle and application		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Have clear concept of Microtomy, Microscopy and Techniques such as FIltration, Distillation and Extraction ● Explain the detail working of Microtome and Microscope ● Have The clear knowledge and understanding of Radioactivity, its detection and measurement in industries ● Knowledge of applications in industries ● Significance of the instruments		
1.1	Microtomy	

	1.1.1 Basic Introduction to Microtomy: Principle and Working of Microtome 1.1.2 Types of Microtome 1.1.3 Procedure and Preparation involved in Microtomy 1.1.4 Applications of Microtomy	1L 1L 1L 1L
1.2	Microscopy 1.2.1 Principle, working and applications of microscopy: a) Light Microscopy b) Phase contrast Microscopy c) Confocal Microscopy d) Fluorescence microscopy e) Polarised Microscopy f) Electron microscopy- TEM and SEM, Preparation of specimen for electron microscope 1.2.2 Concepts of digital microscopy and image analysis	 2L 2L
1.3	Radioactivity 1.3.1 The nature of radioactivity 1.3.2 Units of radioactivity 1.3.3 Detection and measurement of radioactivity - liquid scintillation counting 1.3.4 Basic principles of radioactive labeling.	 1L 1L 1L 1L
1.4	Separation Techniques 1.4.1 Principle and Applications of Vacuum Filtration 1.4.2 Principle and Applications of Steam and Fractional Distillation 1.4.3 Principle and Application of Solvent Extraction	 1L 1L 1L

References

- Bioinstrumentation by L. Veerakumari
- Bioinstrumentation by M. H. Fulekar and Bhawana Pandey
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf

Module II	**Chromatography, Electrophoresis and Spectroscopy**	**15L**

Learning objectives

The module is intended to -

- Understand the concept of Chromatography, Electrophoresis and Spectroscopy
- Understand the principle and working of the instruments
- Applications in different industries
- Understanding the factors affecting different electrophoresis

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Have clear understanding about the principle of Chromatography, Electrophoresis and Spectroscopy
- The knowledge of different instruments application in the industries
- Know the clear working techniques of the instruments

Subtopic	**Title**	**15L**
2.1	Chromatography 2.1.1 Principle of separation, 2.1.2 Working and application: a) Planar Chromatography b) HPTLC c) Column Chromatography d) HPLC e) Size-exclusion Chromatography f) Gradient elution g) Gas Chromatography	 1L 4L
2.2	Electrophoretic Techniques 2.2.1 General principles, applications and factors affecting electrophoresis of a) Native-PAGE; b) Isoelectric focusing (IEF) - pH gradient gels, c) Two Dimensional Gel Electrophoresis (2-DE) d) Pulse field electrophoresis	 1L 1L 1L 1L
2.3	Spectroscopy Principle and applications of Spectroscopy: a) Ultraviolet and visible absorption spectroscopy b) Fluorescence spectroscopy	 1L 1L

	c) FTIR d) Mass spectroscopy e) Atomic absorption spectrophotometer. f) NMRS	1L 1L 1L 1L

Reference

- Bioinstrumentation by L. Veerakumari
- Bioinstrumentation by M. H. Fulekar and Bhawana Pandey
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf

Practicals: 23PS7ZOCCP1

Core course I	**Comparative Vertebrate Anatomy**

Learning Objectives

This practical is intended to

- Explain the structure of vertebrate axial and appendicular skeleton and its significance

Learning Outcomes

After completion of this practical, learner will be able to

- Compare the structure of axial and appendicular skeleton in different vertebrate groups
- State significance of parts of vertebrate axial and appendicular skeleton

1	Comparative study of vertebrate axial skeleton - vertebrae of Cartilaginous fish Bony fish Amphibia Reptile Aves Mammals
2	Comparative study of vertebrate axial skeleton - Skull of Cartilaginous fish Bony fish Amphibia Reptile Aves Mammals
3	Comparative study of vertebrate appendicular skeleton - forelimbs and hindlimbs of Cartilaginous fish, bony fish, Amphibia, Reptile, Aves and Mammal
4	Morphometric studies of appendicular skeletons to identify the species.

Suggested Project:

1. Alizarin stained skeletal preparations of fish
2. Preparation of skeletal whole mount for museum display

23PS7ZOCCP2

Core course II	**Biomolecules and Metabolism**	
Learning Objectives This practical is intended to ● Make the learner understand biochemical assay techniques and their analysis ● Explain the applications of large scale culture and their commercial products		
Learning Outcomes After the successful completion of the practical, the learner will be able to ● Extract various biomolecules from tissues ● Analyse the extracted molecules by colorimetry and electrophoresis ● Calculate the amount of biomolecules extracted using formulae or graphs		
1.	Isolation of β -Amylase from Sweet Potato	https://vlab.amrita.edu/?sub=3&brch=64&sim=730&cnt=1
2.	Gelatin Zymography [PAGE]	https://vlab.amrita.edu/?sub=3&brch=64&sim=700&cnt=1
3.	Construction of Maltose standard curve by DNSA method	https://vlab.amrita.edu/?sub=3&brch=64&sim=163&cnt=1
4.	Construction of protein standard curve using Folin's Lowry method	https://vlab.amrita.edu/?sub=3&brch=64&sim=1087&cnt=1

5.	Extraction of Caffeine from tea/coffee	https://vlab.amrita.edu/?sub=3&brch=64&sim=169&cnt=1
6.	Effect of substrate concentration on Enzyme Kinetics	https://vlab.amrita.edu/?sub=3&brch=64&sim=1090&cnt=1
7.	Effect of temperature on Enzyme Kinetics	https://vlab.amrita.edu/?sub=3&brch=64&sim=1342&cnt=1
8.	Extraction and analysis of liver lipids- Soxhelt extraction	https://www.protocols.io/view/extraction-and-analysis-of-liver-lipids-n92ld7ool5br/v1 http://cyberlipid.gerli.com/soxhlet-type-extraction/

23PS7ZOCCP3

Core course III	**Evolution and Developmental Biology**
Learning objectives This Practical is intended to ● Develop basic laboratory skills of the student ● Make the student understand basic concepts in evolution and developmental biology ● Explain to the learner the practical applications of learning developmental biology	
Learning Outcomes After the successful completion of the Practical, the learner will be able to ● Perform several developmental biology related techniques ● Use basic lab apparatus and equipments ● Apply formula and find values of unknown samples	
1	Introduction to Phylogenetics: Definition and significance of phylogenetics, Historical background and key contributors

2	Tree-Building Methods: Distance-based methods: Neighbor Joining, UPGMA, Character-based methods: Maximum Parsimony, Maximum Likelihood, Bayesian Inference
3	Construction of phylogenetic trees from molecular and morphological data using phylogenetic software (e.g., Chromas Lite, Mega (Molecular Evolutionary Genetics Analysis), BEAST]
4	Interpretation of Phylogenetic Trees [Branch lengths, nodes, and root placement, Monophyletic, paraphyletic, and polyphyletic groups Molecular dating and divergence times,Ancestral character reconstruction]
5	Effect of teratogens on animal development
6	Study of regeneration in Hydra
7	Frog developmental stages – egg, 4 and 8 celled stage, blastula, gastrula and tadpole larva.
8	Developmental changes in Chick Embryo
9	Developmental changes in frog
10	Ontogeny recapitulates phylogeny

23PS7ZOCCP4

Core course IV	**Instrumentation**

Learning Objectives:

This Practical is intended to

- Introduce the learner to several instrumentation techniques such as microtomy and chromatography.
- Demonstrate the process of microtomy by explaining various steps involved in the processing of histological sections such as fixation, embedding, sectioning, staining and preserving the tissues.
- Develop the skills in learners to isolate and separate various biomolecules by using chromatography.

Learning Outcomes:

After the successful completion of the Practical, the learner will be able to

- Identify and recognise various histological sections under microscope. ,
- Make permanent slides of histological sections by performing microtomy for histological studies.
- Separate and extract various plant pigments by performing adsorption chromatography.
- Perform the separation techniques like Ion Exchange Chromatography and 2-D Chromatography in order to isolate and extract various amino acids.

1	Microtomy: i) Fixation of tissue ii) Dehydration iii) Embedding, block preparation and trimming iv) Sectioning and slide preparation v) Staining and mounting
2	Separation of pigments from leaves or flowers by adsorption column chromatography
3	Separation of amino acids by ion exchange chromatography using cation exchanger
4	Identification of amino acids by 2D chromatography
5	Microscopy- Principle and Working
6	Study of Gel Electrophoresis
7	Visit to Instrumentation lab

Suggested projects:

1. Electrophoretic analysis of DNA from different sources
2. PAGE of various serum
3. Chromatography of pigment from different sources

ZOOLOGY SEMESTER VII
DSE- I
COURSE TITLE: Physical and Chemical Oceanography

COURSE CODE 23PS7ZODSE1PCO
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Compare between the organisms, their characters and requirements 2. Discuss the physical factors that affects marine life 3. Elucidate the role of marine bacteria 4. Enlist various marine microorganisms. 5. Compare and contrast between the various groups of microbes found in mangroves and coral reefs. 6. Describe the ecology of coastal water, shallow water and deep-sea microorganisms 7. Discuss the process of breakdown of various xenobiotics by microbes 8. Describe methods for controlling water pollution

Module I	**Physical Oceanography**	**15L**

Learning objectives

The module is intended to -

- Explain the marine environment and its components to the learner
- Elucidate on effect of various physical parameter of seawater on marine animals
- Discuss on marine biotic diversity, intertidal organisms and their zonations and role of marine bacteria in marine environment

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Define various component of marine environment
- Classify between marine biotic diversity
- Explain species richness and diversity gradient models
- Measure species diversity and richness using quadrant method
- Enlist the effect of various physical parameter of seawater on marine animals

Subtopic	Title	Lecture distribution
1.1	Oceanographic circulation: Ekman spiral, geotropic current, westward intensification with dynamic topography.	3L
1.2	Vertical circulation: wind induced circulation, Thermohaline circulation and upwelling of water.	3L
1.3	Waves: Characteristics of waves, deep water and shallow water waves, transitional waves, wind generated waves, internal waves and Tsunami	3L
1.4	Tides: Tides generating forces, equilibrium theory of tides, dynamic theory of tides	3L
1.5	Currents: Types of currents, major currents of the world, Coriolis effect and El Nino effect, Eddy currents	3L

References:

- The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd
- Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd
- Oceanography: An Invitation to Marine Science by Tom Garrison; Brooks/Cole; 9th edition
- A Textbook of Marine Ecology – Nair, N.B. & Thumpy, D.H., the Macmillan Book Company of India Ltd
- Element of marine ecology by R.V. Tait and F.A. Dipper
- Introduction to Physical Oceanography by Robert H. Stewart

Module II	Chemical Oceanography	15L

Learning objectives

The module is intended to -

- Explain the chemical properties of seawater
- Elucidate on various gaseous and nutrient cycle of ocean

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss on chemical properties of seawater
- Explain various gaseous and nutrient cycle of seawater

Subtopic	Title	Lecture distribution
2.1	Composition of sea water- constancy of its composition and factors affecting the composition, major and minor constituents, trace elements and their biological role.	5L
2.2	Dissolved gases in the sea water and their role in the environment, CO2 system, dissolved O2 and oxygen profile, hydrogen sulphide.	5L
2.3	Nutrients in the ocean, their cycles and factors influencing their distribution a) Nitrogen b) Phosphorus c) Silicon	5L

References:

● The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd
● Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd

Practical

DSE I	Physical and Chemical Oceanography

Learning Objectives

This Practical is intended to

- Introduce the learner to several abiotic components of the ocean.

- Explain the significant role of nutrients in the ocean.
- Develop an understanding in the learner about the process of estimation of several physico-chemical parameters such as salinity, dissolved oxygen, carbon dioxide and nutrients.
- Teach the learner the skill to identify foraminiferans and radiolarians.
- Define and explain primary productivity.
- Demonstrate the experiment of sediment analysis to determine soil texture.
- Discuss various intertidal ecosystems.

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Enlist various physico-chemical parameters of the ocean.
- Quantify and measure various physico-chemical parameters of the ocean such as salinity, dissolved oxygen, carbon dioxide etc.
- Determine the presence of nutrients in ocean water.
- Estimate the primary productivity by light and dark bottle reaction
- Calculate the gross and net primary productivity.
- Identify various foraminiferans and radiolarians.
- Determine the soil texture and recognise various types of soil.
- Describe intertidal ecology and discuss types of shores.
- Identify and differentiate various intertidal organisms on the basis of their type of shore.

1	Determination of salinity (Argentometric and conductivity method).
2	Determination of Dissolved oxygen.
3	Determination of Carbon dioxide.
4	Determination of Nitrates-nitrites.
5	Determination of Silicates.
6	Determination of Phosphate-phosphorus.
7	Estimation of Primary Productivity
8	Textural features: Sediment analysis- size fraction (sand, silt, clay)
9	Measuring Turbidity by using Secchi's Disc

10	Determining Salinity by using Salinometer
11	Study of Tide Time-table and Tide Charts
12	Study of various Maps/Satellite Images by India Meteorological Department

ZOOLOGY SEMESTER VII
DSE- II
COURSE TITLE: Insect Classification and Diversity
COURSE CODE: 23PS7ZODSE2ENT
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Describe insect orders with characteristics 2. Explain method of identification of insects using keys 3. Identify insect		
Module I	**Insect Classification, Metamorphosis and Ametabolous Insect Orders**	**15L**
Learning objectives The module is intended to - ● Explain insect classification ● Describe metamorphosis in insects and its regulation ● Describe parthenogenesis ● Describe moulting and its regulation ● Describe ametabolous insect orders		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Analyse insect characters ● Identify insect type ● Recollect life cycle and life stages in insect life		
1.1	Definition and introduction to taxonomy	1L
1.2	Dichotomous key for identification	1L

1.3	Insect classification – past and present	1L
1.4	Metamorphosis – definition and types	1L
1.5	Hormonal regulation of metamorphosis	1L
1.6	Life stages of insect – egg, larva, nymph, and pupae	2L
1.7	Parthenogenesis	2L
1.8	Moulting	1L
1.9	Hormonal regulation of Moulting	1L
1.10	Ametabolous Orders - Thysanura, Diplura, Protura, Collembola	4L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Text book of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Text Book of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gillbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits &

control End. 4, Ms Graw Hill, New York

Module II	Hemimetabolous and Holometabolous Insect Orders	15L

Learning objectives

The module is intended to -

- Describe hemimetabolous
- Describe holometabolous insect order

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Analyse insect characters
- Identify insect type

2.1	Hemimetabolous Insect Orders 2.1.1 Ephemeroptera, Odonata, Orthoptera, Phasmida, Dermaptera, 2.1.2 Hemiptera, Blattaria, Mantoidea, Isoptera, Siphunculata	4L 4L
2.2	Holometabolous Insect Orders 2.2.1 Thysanoptera, Neuroptera, Strepsiptera, Siphunculata, 2.2.2 Diptera, Coleoptera, Lepidoptera, Hymenoptera	3L 4L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Text book of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Text Book of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.

Practical:

DSE II	Entomology
• Discuss Entomological Orders With Examples • Describe Development Of Insect Using Examples • Understand Parthenogenesis • Describe identification using key	
• Relate Insect To The Characteristics Of A Particular Order • Elaborate And Draw Examples Of Insect Orders • Use Dichotomous key to identify insects	
1	Use of dichotomous key for insect identification
2	Study of types of larvae
3	Study of types of pupae
4	Study of parthenogenesis
5	Study of ametabolous insect orders - examples
6	Study of hemimetabolous insect orders - examples
7	Study of holometabolous insect orders – examples
8	Field visit and report – insect identification on field

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Text book of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Text Book of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.

- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gillbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Ms Graw Hill, New York

ZOOLOGY SEMESTER VII
DSE- III
COURSE TITLE: Animal Type study
COURSE CODE 23PS7ZODSE3ATS
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Describe the morphology and organ systems of sepia 2. Elaborate the economic importance and conservation status of sepia 3. Describe the morphology and organ systems of shark 4. Elaborate the economic importance and conservation status of shark		
Module I	**Invertebrate Model Organism - Sepia**	**15L**
Learning objectives The module is intended to - ● Make the learner understand the morphology and anatomy of sepia ● Describe to the learner the importance of this animal in nature		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Classify sepia ● Describe all systems of sepia ● Draw neat and labelled diagrams of the same ● Elaborate on the economic importance and conservation status of sepia		
1.1	Morphology and systemic position	2L
1.2	Digestive system	2L

1.3	Circulatory System	2L
1.4	Nervous system	3L
1.5	Reproductive system - male and female	4L
1.6	Economic importance and conservation status	2L

References

- Invertebrate Zoology by P S Verma (Author), E L Jordon : S Chand; Fifteenth edition

Module II	**Type Study of Vertebrate - Shark**	**[15L]**

Learning objectives

The module is intended to -

- Make the learner understand the morphology and anatomy of shark
- Describe to the learner the importance of this animal in nature

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Classify shark
- Describe all systems of shark
- Draw neat and labeled diagrams of the same
- Elaborate on the economic importance and conservation status of shark

2.1	Morphology and systemic position	2L
2.2	Digestive system	2L
2.3	Circulatory System	2L
2.4	Nervous system	3L

2.5	Reproductive system - male and female	4L
2.6	Economic importance and conservation status	2L

References:

- P.S. Dhami & J.K. Dhami, 1981. Chordate zoology. (R. Chand & Co.).
- R.L.Kotpal, 2000. Modern textbook of zoology, Vertebrates. (Rastogi Publ., Meerut).
- E.L. Jordan & P.S. Verma, 1998. Chordate zoology. (S. Chand & Co.)

Practical:

DSE III	**Type Study of Invertebrate and Vertebrate**

Learning Objectives

This practical is intended to

- Make the learner understand the morphology and anatomy of sepia and Shark

Learning Outcomes

After the successful completion of the practical, the learner will be able to

- Describe the morphology and organ systems of sepia
- Describe the morphology and organ systems of shark

1. Study of Digestive system of Sepia
2. Study of Circulatory system of Sepia
3. Study of Nervous system of Sepia
4. Study of male Reproductive system of Sepia
5. Study of Female reproductive of Sepia
6. Morphometric study of any available (Lab bred) fish
7. Study of Digestive system of Shark

8. Study of Circulatory system of Shark
9. Study of Nervous system of Shark
10. Study of male Reproductive system of Shark
11. Study of Female reproductive of Shark

- Above practicals will be based on study of systems using diagrams and virtual resources. Dissection of animals will not be performed under this course.

ZOOLOGY SEMESTER VIII
Core Course- I
COURSE TITLE: Industrial Biotechnology
COURSE CODE 23PS8ZOCC1IBT
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe the process of large scale culture of various biomolecules by recombinant microorganism and genetically engineered animal cells by various fermentation methods. 2. Discuss the various types of vaccines, their production and advantages over conventional vaccines 3. Explain the production and applications of monoclonal antibodies 4. Enlist applications of biotechnology in agricultural fields such as use of biotechnology techniques for better nitrogen fixation, pest resistance and disease resistance. 5. Explore the use of algae for biofuel and its various bioactive compounds.

Module I	**Large scale culturing techniques**	**15L**

Learning objectives

The module is intended to -

- Make the learner understand large scale culturing techniques and downstream processing involving recombinant bacterial and animal cells
- Explain the applications of large scale culture and their commercial products

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain different types of bioreactor designs based on the requirement of the culture
- Discuss the optimum parameters required for large scale culture system
- Enlist different animal cell lines and their applications in large scale culture

Subtopic	Title	15L
1.1	Large scale culture & production from recombinant microorganisms- 1.1.1 Batch fermentation 1..1.2 Fed batch fermentation 1.1.3 Continuous fermentation 1.1.4 Maximizing the efficiency of fermentation process 1.1.5 Harvesting, disrupting & downstream processing 1.1.6 Typical Large-scale fermentation systems : Two-Stage Fermentation in Tandem Airlift Reactors , Two-Stage Fermentation in a Single Stirred-Tank Reactor, Batch versus Fed-Batch Fermentation	 1L 1L 1L 1L 1L 4L
1.2	Large scale culture & production from genetically engineered animal cell cultures - 1.2.1 Basic structure of Bioreactors, Design of bioreactors for large scale animal cell culture-Batch, Fed batch 1.2.2 Mammalian cell lines & their characteristics 1.2.3 Media for the cultivation of mammalian cells 1.2.4 Commercial products produced with mammalian cell culture	 1L 2L 2L 1L

References

- Molecular Biotechnology- Principles and applications of recombinant DNA- B. Glick and J. Pasternak, 3rd edition
- Biotechnology - U. Satyanarayana, Books and Allied Ltd.
- Basic Biotechnology- Colin Ratledge , 3rd Edition

Module II	Agricultural Biotechnology	15L

Learning objectives

The module is intended to -

- Convey the importance of new biotechnological practices in improving agricultural produce
- Make the learner understand the concepts of biofertilizers and biopesticides
- Impress upon the learner the need to explore alternative energy sources from marine environment

Learning outcomes

After the successful completion of the module, the learner will be able to -

- State the drawbacks of conventional fertilizers and pesticides
- Schematically explain process of nitrogen fixation and nodulation
- Describe the genetic engineering of nif,hup and nod genes
- Define genetic complementation
- Explain the production of Bt based pesticides
- Elaborate the processes to make various resistant crops/ plants
- Enumerate marine natural products and their applications

2.1	Bio-fertilizers 2.1.1 Concept of Nitrogen fixation 2.1.2 Nitrogenase-Component of nitrogenase; Genetic engineering of nitrogenase cluster 2.1.3 Hydrogenase-Hydrogen metabolism 2.1.4 Genetic engineering of hydrogenase gene 2.1.5 Nodulation-Competition among nodulation organisms, genetic engineering of nodulation gene	 1L 1L 1L 1L 1L
2.2	Bio-insecticides 2.2.1 Toxins of *Bacillus thuringiensis*, 2.2.2 mode of action & use of *thuringiensis* toxins, 2.2.3 Thuringiensis toxin gene isolation, 2.2.4 Genetic engineering of *Bacillus thuringiensis* strains 2.2.5 Cloning of *thuringiensis* toxin gene.	 1L 1L 1L 1L 1L
2.3	Transgenic Plant Technology 2.3.1 Insect resistant plants 2.3.2 Virus resistant plants 2.3.3 Herbicide resistant plants	 1L 1L 1L
2.4	Algal products 2.4.1 Fuels from algae 2.4.2 Marine natural products & their medical potential-anticancer, antiviral compounds, antibacterial agents.	 1L 1L

References

- Molecular Biotechnology- Principles and applications of recombinant DNA- B. Glick and J. Pasternak, 3rd edition

- Biotechnology - U. Satyanarayana, Books and Allied Ltd.
- Basic Biotechnology- Colin Ratledge , 3rd Edition

ZOOLOGY SEMESTER VIII
Core Course- II
COURSE TITLE: Ethology - Animal Behavior and Behavioral Ecology
COURSE CODE 23PS8ZOCC2ABE
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Understand the fundamental concepts, theories, and methodologies in ethology and animal behavior. 2. Analyze the proximate and ultimate causes of animal behavior, including genetic, physiological, and evolutionary factors. 3. Apply observational and experimental methods to study and interpret animal behavior. 4. Evaluate the ecological and evolutionary implications of animal behavior in various contexts.

Module I	**Introduction to Ethology**	**15L**

Learning objectives

The module is intended to -

- Understand the concepts, scope, and historical development of ethology
- Differentiate between proximate, ultimate causes of behavior and develop proficiency in observational and experimental studies, modes of communication.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain the concept and scope and contributions in ethology.

- Differentiate between proximate and ultimate causes of animal behavior and provide examples of genetic, physiological, and developmental factors influencing behavior.
- Observe and interpret experimental methods to study animal behavior.

Subtopic	Title	Lecture distribution
1.1	Overview of Ethology 1.1.1 Definition and scope of ethology 1.1.2 Historical perspectives and key contributors	 2L 2L
1.2	Animal Behavior: Proximate and Ultimate Causes 1.2.1 Proximate causes: Genetic, physiological, and developmental mechanisms 1.2.2 Ultimate causes: Adaptive significance and evolutionary explanations 1.2.3 The role of genes and environment in shaping behavior	 2L 1L 1L
1.3	Methods in Ethology 1.3.1 Observational methods: Direct and indirect observations 1.3.2 Experimental methods: Field experiments, laboratory experiments, and controlled studies 1.3.3 Data collection and analysis techniques	 1L 2L 1L
1.4	Communication and Signaling 1.4.1 Types of animal communication: Visual, auditory, chemical, and tactile 1.4.2 Signaling mechanisms: Signals, cues, and displays 1.4.3 Functions and evolution of animal communication	 1L 2L 1L

References

- John Alcock, 2009. Animal Behavior: An Evolutionary Approach. Ninth Edition. Sinauer Associates.
- Michael Begon, Colin R. Townsend, John L. Harper, 2006. Ecology From Individuals to Ecosystem. Fourth Edition. Blackwell Publishing.
- Aubrey Manning, Marian Stamp Dawkins, 2012. AN INTRODUCTION TO ANIMAL

BEHAVIOUR. Sixth Edition. Cambridge University Press.
- Eugene P. Odum, Gray W. Barrett, 2017. Fundamental of Ecology. Fifth Edition. Cengage India.

Module II	**Behavioral Ecology**	**15L**

Learning objectives

The module is intended to -

- Understand the theories of foraging and decision-making strategies.
- Analyze the different forms of reproductive behavior, influence of parental investment on reproductive success.
- Examine the concepts of territoriality, home range and migration.
- Explore the evolutionary mechanisms of social organization and cooperation.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Apply the principles of optimal foraging theory to explain food choice and decision-making in animals.
- Describe the mechanisms of sexual selection, mate choice and territoriality.
- Analyze the patterns, navigation strategies and mechanisms of migration,
- Explain the evolutionary drivers of social organization and cooperation.

Subtopic	**Title**	**15L**
2.1	Foraging Behavior: 2.1.1 Optimal foraging theory 2.1.2 Food choice and decision-making 2.1.3 Predation risk and anti-predator strategies	 2L 1L 1L
2.2	Reproductive Behavior: 2.2.1 Sexual selection and mate choice 2.2.2 Mating systems and strategies 2.2.3 Parental investment and reproductive success	 2L 1L 1L
2.3	Territoriality and Home Range:	

	2.3.1 Territory establishment and defense 2.3.2 Resource distribution and territorial behavior 2.3.3 Ecological and evolutionary implications of territoriality	1L 1L 1L
2.4	Social Organization and Cooperation: 2.4.1 Evolution of sociality: Kin selection and inclusive fitness 2.4.2 Altruism and reciprocal cooperation, Reciprocal altruism and cooperation among non-relatives 2.4.3 Cooperative breeding and eusociality	 2L 1L 1L

References

- John Alcock, 2009. ANIMAL BEHAVIOR: AN EVOLUTIONARY APPROACH. Ninth Edition. Sinauer Associates.
- Michael Begon, Colin R. Townsend, John L. Harper, 2006. ECOLOGY FROM INDIVIDUALS TO ECOSYSTEM. Fourth Edition. Blackwell Publishing.
- Aubrey Manning, Marian Stamp Dawkins, 2012. AN INTRODUCTION TO ANIMAL BEHAVIOUR. Sixth Edition. Cambridge University Press.
- Eugene P. Odum, Gray W. Barrett, 2017. FUNDAMENTAL OF ECOLOGY. Fifth Edition. Cengage India.

ZOOLOGY SEMESTER VIII
Core Course- III
COURSE TITLE: Human Diseases
COURSE CODE 23PS8ZOCC3HUD
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Explain the various metabolic errors observed in humans 2. Analyze the causes and treatments of these disorders 3. Enlist various lifestyle disorders commonly observed in society 4. State the risk factor, causes, symptoms, treatment and prevention of major lifestyle diseases

Module I	Inborn errors of Metabolism	[15L]

Learning Objectives
The module is intended to
- Explain the significance of errors in metabolism, their occurrence in the human population, causes and effects
- Make the learner aware of the genetic basis and clinical manifestations of inborn errors of metabolism

Learning Outcomes
After the successful completion of the module, the learner will be able to
- Enlist the causes , symptoms and clinical presentations for various inborn errors of metabolism
- Elaborate on the treatment modalities for the same

Subtopic	Title	Lectu

		re distribution
1.1	Concept of Inborn Errors in Metabolism	1L
1.2	1. Carbohydrate metabolism 2. G-6PD deficiency 3. Pompe's Disease 4. Kori's disease	3L
1.3	Lipid metabolism: Metabolic disorders of cerebrosides Gaucher's disease Tay Sachs disease Niemann Pick disease	3L
1.4	Protein metabolism Alkaptonuria PKU Albinism	3L
1.5	Purine metabolism Primary Gout Lesch Nyhan Syndrome	2L
1.6	Mineral metabolism and diseases Hypocalcaemia Hypercalcaemia Osteoporosis	3L

References:

● iGenetics- A Molecular approach by Peter J.Russell, 3rd edition
● Genetics- Strickberger, Monroe W.,Second edition, Macmillan Publication.

Module II	**Lifestyle diseases**	**15L**

Learning Objectives

The module is intended to

- Explain the significance of lifestyle factors affecting human health

- Make the learner aware of various lifestyle related diseases
- Discuss characteristics and causes of non communicable diseases with respect to lifestyle disease

Learning Outcomes

After the successful completion of the module, the learner will be able to

- Enlist the risk factor, causes, symptoms, treatment and prevention of major lifestyle disease
- Elaborate on dynamics of lifestyle disease in India
- Explain and differentiate between characteristics and causes of non communicable diseases with respect to lifestyle disease

2.1	Non communicable diseases: characteristics and causes with respect to lifestyle disease	2L
2.2	Risk factor, causes, symptoms, treatment and prevention of major lifestyle disease: a. Cardiovascular diseases b. Diabetes c. Cancer (lung, cervical, breast, prostate and colorectal) d. Chronic Obstructive Pulmonary Disease (COPD) e. Obesity f. PCOS	 2L 2L 2L 2L 2L 1L
2.3	Dynamics of lifestyle disease in India - Trends in population and Governments measures	2L

References:

- https://www.un.org/en/chronicle/article/lifestyle-diseases-economic-burden-health-services
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2862441/
- https://pib.gov.in/Pressreleaseshare.aspx?PRID=1540840
- Lifestyle Diseases Paperback by Surendra G Gattani (Author), Ajay D Kshirsagar

ZOOLOGY SEMESTER VIII
Core Course- IV
COURSE TITLE: Biostatistics - Basic concepts and hypothesis testing
COURSE CODE 23PS8ZOCC4BHT
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Define basic terminology of biostatistics 2. Compare between various sampling methods and distribution tables 3. Apply the rules of probability to biological systems 4. Analyze data using t-test, z test and chi square test 5. Use computers to solve statistical problems

Module I	**Basic Concepts In Biostatistics**	**15L**
Learning objectives The module is intended to - ● Make the learner understand the basic concepts of Biostatistics.		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Analyze basic data using principles of Biostatistics. ● Define terminologies related to Biostatistics. ● Classify the given data through various representation methods.		
Subtopic	**Title**	**15L**
1.1	Scope of biostatistics- definition and limitations Use of computers in biostatistics	2L

1.2	1.2.1 Classification of data : Tabulation-simple tables , complex tables, frequency distribution tables, 1.2.2 Diagrammatic presentation—frequency polygon, frequency curves, bar, column, (simple, multiple, segmented, 100% stacked), area, line, pie diagrams. Using Graph paper and MS excel	1L 3L
1.3	Measure of central tendency and dispersion : Mode, Median, Mean, range, Variance and Standard deviation Using manual method and MS Excel	4L
1.4	Normal distribution Curve: Properties and Significance	2L
1.5	Rules of Probability and its application	3L

References

- Cochran W.G. : Sampling Technique Third edition. Wiley Eastern.
- Des Raj and Chandok: Sampling Design. Tata McGraw Hill.

Module II	**Various Tests In Biostatistics**	**15L**

Learning objectives

The module is intended to -

- Acquaint the learner with the concepts of probability and the parametric and non-parametric tests in Biostatistics.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Demonstrate the applications of probability and various tests in Biostatistics in biological scenarios.

Subtopic	Title	15L
2.1	Statistical hypothesis- null hypothesis, alternative Hypothesis	2L
2.2	Parametric test of significance - student's t test	3L
2.3	Z- test and its applications	2L
2.4	F-test and its application	2L
2.5	Non parametric test - chi-square test	2L
2.5	ANOVA and types	4L

References

- Veer Bala Rastogi, Biostatistics third edition,medtech pub 2017
- B. K. Mahajan Methods in Biostatistics 7th edition,Jaypee pub. Jan2010

Practical
23PS8ZOCCP1

Core course I	Biotechnology and Culturing Techniques

Learning Objectives

This Practical is intended to

- Demonstrate basic aseptic skills to the learner
- Emphasise on the need to maintain asepsis in the Biotechnology laboratory
- Prepare the student for performing basic microbiological practicals and projects independently

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Perform aseptic transfers of cultures
- Prepare sterile media and glassware for tissue culture
- Demonstrate various streaking techniques for Bacterial isolation
- Carry out various bacteriological enumeration experiments
- Immobilize yeast cells in calcium alginate and test its activity
- Use the mini-prep test kit to demonstrate isolation of plasmid DNA

1. Demonstration of aseptic Techniques
2. Media Preparation - to prepare and sterilise various media such as NA,NB,LB and check the sterility
3. Preparation of LB agar slant, butt and plate
4. Streaking Techniques - T streak, side streak, quadrant streak
5. Determination of viable cell count in the given culture of bacteria by Serial dilution & spreading technique.
6. Nephelometry-To estimate the number of bacteria in the given culture by Nephelometry
7. Using Mini-prep method isolate Plasmid DNA from the given strain of bacteria & show the purity of the isolate by performing agarose gel electrophoresis
8. Immobilize Yeast cells in calcium alginate & prepare a bioreactor column to demonstrate Invertase activity in the bioreactor column
9. To plot a growth curve for the given bacterial population and compare the growth pattern in various media

Suggested project:

1. To Compare the bacterial profile of processed and fresh foods/ beverages

23PS8ZOCCP2

Core course II	**Ethological data collection and interpretation**

Learning Objectives

This Practical is intended to make the students

- Understand the key concepts of Ethology, data collection on field and its analysis
- Document comparative animal behaviour under various stimuli
- Apply Ethological concepts on field and frame experiments

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Collect data from the field using various techniques
- Apply concepts of animal behaviour and draw conclusions
- Perform field experiments to various taxa
- Create an ethogram and analyse time budget using software

1	Study of Field sampling methods - Focal sampling, scan sampling
2	Study of Field sampling methods - behaviour sampling, ad lib sampling
3	Study of construction of ethogram
4	Recording animal behaviour and calculating time budget using BORIS
5	Study of Burrow and chimney building behaviour of sand bubbler crabs
6	Report writing on documentary
7	Zoo visit to record animal behaviour in captivity
8	Study of behaviour system using fish display tank

23PS8ZOCCP3

Core course III	**Human Diseases**

Learning Objectives:

The practicals are intended to help the learner

- Analyze various lifestyle diseases dynamics
- Assess the significance of BMI
- Estimate level of glucose, triglycerides and protein from blood

Learning Outcomes

After successful completion of the practical the learner will be able to

- Describe the dynamics of lifestyle diseases
- Measure BMI
- Quantify level of glucose, triglycerides and protein from blood

1. Test kit for G6PD
2. Conduct a Case study on-
   - PCOS
   - COPD
   - Lung cancer
   - Obesity
   - Type 2 diabetes
3. Survey and analysis on any lifestyle diseases and metabolic disorders
4. Survey, calculation and analysis of BMI
5. Estimation of blood sugar level using glucometer/ GOD POD test kit
6. Estimation of cholesterol from blood/serum sample
7. Estimation of triglycerides from blood/serum sample

Suggested projects:

1. Comparative study of fiber content of various food groups
2. Survey of various dietary practices
3. Comparative study of protein content of various food groups
4. Comparative study of sugar content of various food/ fruit groups

23PS8ZOCCP4

Core course IV	**Biostatistics - Basic concepts and hypothesis testing**

Learning Objectives

The practicals are intended to

- Make the learner understand the basic concepts of Biostatistics.
- Acquaint the learner with the concepts of probability and the parametric and non-parametric tests in Biostatistics.

Learning Outcomes

After successful completion of the practical the learner will be able to

- Analyze basic data using principles of Biostatistics.
- Solve the given data through various representation methods
- Demonstrate the applications of probability and various tests in Biostatistics in biological scenarios.

1. Descriptive statistics and graphical presentation using Microsoft Excel
2. Calculation of Mean, Mode and Median using spreadsheet application.
3. Problems based on sampling techniques
4. Problems based on Probability
5. Problems based on T-test, Z-test and Chi-square test
6. Problems based on statistical tests for accepting or rejecting the null hypothesis ANOVA using free online tools (Demo)
7. Introduction to R Software

Suggested Projects

1. Introduction to literature database at NCBI and querying the PUBMED central database using the ENTREZ search engine
2. Study of Any two proteins and two genes sequences using online databases

ZOOLOGY SEMESTER VIII
DSE- I
COURSE TITLE: Biological Oceanography And Marine Microbiology

COURSE CODE: 23PS8ZODSE1BOM
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Compare between the organisms, their characters and requirements 2. Discuss the physical factors that affects marine life 3. Enlist various marine microorganisms, Compare and contrast between the various groups of microbes found in mangroves and coral reefs. 4. Discuss the process of breakdown of various xenobiotics by microbes and Describe methods for controlling water pollution

Module I	**Biological Oceanography**	**15L**
Learning objectives The module is intended to - ● Explain the marine environment and its components to the learner ● Elucidate on effect of various physical parameter of seawater on marine animals ● Discuss on marine biotic diversity, intertidal organisms and their zonations and role of marine bacteria in marine environment		
1.1	Division of marine environment	1L
1.2	1.2.1 Marine biotic diversity: Plankton, Nekton, Benthos- Classification and adaptation 1.2.2 Factors influencing the distribution and abundance of plankton, plankton bloom, patchiness and their vertical distribution, Diurnal	2L 3L

	migration of zooplankton, Inter-relationship between phytoplankton and zooplankton. 1.2.3 Benthic organisms in relation to food chain and their ecological role 1.2.4 Intertidal organisms and their zonation, adaptation	1L 1L
1.3	Effect of physical factors on marine life a) Light- photosynthesis, colouration, structural adaptations, bioluminescence. b) Temperature- tolerance, geographical distribution, size, calcium precipitation, metabolism, bipolarity, tropical submergence and periodicity. c) Salinity- tolerance and distribution, size, buoyancy and osmoregulation. d) Currents- role in nutrition, transportation and propagation	2L 2L 2L 1L

References

- The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd
- Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd
- Oceanography: An Invitation to Marine Science by Tom Garrison; Brooks/Cole; 9th edition
- A Textbook of Marine Ecology – Nair, N.B. & Thumpy, D.H., the Macmillan Book Company of India Ltd
- Element of marine ecology by R.V. Tait and F.A. Dipper
- Biological Oceanography: An Introduction by Carol M. Lalli and Timothy R. Parsons; Butterworth-Heinemann; 2nd edition

Module II	**Marine Microbiology and biodegradation**	**15L**

Learning objectives

The module is intended to -

- Discuss the diversity of various marine microorganisms.
- Elaborate the importance of microbial ecology of coastal, shallow and deep sea waters.
- Describe various groups of microbes found in mangroves and coral environments.
- Elucidate the bioremediation process with respect to various synthetic compounds in marine water bodies

- Elaborate on the types of microbes involved in bioremediation

Learning outcomes

After the successful completion of the module, the learner will be able to -

he successful completion of the module, the learner will be able to

- Enlist different marine microbes along with their roles in the ecosystem.
- Compare the microbial ecology of coastal, shallow and deep sea waters.
- Conclude the significance of various microorganisms found in mangroves and coral environments.
- Emphasize on the need for bioremediation in marine environment
- Describe the mechanisms involved in bioremediation
- Enlist the microbes involved in bioremediation of different compounds

Subtopic	**Title**	**15L**
2.1	Ecology of coastal, shallow and deep sea microorganisms - importance and their significance.	2L
2.2	Diversity of microorganism - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment	3L
2.3	Natural and synthetic material in the marine environment- pesticide, cellulose degradation, hydrocarbon production.	5L
2.4	Bioremediation of xenobiotics, oil, heavy metals, pesticides, plastics, etc. Mining and metal biotechnology.	5L

References

- John Paul 1999. Marine Microbiology, Elsevier.
- Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
- Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons. Hans G. Truperet. al 1991.
- Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications

Practical:

23PS8ZODSEP1

DSE I	Biological Oceanography And Marine Microbiology

Learning Objectives

This Practical is intended to

- Demonstrate various methods for plankton population estimation
- Assist the learner identify various zooplanktons
- Study fecundity of fish by correlating various biometric parameters and by measuring fish ova diameter

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Calculate plankton population from given sample
- Identify common zooplanktons by observing their permanent slides
- Calculate fecundity-maturation of fish by their biometric parameters and ova diameter

1. Laboratory procedure for quantitative estimation of plankton settling method, wet weight method, weight displacement method, counting method.
2. Preparation of permanent slides for zooplankton
3. Introduction to sampling techniques for Benthos
4. Identification of Zooplankton permanent slides (Noctiluca, Obelia medusa, Zoea, Copepods, Mysids, Echinoderm larvae, Nauplius, Sagitta, Doliolum, Salpa, Lucifer sp., Chaetognaths, Fish eggs and larvae, Jellyfish, Physalia, Porpita)
5. Study of fecundity-maturation in fish.
6. Plotting the frequency polygon by ova diameter measurement.
7. Isolation of pathogenic organism from seafood
8. Characterization of marine bacteria using biochemical tests and staining techniques
9. Comparative bacterial profile of processed and fresh seafood
10. Study of Microbial diseases in fishes
11. Visit to intertidal zone and submission of report

ZOOLOGY SEMESTER VIII
DSE- II
COURSE TITLE: Entomology – Type animal and Insect control
COURSE CODE 23PS8ZODSE2TIC
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Recognize various morphological features of cockroach as a type animal 2. Understand anatomy of cockroach as a type animal 3. Identify different insect toxicants and their effect 4. Summarize Biological Control and IPM techniques		
Module I	**Study of type animal – Cockroach**	**15L**
Learning objectives The module is intended to - ● Describe morphology of cockroach ● Describe anatomical organization of cockroach ● Discuss ecosystem services by cockroach		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Identify cockroach in field ● Analyze relation between various anatomical features of cockroach		
1.1	Classification and diversity	1L

1.2	Morphology	1L
1.3	Digestive system	1L
1.4	Circulatory system	2L
1.5	Excretory system	2L
1.6	Nervous system	2L
1.7	Reproductive system	2L
1.8	Development	2L
1.9	Ecosystem services by cockroach	1L
1.10	Cockroach in entomological research	1L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gilbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.

- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Mcgraw Hill, New York

Module II	**Principles of Insect Control**	**15L**

Learning objectives

The module is intended to -

- Explain different methods of control
- Classify types of insecticides
- Identify mode of action and resistance to the methods
- Identify integrated pest management

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Understand the type of infection and apply control method/s
- Recognize importance of integrative approach to insect control
- Categorize insecticides based on their effect

Subtopic	**Title**	**15L**
2.1	Scope, definition, and history of insecticides	1L
2.2	Chemical control – classification and evolution of insecticides, types, mode of action, insecticide formulation and application	4L
2.3	Biological control methods	1L
2.4	Integrated pest management	2L
2.5	Principles of toxicology. Evaluation of insecticide toxicity, synergists, potentiation, antagonism	3L

2.6	Insecticide metabolism	2L
2.7	Insecticide residues	1L
2.8	Pest resistance to insecticides	1L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.

Practical

23PS8ZODSEP2

DSE 2	Type animal and Insect control

Learning objectives

This practical is intended to

- Describe morphology and anatomy of locally available pest insect
- Understand the effect of pesticide on organisms

Learning outcomes

After the successful completion of the practical, the learner will be able to

- Draw morphological and anatomical features of cockroach
- Relate insecticide and toxicant and its effect on insects

1. Study of morphology of cockroach

2. Study of different species of cockroaches in India
3. Study of digestive system of cockroach
4. Study of circulatory system of cockroach
5. Study of nervous system of cockroach
6. Study of excretory system of cockroach
7. Study of reproductive system of cockroach
8. Effect of insecticide (Lc50)
9. Study of different types of insecticides – structure, mode of action

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gilbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Mcgraw Hill, New York

ZOOLOGY SEMESTER VIII
DSE- III
COURSE TITLE: Model organisms in biological research
COURSE CODE 23PS8ZODSE3MOB
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Enlist examples of model organisms used in biological research 2. Elaborate on their characteristics, Morphology, Genome , Breeding, maintenance and applications 3. Compare and contrast between vertebrate and invertebrate systems 4. Plan research using these model organisms		
Module I	**Invertebrate Model organisms**	**15L**
Learning objectives The module is intended to - ● Familiarize the learner with some invertebrate model organisms used in research ● Make the learner understand the significance of invertebrate systems		
Learning outcomes After the successful completion of the module, the learner will be able to - ● Describe various invertebrate model organisms ● Explain their characteristics, Morphology, Genome , Breeding, maintenance and applications ● Comment on the ethical use of animals ● Design experiments employing model organisms		
1.1	Concept and significance of model organism	1 L

1.2	General characteristics, Morphology, Genome characteristics, Breeding, maintenance and applications of following model organisms in biological research 1. *Dictyostelium* 2. *Caenorhabditis elegans* 3. *Drosophila*	2L 2L 2L
1.3	Advantages and disadvantages of invertebrate model organisms	2L
1.4	Experimental design and requirements for using invertebrate model organisms	3L
1.5	Ethical use of laboratory animals	3L

References

- Leonelli, S., & Ankeny, R. A. (2013). What makes a model organism?. *Endeavour*, *37*(4), 209-212.
- Bozzaro, S. (2013). The model organism *Dictyostelium discoideum*. *Dictyostelium Discoideum Protocols*, 17-37.
- Meneely, P. M., Dahlberg, C. L., & Rose, J. K. (2019). Working with worms: *Caenorhabditis elegans* as a model organism. *Current Protocols Essential Laboratory Techniques*, *19*(1), e35
- Roberts, D. B. (2006). Drosophila melanogaster: the model organism. *Entomologia experimentalis et applicata*, *121*(2), 93-103.
- Baumans, V. (2004). Use of animals in experimental research: an ethical dilemma?. *Gene therapy*, *11*(1), S64-S66.
- American Psychological Association. (1986). Guidelines for ethical conduct in the care and use of animals. *Journal of the Experimental Analysis of Behavior*, *45*(2), 127.

Module II	**Vertebrate Model organisms**	**15L**

Learning objectives

The module is intended to -

- Familiarize the learner with some vertebrate model organisms used in research
- Make the learner understand the significance of vertebrate systems

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Describe various vertebrate model organisms
- Explain their characteristics, Morphology, Genome , Breeding, maintenance and applications
- Elaborate on CPCSEA guidelines for animal research
- Design experiments employing model organisms

Subtopic	**Title**	**15L**
2.1	General characteristics, Morphology, Genome characteristics, Breeding, maintenance and applications of following model organisms in biological research 1. Zebrafish 2. *Xenopus* 3. Mice 4. Rat	 2L 2L 2L 2L
2.2	Advantages and disadvantages of vertebrate model organisms	2L
2.3	Experimental design and requirements for using vertebrate model organisms	3L
2.4	CPCSEA guidelines for use of model organisms for biological research	2L

References

- Meyers, J. R. (2018). Zebrafish: development of a vertebrate model organism. *Current Protocols Essential Laboratory Techniques*, *16*(1), e19.
- Cannatella, D. C., & De Sá, R. O. (1993). *Xenopus laevis* as a model organism. *Systematic Biology*, *42*(4), 476-507.
- Canales, C. P., & Walz, K. (2019). The mouse, a model organism for biomedical research. In *Cellular and animal models in human genomics research* (pp. 119-140). Academic Press.
- Rubio-Aliaga, I. (2012). Model organisms in molecular nutrition research. *Molecular nutrition & food research*, *56*(6), 844-85
- Committee for the Purpose of Control and Supervision on Experiments on Animals. (2003). CPCSEA Guidelines for laboratory animal facility. *Indian J. Pharmacol.*, *35*(4)

Practical
23PS8ZODSEP3

DSE III	**Model organisms in biological research**

Learning objectives

The practicals are intended to help the learner

- Understand the significance of model organisms in research
- Plan experiments related to model organisms

Learning outcomes

After successful completion of the practical the learner will be able to

- Identify various mutants of drosophila
- Prepare media for drosophila culture
- Describe various laboratory techniques employing model organisms
- Write detailed reports of the various visits

1. Visit to a research lab.
2. Workshop on *Drosophila* culture.
3. Observation of permanent slides of *Drosophila* mutants.
4. Visit to an Animal house.
5. Media and setup preparation for *Drosophila* culture.
6. To estimate LC50 of salt of heavy metal for daphnia
7. Observation of changes in giant Chromosome of chironomus larvae due to exposure to toxicants.
8. Setting up and maintenance of E.Coli culture
9. Visit the CPCSEA website to understand various application procedures.