Anekant Education Society's

TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE & COMMERCE, BARAMATI, DIST – PUNE. AUTONOMOUS

POST GRADUATE DEPARTMENT OF ZOOLOGY

SYLLABUS
M.Sc. Zoology
Part-I, SEMESTER-I

ACADEMIC YEAR 2022-2023

Anekant Education Society's

TULJARAM CHATURCHAND COLLEGE OF ARTS, SCIENCE & COMMERCE, BARAMATI.

AUTONOMOUS

Scheme of Course Structure (CBCS) Faculty of Science Post Graduate Department of Zoology

SEMESTER I

Class: M.Sc. I **Pattern: 40 (IA) + 60 (EA)**

Sr. No.	Code	Paper	Paper Title	Credit	Exam	Marks
1	PSZO 111	**Theory**	**Biochemistry & Bioenergetics**	**4**	I / E	**40 + 60**
2	PSZO 112	**Theory**	**Cell Biology**	**4**	I / E	**40 + 60**
3	PSZO 113	**Theory**	**Fresh Water Zoology & Ichthyology**	**4**	I / E	**40 + 60**
4	PSZO 114	**Theory**	**Biostatistics & Genetics**	**4**	I / E	**40 + 60**
5	PSZO 115	Zoology **Practical-I**	**Zoology Practical-I (Practicals Corresponding toPSZO 111 and PSZO 112)**	**4**	I / E	**40 + 60**
6	PSZO 116	Zoology **Practical-II**	**Zoology Practical-II (Practicals Corresponding toPSZO 113 and PSZO 114)**	**4**	I / E	**40 + 60**

IA* - Internal Assessment

EA*- External Assessment

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**
Class: M.Sc. - I **Semester: I**
Course Name: Biochemistry and Bioenergetics **Course Code: PSZO 111**
Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- To comprehend processes of gametogenesis, fertilization, and oviposition.
- To understand early insect embryonic development.
- To give a brief overview of segmentation, appendage formation, and organogenesis.
- To explore post-embryonic insect development.
- To explore strategies of emergence of adults from pupae or cocoons.
- To analyse Hadorn's experiments, specifically focusing on imaginal disc experiments.
- To familiarize with diapause in insects, and control mechanisms, gaining a precise understanding of this biological phenomenon.

Course Outcomes:-

After completion of this course students will-

CO1: analyse the structure and function of key biomolecules like water, carbohydrates, lipids, proteins, and vitamins, explaining their interactions in biological systems.

CO2: describe the different levels of protein structure (primary, secondary, tertiary, and quaternary) and explain the forces stabilizing and influencing protein folding. Apply this knowledge to predict the impact of changes on protein function.

CO3: calculate and interpret enzyme kinetics using Michaelis-Menten equation and Lineweaver-Burk plots. Explain factors affecting enzyme activity and design experiments to investigate enzyme inhibition and regulation.

CO4: diagram and analyse major metabolic pathways like glycolysis, TCA cycle, and oxidative phosphorylation, explaining their roles in energy production and regulation.

CO5: differentiate between various types of lipids, discuss their diverse functions in the body, and analyse the processes like biosynthesis of palmitic acid and beta oxidation of fatty acids.

CO6: demonstrate proficiency in conducting enzyme assays and kinetics experiments in the laboratory, interpreting data, and applying statistical methods to evaluate results.

CO7: integrate knowledge of biomolecules, enzymes, and metabolism to explain real-world biological phenomena, critically evaluate scientific research, and apply biochemical principles to solve problems in healthcare and biotechnology.

TOPICS:

UNIT NO.	SUB UNIT NO.	DETAILS
1. Biomolecules: Classification, Structure and Function (20L)	1.1	Stabilizing Interactions in Biomolecules
	1.2	Water: Structure and Function pH and Buffers Biological Buffer System
	1.3	Carbohydrates: Classification of Carbohydrates Structure, general properties and functions
	1.4	Lipids: Classification, Structure and function Major subclasses.
	1.5	Vitamins and coenzymes: Biochemistry and Functions

	1.6	Proteins: General properties of proteins, Structure of amino acid, Structure of proteins: Primary structure and its importance, Secondary structure-alpha-helix, beta-helix, Ramachandran plot, X ray diffraction, Tertiary structure: Myoglobin, Forces stabilizing, unfolding and refolding Quaternary structure-haemoglobin; Biological Roles
2. Enzymes (10L	2.1	Classification, Types of enzymes, Nomenclature Properties
	2.2	Enzyme Kinetics -One Substrate Reaction Michaelis-Menten Equation, Lineweaver-Burk plot
	2.3	Specific Activity
	2.4	Factors affecting enzyme activity
	2.5	Enzyme inhibition
	2.6	Allosteric Enzymes Isozymes (LDH)
3. Bioenergetics: - Metabolic Pathways and its energetics (30L)	3.1	Internal energy, enthalpy, entropy, concept of free energy, redox potentials, high energy compounds, structure and function of ATP.
	3.2	Concepts of metabolism: Metabolic Pathways- Catabolic and anabolic, Regulation of metabolic pathways.
	3.3	Carbohydrate metabolisms: Glycolysis TCA Glycogenesis, Glycogenolysis and Glyconeogenesis
	3.4	Electron transport chain and Oxidative phosphorylation.
	3.5	Lipid metabolism: Introduction, Biosynthesis of palmitic acid, Beta oxidation of fatty acid

REFERENCES

1. Voet, D., & Voet, J. G. (2010). Biochemistry. John Wiley & Sons.
2. Berg Jeremy, Tymoczko John, Stryer Lubert (2007), Biochemistry. Publisher: W. H.Freeman, New York.
3. Calculations, B. (1997) Segel Irvin H. Publisher: John Wiley and Sons, New York, 34.
4. Trevor, P. (2004). Enzymes: Biochemistry, Biotechnology and Clinical Chemistry.Horwood Series in Chemical Science.
5. Murray, R. K., Granner, D. K., & Rodwell, V. W. (2010). Harper's illustrated biochemistry.
6. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). Lehninger principles of biochemistry.Macmillan.

Course Articulation Matrix of PSZO 111: Biochemistry and Bioenergetics
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	1	1	1	1	1	1
CO2	3	3	1	2	1	1	1	1	1
CO3	3	3	1	3	1	2	1	1	1
CO4	3	3	1	2	1	1	1	1	1
CO5	3	2	1	1	1	2	1	1	1
CO6	2	3	1	3	1	3	1	1	1
CO7	3	3	2	3	2	1	2	1	2

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because they require students to have strong understanding of key concepts of Biochemistry. For example, CO1,2, and 5 requires students to have an in-depth understanding of biomolecule structure, protein folding, enzyme kinetics, metabolic pathways, and lipid functions.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because they require students to design experiments, interpretation and evaluation of data and applying biochemistry to solve problems demand high-level critical thinking and problem-solving abilities.

PO3: Social Competence
CO6 and 7 are directly mapped to PO3 because they require students to interact with others in a professional and effective manner. For example, CO5 requires students develops communication skills to Conducting laboratory experiments, presenting data, and working on research projects.

PO4: Research-related skills and Scientific temper
CO6 and 7 are directly mapped to PO3 because they involves designing experiments, conducting assays, analysing data statistically, and critically evaluating research directly contribute to research skills and scientific methodology.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 because they require students to apply knowledge from different disciplines to solve problems in the field of biochemistry. Applying biochemical principles to solve problems in healthcare and biotechnology demonstrates the ability to connect biochemistry to other fields.

PO6: Personal and professional competence
CO1-5 are directly mapped to PO6 because these COs primarily focus on technical skills and knowledge within biochemistry. Personal and professional competence might be indirectly developed through independent learning and critical thinking.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because they require students to uphold the ethical standards in zoology. For example, CO6 and 7 involves applying biochemical knowledge to solve problems in healthcare and biotechnology might involve ethical considerations and responsible application of knowledge.

PO8: Environment and Sustainability
CO6 and 7 are indirectly mapped to PO3 because applying biochemical principles to solve problems in biotechnology might indirectly contribute to developing sustainable technologies or addressing environmental challenges.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because they require students to design experiments, applying knowledge to real-world problems requires self-directed learning, independent research, and continuous learning to stay updated with scientific developments.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**
Class: M.Sc. - I **Semester: I**
Course Name: Cell Biology **Course Code: PSZO 112**
Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Understand the basic chemical principles that underlie the structure and function of biological molecules.
- Explain the structure and function of the plasma membrane, including the various mechanisms of membrane transport.
- Describe the structure and function of the organelles of the endomembrane system and peroxisomes.
- Explain the structure and function of the nucleus, including the role of the nuclear envelope in regulating gene expression.
- Compare and contrast the structure and function of mitochondria and chloroplasts.
- Explain the different types of cell signaling pathways and the role of cell adhesion molecules in cell communication.
- Describe the cell cycle and the factors that regulate it.

Course Outcomes:-

After completion of this course students will-

CO1: analyse the interactions and roles of key biomolecules like carbohydrates, lipids, proteins, and nucleic acids, understanding how their chemical properties dictate their functions within the cell.
CO2: explain the different models of plasma membrane structure and describe the various mechanisms of membrane transport along with their regulation and energetics.
CO3: compare and contrast the structure and function of cell organelles, including their roles in protein processing, secretion, and intracellular digestion.
CO4: differentiate between the components of the nucleus, like the nuclear envelope, nucleolus, and nuclear lamina, and explain their roles in regulating gene expression, DNA replication, and cell division.
CO5: distinguish between the structures and functions of mitochondria and chloroplasts, analysing their roles in energy production and protein import processes.
CO6: evaluate the different types of cell signaling pathways and the roles of receptors, second messengers, and G-protein coupled receptors in cell communication and response.
CO7: describe the phases of the cell cycle and their importance in maintaining cell integrity and preventing proliferation errors

TOPICS:

Unit No.	Subunit No.	Details
1. Overview of Chemical Nature of the Cell (2L)	1.1	Carbon as backbone of biologically important molecules.
	1.2	Macromolecules and their role in the living systems.
2. Plasma Membrane (6L	2.1	Models of cell membrane structure
	2.2	Membrane Transport: Carrier proteins (uniporters, symporters and antiporters), Active and passive transport,Voltage and transmitter gated ion channels, energetics of transport
	2.3	Membrane potential and synaptic transmission
	2.4	Nernst equation
3. The Endomembrane	3.1	Endoplasmic reticulum: Signal peptide hypothesis, protein folding, processing and secretion, lipid synthesis
	3.2	Golgi complex: Protein glycosylation and proteolytic processing

System and Peroxisomes (7L)	3.3	Lysosomes: Structure, Role in intracellular digestion andApoptosis, Lysosomal Storage Diseases
	3.4	Peroxisomes and Glyoxysomes: Structure and functions
	3.5	Intracellular Transport and protein trafficking
4. Nucleus (3L)	4.1	Ultrastructure, Nuclear pore complex
	4.2	Export and import of proteins
	4.3	Nucleolus, Nuclear lamina and its role in Cell Division
5. Mitochondria and Chloroplast (3L)	5.1	Structure, Genetic system, Functions, Protein Import andbiogenesis of mitochondria and chloroplast
6. Extracellular Matrix, Cell-Cell Junction and Adhesion (5L)	6.1	Polarity proteins
	6.2	Cell junctions: tight junction, claudins, desmosome, hemidesmosome, gap junctions and Plasmodesmata
	6.3	Cell adhesion molecules: cadherins, integrins and selectins
	6.4	Extracellular matrix of animal and plant cell
7. Cell Signaling and Transduction (7L)	7.1	Categories of chemical signaling in multicellular organisms: paracrine signaling, autocrine signaling,endocrine signaling and juxtracrine signaling
	7.2	General structure of cellular receptors
	7.3	Second messengers in cell signaling: Types and their role
	7.4	G-Protein Coupled Receptors and its associated pathway
	7.5	Receptor tyrosine kinases and its associated pathway
	7.6	Hormonal Signaling
8. Cell Cycle and its regulation (4L)	8.1	Check points of cell cycle.
	8.2	Regulation of Cyclin and Cyclin dependent kinases (Cdk),Check points- role of Rb and p53
	8.3	Inhibitors of cell cycle
9. Cytoskeleton and Motor Proteins (7L)	9.1	Microtubules: Structure, MTOC's and functions of microtubules
	9.2	Intermediate filaments: Structure, types and functions of intermediate filaments.
	9.3	Microfilaments: Actin polymerization, role in cell movement.
	9.4	Dynein, Kinesin and Myosin
	9.5	Role of the Cytoskeleton in Cancer and its pharmaceutical applications
	9.6	Inhibitors of cytoskeleton organization
10. Cancer Biology (7L)	10.1	Cancer: Types and development
	10.2	Causes of cancer: Physical, Chemical and biological agents
	10.3	Characteristics of Cancer Cell
	10.4	Tumor viruses: Hepatitis B viruses, Adenoviruses, SV40, Papillomaviruses and Retroviruses
	10.5	Oncogene and Tumor suppresser gene
	10.6	Diagnosis, Screening and treatment of cancer
11. Cell death mechanisms (4L)	11.1	Autophagy
	11.2	Apoptosis
	11.3	Anoikis

12. Stem Cell Biology (5L)	12.1	Concept, types, self-renewal, pluripotency, differentiation
	12.2	Isolation and characterization of stem cells
	12.3	Use of stem cells in tissue repair

REFERENCES

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2003). Molecular biology of the cell. Scandinavian Journal of Rheumatology, 32(2), 125-125.
2. Lodish, H., D. Baltimore, A. Berk, L. Zipursky, M. Matsudaira and J. Darnell. (1995). Molecular Cell Biology, Eds. 3, Scientific American and W. H. Freeman. New York.
3. Robertis, D. (1987). Cell and molecular biology.
4. Becker, W. M. (2005). The world of the cell.
5. Cooper, G. M., & Hausman, R. E. (2016). The Cell: A Molecular Approach.

Course Articulation Matrix of PSZO 112: Cell Biology
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	2	1	1	1	1	1	1
CO2	3	3	1	2	1	1	1	1	1
CO3	3	3	1	2	1	1	1	1	1
CO4	3	3	1	2	1	1	1	1	1
CO5	3	3	1	2	1	1	1	1	1
CO6	3	3	1	2	1	1	1	1	1
CO7	3	3	1	2	1	1	1	1	1

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because analysing biomolecule interactions, understanding membrane structure and transport, comparing organelle functions, dissecting nuclear components, contrasting energy production in organelles, evaluating signaling pathways, and describing cell cycle phases require in-depth knowledge of cell biology concepts.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because understanding how chemical properties affect biomolecule functions, comparing membrane models, evaluating transport mechanisms, analysing organelle roles, distinguishing nuclear components and their functions, differentiating energy production processes, interpreting signaling pathways, and explaining cell cycle phases require critical thinking and problem-solving skills.

PO3: Social Competence
All of the COs are directly mapped to PO3 because they primarily focus on individual knowledge and comprehension of cell biology concepts. Social interaction or collaboration might be involved in group projects or research settings.

PO4: Research-related skills and Scientific temper
All of the COs are directly mapped to PO4 because, analysing biomolecule interactions, understanding membrane models, and relating functions to biochemical properties contribute to a scientific mind-set.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 because they require students to apply knowledge from different disciplines like medicine, biotechnology, or ecology to solve problems.

PO6: Personal and professional competence
All of the COs are directly mapped to PO6 because these COs primarily focus on technical knowledge and understanding of cell biology concepts. Personal and professional competence might be indirectly developed through independent learning and critical thinking.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because understanding cell biology principles might indirectly relate to responsible use of biotechnologies or ethical considerations in medical research.

PO8: Environment and Sustainability
All of the COs are indirectly mapped to PO8 because understanding cellular processes might relate to understanding environmental issues like bioremediation or cellular adaptations.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because understanding complex cell biology concepts, analysing intricate pathways, and relating functional relationships encourages self-directed learning and staying updated with advancements in the field.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**
Class: M.Sc. - I **Semester: I**
Course Name: Freshwater Zoology and Ichthyology **Course Code: PSZO 113**
Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Develop a comprehensive understanding of different types of aquatic habitats, their physical conditions, chemical compositions, and their significance in supporting aquatic life.
- Explore and comprehend the physiological and protective adaptations in diverse freshwater organisms and emphasizing their survival strategies.
- Analyze and understand the diagnostic features and life cycles of temporary rainwater pool animals like shrimps and highlighting their biological traits and ecological roles.
- Examine the general characteristics of zooplankton with a focus on taxonomic features in groups like Rotifera, Copepoda, Cladocera, and Ostracoda, emphasizing traits used in classification.
- Gain proficiency in the classification of fish orders and explore external morphology, body forms, appendages, pigmentation, skin, scales, and phylogeny.
- Comprehend the endoskeleton structures, anatomy, physiology and emphasizing their adaptations for survival in aquatic environments.
- Evaluate and appreciate the economic importance of freshwater animals and the productivity of aquatic habitats.

Course Outcomes:-

After completion of this course students will-

CO1: demonstrate a comprehensive understanding of various aquatic habitats, including their physical conditions, chemical compositions, and the pivotal role they play in sustaining diverse aquatic life forms, fostering an appreciation for the intricate ecosystems.

CO2: develop a nuanced comprehension of the physiological and protective adaptations in a wide array of freshwater organisms, recognizing and emphasizing their intricate survival strategies in diverse aquatic environments.

CO3: analyse and understand the diagnostic features and life cycles of temporary rainwater pool animals such as shrimps, elucidating their biological traits and ecological roles within the context of dynamic freshwater ecosystems.

CO4: gain proficiency in examining the general characteristics of zooplankton, with a specific focus on taxonomic features in groups like Rotifera, Copepoda, Cladocera, and Ostracoda.

CO5: attain proficiency in the classification of fish orders, enabling a comprehensive understanding of the diversity within the aquatic vertebrate group.

CO6: comprehend the endoskeleton structures, anatomy, physiology, and various adaptations of fishes, fostering a detailed understanding of their physiological mechanisms.

CO7: evaluate and appreciate the economic importance of freshwater animals and the overall productivity of aquatic habitats, recognizing the ecological significance.

TOPICS:

Unit No.	Subunit No.	Details
Section A: Freshwater Zoology		
1. Types of Aquatic Environment (4L)	1.1	Lotic Habitat: Major river in India
	1.2	Lentic Habitat: Lakes, Ponds and Swamps, Bogs lakesand succession of lakes
	1.3	Ephemeral water bodies (Temporary habitat).
2: Physical Conditionsof Water (4L)	2.1	Movement of water, depth, viscosity, density, transparency turbidity and thermal stratification

3: Chemical Conditionsof Water (4L)	3.1	Dissolved oxygen and carbon di-oxide, pH, phosphates,sulphate content, nitrates
	3.2	Acidity, alkalinity, Mg-hardness, Ca-hardness, dissolvedsolids
	3.3	Importance of chemical conditions to aquatic life.
4: Physiological and protective adaptationsof the following (2L)	4.1	Protozoa, Rotifera, Crustaceans and Fishes.
5: Diagnostic features and life cycle of temporary rainwater pool animals (3L)	5.1	Fairy shrimps, Tadpole shrimps and Clam shrimps.
6: Respiratory and locomotory adaptations (3L)	6.1	Adaptations in freshwater insects and their larvae
7: Adaptations in freshwater reptiles (3L)	7.1	Terrapin and crocodiles
8. Economic importance of fresh water animals (2L)	8.1	Economic importance of freshwater molluscs
	8.2	Economic importance of reptiles
9. Aquatic habitat (2L)	10.1	Productivity of water bodies and its importance
10. Zooplanktons (3L)	10.1	General characters of zooplankton with special emphasis on the characters used in taxonomy: Rotifera,Copepoda, Cladocera and Ostracoda
Section B: Ichthyology		
1. Classification and Diagnostic Characters (up to orders) (4L)	1.1	Extant Cyclostomata, Chondrichthyes and Osteichthyes(9 major orders of fishes)
	1.2	Phylogeny of fishes
2.External morphology (4L)	2.1	Body form, appendages, pigmentation, skin and scales
3. Endoskeleton (5L)	3.1	Skull
	3.2	Axial Skeleton
	3.3	Appendicular skeleton.
4. Digestion (5L)	4.1	Food and feeding habits
	4.2	Digestive system and its anatomical modifications.
5. Respiration (6L)	5.1	Structure and functions of gills
	5.2	Adaptations for air breathing
	5.3	Role of air bladder in respiration and bouyancy
6. Excretion and Osmoregulation (6L)	6.1	Glomerular and aglomerular kidneys;
	6.2	Nitrogen (Ammonia, Urea and TMAO) excretions

REFERENCES

1. Mellanby, H (1975) Animal life in freshwater, 6th Edn. Chapman-Hall.
2. Welch, P. S. (1935). Limnology.
3. Hutchinson, G. E., & Edmondson, Y. H. (1957). Treatise on limnology. Wiley.
4. Laws, E. A. (2000). Aquatic pollution: an introductory text. John Wiley & Sons.
5. Macan, T. T., & Worthington, E. B. (1951). Life in lakes and rivers.

6. Bal, D. V., & Rao, K. V. (1984). Marine fisheries. Tata McGraw Hill.
7. Bone, Q., N.B. Marshall and J. H. S. Blaxter (1995). Biology of Fishes, Edn.2, Blackie, Academic, Professional (Chapman and Hall), London.
8. Hoar, W.S. and D.J. Randall, (1969). Fish Physiology. Vols. I onwards, Academic Press, New York
9. Jayaram, K.C. (1981). The freshwater fishes of India. Pakistan, Bangladesh, Burma and Sri Lanka- A Handbook. Zool. Survey of India, Academic Press, New York.
10. Khanna, S.S. (1984). An Introduction to Fishes. Central Book Depot., Allahabad.

Course Articulation Matrix of PSZO 113: Freshwater Zoology and Ichthyology
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	2	1	1	2	3	2
CO2	3	3	1	2	1	1	2	3	2
CO3	2	3	1	2	1	1	2	2	2
CO4	2	1	1	2	1	1	1	2	1
CO5	3	1	1	1	1	1	2	2	2
CO6	3	2	1	1	1	1	2	3	2
CO7	3	3	1	3	2	1	1	1	1

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because understanding diverse aquatic habitats, adaptations of freshwater organisms, fish classification, and fish anatomy require deep knowledge of freshwater ecology concepts.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because understanding intricate ecosystems, analysing survival strategies, interpreting diagnostic features, and linking physiological mechanisms to adaptations require critical thinking and problem-solving skills.

PO3: Social Competence
All of the COs are directly mapped to PO3 because they primarily focus on individual knowledge and comprehension of freshwater ecology concepts. Social interaction or collaboration might be involved in group projects or field work.

PO4: Research-related skills and Scientific temper
All of the COs are indirectly mapped to PO4 because, analysing ecosystems, adaptations, life cycles, and physiological mechanisms contribute to research skills and a scientific mind-set.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 because they require students to apply knowledge from different disciplines like conservation biology, water resource management, or environmental science to understand freshwater ecology.

PO6: Personal and professional competence
All of the COs are directly mapped to PO6 because these COs primarily focus on technical knowledge and understanding of freshwater ecology concept. Personal and professional competence might be indirectly developed through independent learning and critical thinking.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because appreciating the importance of aquatic habitats and their inhabitants, recognizing ecological significance, and understanding freshwater resource management can relate to environmental ethics and responsible citizenship.

PO8: Environment and Sustainability
All of the COs are indirectly mapped to PO8 because understanding diverse habitats, adaptations, and fish physiology directly relate to understanding environmental issues and the importance of sustainable resource management.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because understanding complex ecological concepts, analysing adaptations, and fostering appreciation for biodiversity encourages self-directed learning and staying updated with advancements in freshwater ecology.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**
Class: M.Sc. - I **Semester: I**
Course Name: Genetics and Biostatistics **Course Code: PSZO 114**
Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Develop a comprehensive understanding of Mendelian principles, gene interactions, and deviations from Mendelian inheritance, multiple alleles, linkage, and crossing over, emphasizing genetic variations.
- Analyze and interpret inheritance mechanisms for qualitative and quantitative traits, and QTL mapping.
- Explore the genetic structure of populations, applications of Hardy-Weinberg equilibrium, and comprehend how gene pools and allele frequencies contribute to population genetics.
- Evaluate the applications of somatic cell genetics, gene therapy, and gene transfer technology.
- Investigate the various types, causes, detection methods of gene mutations, and gain an introductory understanding of epigenetics.
- Gain foundational knowledge in biostatistics; understand data classification, measures of central tendency and dispersion, correlation, regression, probability, and probability distributions, preparing for statistical applications in biological sciences.
- Develop competence in conducting hypothesis tests for mean, proportions, equality of population means and variances, chi-square tests, t-tests, F-tests, ensuring a sound grasp of statistical inference in biological data analysis.

Course Outcomes:-

After completion of this course students will-

CO1: demonstrate a comprehensive understanding of Mendelian principles, gene interactions, variations from Mendelian inheritance, multiple alleles, linkage, and crossing over, showcasing their ability to interpret and explain genetic variations.

CO2: proficiently analyse and interpret inheritance mechanisms for qualitative and quantitative traits, including QTL mapping, demonstrating their capability to apply genetic principles in trait analysis and mapping.

CO3: showcase a profound grasp of population genetics, elucidating the genetic structure of populations, applications of Hardy-Weinberg equilibrium, and explaining the contribution of gene pools and allele frequencies in shaping populations.

CO4: illustrate their understanding and competency in applying somatic cell genetics principles, gene therapy, and gene transfer technology, demonstrating their ability to explore and utilize genetic technologies.

CO5: demonstrate knowledge of various gene mutation types, their causes, detection methods, and gain introductory insight into epigenetics, showcasing their awareness of genetic alterations and epigenetic mechanisms.

CO6: exhibit foundational knowledge in biostatistics, adeptly applying data classification, measures of central tendency and dispersion, correlation, regression, probability, and distributions, preparing for statistical applications in biological sciences.

CO7: showcase competence in conducting hypothesis tests for various parameters, such as mean, proportions, equality of population means and variances, employing tests like chi-square, t-tests, F-tests, displaying their proficiency in statistical inference within biological data analysis.

TOPICS:

Unit No.	Subunit No.	Details
Section-I: Genetics		
1. Gene Interactions and Deviations from Mendelian Inheritance (4L)	1.1	Introduction to Mendelian principles
	1.2	Incomplete and co-dominance
	1.3	Dominant Epistasis & Recessive Epistasis
	1.4	Duplicate Dominant Epistasis, Duplicate recessive epistasis
2. Multiple alleles (2L)	2.1	Coat colour in mice
3. Linkage and crossing over (4L)	3.1	Linkage, linkage groups, types of crossing over
	3.2	Models of molecular basis of recombination
	3.3	3-point test cross for diploids
4. Inheritance of qualitative and quantitative traits (4L)	4.1	QTL Mapping
	4.2	Quantitative Genetics: Concepts of penetrance, expressivity and variance, Heritability
	4.3	Genetic basis and influence of environment on quantitative inheritance
5. Principles of Population Genetics (4L)	5.1	Genetic structure of populations –Gene pool, Genotype Frequency, Allelic frequency
	5.2	Hardy-Weinberg law and its application
6. Somatic Cell Genetics (3L)	6.1	Its applications, Gene Therapy, Gene transfer technology
7. Human genetics (5L)	7.1	Dominant and recessive disorders,
	7.2	Pedigree Analysis
	7.3	Physical and physiological traits
8. Gene Mutation (3L)	8.1	Types, Causes and Detection
9. Introduction to epigenetics (1L)		
Section-II: Biostatistics		
1. Introduction to Biostatistics (2L)	1.1	Applications and Uses of Statistics
	1.2	Definition of Population, sample, sample sizes, Different types of Samples in scientific experiments
	1.3	Exercise and problems related to various sampling datasets
2. Data Classification (3L)	2.1	Some important terms (Class frequency, class-limits, Class-width, class –mark)
	2.2	Frequency distribution, Cumulative frequency
	2.3	Graphical representation of data (Histogram, Pie-Diagram, Ogive-curve.)
	2.4	Exercise and Problems.

3. Measures of central tendency (4L)	3.1	Concept of central tendency, Types of central tendency (Arithmetic mean, Median and mode) combined mean.
	3.2	Partition values (Quartiles, Deciles, and Percentiles)
	3.3	Exercise and problems related to Mean mode median
4. Measures of dispersion (3L)	4.1	Concept of dispersion, absolute and relative measure of dispersion
	4.2	Different measures of dispersion (Range, Quartile-Deviation, Variance and standard deviation, Coefficient of Variation) combined variance
	4.3	Exercise and Problems
5. Correlation and Regression (5L)	5.1	Bivariate data, concept of correlation, Types of Correlation, Scatter plot
	5.2	Karl Pearson's coefficient of correlation and its properties.
	5.3	Concept of regression, linear regression, regression coefficients and its properties.
	5.4	Exercise and problems.
6. Probability and probability distribution (5L)	6.1	Some important terms (types of experiment, sample space and types of sample space, events and types of events.)
	6.2	Definition of probability (mathematical and classical) conditional probability.
	6.3	Concept of random variable, univariate probability distribution and its mathematical expectation.
	6.4	Some standard probability distributions (binomial, Poisson and normal) their probability distribution, mean, variance and properties of these distribution.
	6.5	Exercise and Problems.
7. Test of hypothesis (8L)	7.1	Some important terms (hypothesis, types of hypothesis, Test, Critical region, acceptance region, type I error, type II error, level of significance, p-value)
	7.2	Test for mean and equality of two population means, Test for proportion and equality of two population proportions.
	7.3	Chi-square test for goodness of fit, Unpaired and paired 't' test,
	7.4	F test for equality of two population variances.
	7.5	Exercise and Problems.

REFERENCES

1. William S Klug and Michael R Cummings. Concepts of Genetics. Edn. IX. Prentice HallInternatl, Inc., New York, 2008.
2. Trends in Genetics. Elsevier Publications, Amsterdam.
3. Lewin, B., Krebs, J., Kilpatrick, S. T., & Goldstein, E. S. (2011). Lewin's genes X. Jones &Bartlett Learning.
4. Verma, P. S., & Agarwal, V. K. (2009). Genetics, (Multicolour Edition). S. Chand Publishing.
5. Russell, P. J. (2006). iGenetics: A Molecular Approach. ed. B. Cummings.
6. G. Vijayalakshmi and C. Sivapragasam. (2008) Research Methods –Tip and Techniques,MJP Publishers, Chennai. WWW.mjppublishers.com
7. Principles And Practice of Biostatistics : Dr J.V. Dixit
8. Antonisamy, B., Christopher, S., & Samuel, P. P. (2010). Biostatistics: principles and practice.Tata McGraw Hill Education.
9. Sokal, R. R., & Rohlf, F. J. (1987). Biostatistics. Francise & Co, New York.

Course Articulation Matrix of PSZO 114: Genetics and Biostatistics
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	2	1	1	1	1	2
CO2	3	2	1	2	1	1	1	1	2
CO3	3	2	1	2	1	1	1	1	2
CO4	3	2	1	2	1	1	1	1	2
CO5	3	2	1	2	1	1	1	1	2
CO6	2	1	2	3	2	2	2	2	3
CO7	2	1	2	3	2	2	2	2	3

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because for in-depth understanding of Mendelian principles, quantitative trait analysis, population genetics, gene transfer technologies, and mutation types requires deep knowledge of genetic concepts.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because interpreting genetic variations, analysing trait inheritance, explaining population structures, evaluating gene therapy techniques, and understanding mutation effects require critical thinking and problem-solving skills.

PO3: Social Competence
All of the COs are directly mapped to PO3 because they primarily focus on individual knowledge and comprehension of genetic concepts. Social interaction or collaboration might be involved in group projects or research settings.

PO4: Research-related skills and Scientific temper
All of the COs are indirectly mapped to PO4 because, analysing inheritance patterns, applying QTL mapping, understanding population dynamics, interpreting gene transfer mechanisms, and appreciating mutation impact contribute to research skills and a scientific mind-set.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 because they require students to apply knowledge from different disciplines like medicine and physiology to understand genetic principles.

PO6: Personal and professional competence
All of the COs are directly mapped to PO6 because these COs primarily focus on technical knowledge and understanding of genetic concepts. Personal and professional competence might be indirectly developed through independent research or critical thinking.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because analysing data objectively, reporting results accurately, and interpreting them responsibly are crucial for upholding scientific integrity and contributing to effective citizenship.

PO8: Environment and Sustainability
All of the COs are indirectly mapped to PO8 because applying statistical tools to analyse environmental data can contribute to research in areas like sustainability, resource management, and ecological studies.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because designing and interpreting statistical analyses, mastering data analysis techniques, and staying updated with statistical tools requires self-directed learning, independent research, and continuous learning to stay updated with advancements in biological data analysis.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**

Class: M.Sc. - I **Semester: I**

Course Name: Zoology Practical-I (Practicals Corresponding to PSZO 111, PSZO 112) **Course Code: PSZO 115**

Number of Credits: 04 **Number of Practicals: 10**

Course Objectives:-

- Demonstrate proficiency in preparing standard acid and alkali solutions and conduct accurate acid-base titrations, showcasing fundamental skills in solution preparation and titration techniques.
- Acquire the ability to prepare buffers of known pH and molarity, determine pH levels in various samples, and assess their buffering capacity.
- Develop expertise in biochemical estimation techniques by accurately estimating inorganic phosphates, sugar (glucose), tyrosine, vitamin C, amylase activity, and protein levels using respective methods.
- Analyze enzyme behaviour by determining optimum pH, investigating the impact of substrate concentration, pH, temperature, inhibitors, and activators on enzyme activity.
- Gain proficiency in measuring cell size using micrometres, conducting differential centrifugation for subcellular molecule harvesting, and assessing cell viability through various assays.
- Demonstrate competency in differential staining for DNA and RNA, Feulgen staining for DNA, collagen demonstration, cell culturing, and aseptic technique application.
- Develop skills in preparing metaphase chromosomes, evaluating the effect of colchicine treatment on mitosis, and conducting short-term cultures for chromosome analysis.

Course Outcomes:-

After completion of this course students will-

CO1: proficiently prepare standard acid and alkali solutions and execute accurate acid-base titrations, establishing a strong foundation in fundamental solution preparation and titration techniques.

CO2: gain proficiency in preparing buffers of known pH and molarity, along with evaluating pH levels in diverse samples and assessing their buffering capacities.

CO3: demonstrate competency in employing various biochemical estimation techniques to precisely measure inorganic phosphates, sugar (glucose), tyrosine, vitamin C, amylase activity, and protein levels using respective methods.

CO4: analyse enzyme behaviour by investigating optimal pH conditions and exploring the impact of substrate concentration, pH, temperature, inhibitors, and activators on enzyme activity.

CO5: gain proficiency in measuring cell dimensions using micrometres, performing differential centrifugation for subcellular molecule harvesting, and assessing cell viability via various assays.

CO6: demonstrate competency in executing differential staining for DNA and RNA, Feulgen staining for DNA, collagen demonstration, cell culturing, and aseptic technique application.

CO7: skilfully prepare metaphase chromosomes, assess the effects of colchicine treatment on mitosis, and conduct short-term cultures for chromosome analysis.

PRACTICALS:

Section I –PSZO 111: Biochemistry and Bioenergetics		
Sr. No	**Title of the Practical**	**E/D**
1	Preparation of standard Acid and Alkali solutions and acid-base titration.	E
2	Preparation of Buffers of known pH and molarity. Measurement of pH of Various samples and their buffering capacity	E
3	Estimation of inorganic phosphates from plasma	E
4	Estimation of Sugar (Glucose) by GOD-POD Method	E
5	Estimation of Tyrosine by Folin Ciocalteu Reagent	E

6	Estimation of vitamin 'C' by iodine method.	E
7	Estimation of amylase activity	E
8	Estimation of protein by Lowry et.al method.	E
9	Determination of optimum pH of enzyme	E
10	Effect of substrate concentration, pH, temperature, inhibitor and activator on enzyme activity	E
Section II – PSZO 112: Cell Biology		
1	Measurements of cell size using stage micrometer and ocular micrometer.	E
2	Differential centrifugation for harvesting subcellular molecules	D
3	Effect of Colchicine treatment on Mitosis from any suitable material.	E
4	Demonstration of collagen by Van Gieson's Stain in Liver/Tissue Sections.	E
5	Differential staining for DNA and RNA in human cheek epithelial cells.	E
6	Aseptic technique and good cell culture practice.	D
7	Short term culture of whole blood and preparation of metaphase chromosomes.	E
8	Cell viability assay by Trypan blue exclusion.	E
9	MTT assay for cell viability.	E
10	Feulgen staining for DNA.	E

***E- Experiment *D- Demonstration**

Course Articulation Matrix of PSZO 115: Zoology Practical-I
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	2	1	2	1	1	2
CO2	3	2	1	2	1	2	1	1	2
CO3	3	2	1	2	1	2	1	1	2
CO4	3	2	1	2	1	2	1	1	2
CO5	3	2	1	2	1	2	1	1	2
CO6	3	2	1	2	1	2	1	1	2
CO7	3	2	1	2	1	2	1	1	2

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because Preparing solutions, buffers, conducting enzymatic assays, staining techniques, cell culture, chromosome analysis require in-depth knowledge of biochemical and cell biology concepts.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because Optimizing techniques, interpreting results, analyzing enzyme behavior, troubleshooting experiments, assessing cell viability, and analysing chromosome preparations require critical thinking and problem-solving skills.

PO3: Social Competence
All of the COs are directly mapped to PO3 because they primarily focus on individual technical skills and knowledge in the laboratory. Social interaction or collaboration might be involved in group work or sharing techniques.

PO4: Research-related skills and Scientific temper

All of the COs are indirectly mapped to PO4 because, preparing reagents, measuring parameters, observing results, and recording data contribute to developing research skills and a scientific mind-set.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 because they require students to apply knowledge from different disciplines like medicine and biotechnology to understand biochemical and cell biology principles.

PO6: Personal and professional competence
All of the COs are directly mapped to PO6 because mastering laboratory techniques, following protocols, managing time effectively, and maintaining accurate records contribute to developing personal and professional competence.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because practicing aseptic techniques, handling biological materials responsibly, and using chemicals safely might indirectly relate to ethical conduct in research.

PO8: Environment and Sustainability
All of the COs are indirectly mapped to PO8 because practicing proper waste disposal, minimizing reagent use, and following safety protocols might indirectly relate to environmental sustainability in the laboratory.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because mastering techniques, analysing results, troubleshooting problems, and adapting protocols encourage self-directed learning and staying updated with advancements in laboratory techniques.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY Sem. IV (w. e. f. June, 2022)

Name of the Program: M.Sc. Zoology **Program Code: PSZO**

Class: M.Sc. - I **Semester: I**

Course Name: Zoology Practical-II (Practicals Corresponding to PSZO 113, PSZO 114) **Course Code: PSZO 116**

Number of Credits: 04 **Number of Practicals: 10**

Course Objectives:-

- Acquire proficiency in qualitative and quantitative analysis of zooplankton using Sedgwick rafter counting cell, demonstrating adeptness in aquatic fauna assessment techniques.
- Investigate locomotory and respiratory adaptations in aquatic insects and their larvae (*Ranatra*, *Notonecta*, *Gerris*, *Belostoma*, *and Dytiscus*), emphasizing specialized adaptations for aquatic habitats.
- Develop skills in estimating chlorides in water samples and analyse bioindicators of pollution using insects, rotifers, algae, and diatoms, showcasing competence in water quality assessment.
- Proficiently analyze water hardness (total and calcium), estimate primary productivity using dark and light bottle methods, demonstrating expertise in freshwater quality evaluation.
- Gain proficiency in analyzing external fish characteristics, fins, scales, and morphometric measurements, and conducting anatomical observations of digestive and reproductive systems of specific fish species (carp/catfish/Tilapia).
- Develop competency in studying sex-linked inheritance, gene distances, gene order in three-point test crosses, and chromosomal banding patterns, showcasing skill in genetic analysis.
- Acquire skills in statistical analysis using computer software packages.

Course Outcomes:-

After completion of this course students will-

CO1: demonstrate mastery in assessing and categorizing aquatic fauna through the qualitative and quantitative analysis of zooplankton, using precise techniques like the Sedgwick rafter counting cell.

CO2: showcase an in-depth understanding of specialized locomotory and respiratory adaptations in aquatic insects and their larvae, emphasizing their unique strategies for survival in aquatic environments.

CO3: Display expertise in evaluating water quality by proficiently estimating chlorides and analysing pollution bioindicators.

CO4: demonstrate expertise in freshwater quality assessment by accurately analysing water hardness, estimating primary productivity, and understanding the ecosystem dynamics through light and dark bottle methods.

CO5: showcase mastery in morphometric analysis and anatomical observations of fish species, exemplifying a comprehensive understanding of their external features and internal systems.

CO6: exhibit advanced skills in genetic analysis, including the study of sex-linked inheritance, gene distances, three-point test crosses, and chromosomal banding patterns.

CO7: demonstrate expertise in statistical analysis using computer software packages, showcasing proficiency in data interpretation and analysis within biological contexts.

PRACTICALS:

Section I –PSZO 113 Fresh Water Zoology		
Sr. No	**Title of the Practical**	**E/D**
1	A qualitative and quantitative analysis of Zooplankton from a given sample of water using Sedgwick rafter counting cell.	**E**
2	Study of locomotory and respiratory adaptations in aquatic insects and their larvae. (*Ranatra*, *Notonecta*, *Gerris*, *Belostoma*, *Dytiscus*).	**D**
3	Estimation of Chlorides in given sample of water.	**E**
4	Study of Bioindicators of pollution by insects, rotifers, algae, diatoms.	**D**
5	Water analysis with regards to hardness (Total and Calcium).	**E**
6	A Compulsory visit ZSI/ to local freshwater body and submission of reporton physicochemical conditions and faunal organisms.	**E**

7	Estimation of primary productivity of water body with dark and light bottle method	**E**
Section II – PSZO 113 Ichthyology		
1	General external characters, fins and scales (permanent slides and temporary preparations) and morphometric measurements.	**E**
2	Length-weight relationship, conditions factors, gonosomatic and hepatosomatic indices of any one fish	**E**
3	Classification of locally available fish genus level with the use of diagnostic keys.	**E**
4	Adaptations of fish (adhesive organs, accessory respiratory organs, stomachless fish, spiral valve, rostral spines etc.	**D**
5	Anatomical observations and demonstration of Digestive and reproductive system of carp/ catfish/ Tilapia.	**E**
6	Visit to fish farm/fish market/any aquarium	**E**
7	Study of common diseases in fish their diagnosis and control strategies.	**D**
Section III – PSZO 114 Genetics		
1	Study of sex linked inheritance in *Drosophila* sp.	**D**
2	Determination of gene distances and gene order for a given three point test cross	**E**
3	Polytene chromosomes of *Drosophila*/ Chironomous-examination of puff and bands	**E**
4	Study of Banding Pattern in Chromosome (G- Banding and/or C-Banding)	**E**
5	Estimation of allelic frequencies, heterozygote frequencies in human populations	**E**
6	Effect of toxicant on Hydra regeneration.	**E**
Section IV – PSZO 114 Biostatistics		
1	Construction of frequency distribution and its graphical representation.	**E**
2	Measures of Central Tendency and Dispersion.	**E**
3	Correlation and Regression.	**E**
4	Computation and application of normal, binomial and Poisson probabilities.	**E**
5	Test for means and proportions.	**E**
6	Chi-square test of goodness of fit, Paired and unpaired t- test, F-test	**E**
7	Statistical analysis with Computer software packages.	**E**

***E- Experiment *D- Demonstration**

Course Articulation Matrix of PSZO 116: Zoology Practical-II

Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**2**
CO2	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**2**
CO3	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**2**
CO4	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**2**
CO5	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**2**	**2**
CO6	**2**	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**3**
CO7	**2**	**3**	**2**	**3**	**2**	**3**	**2**	**2**	**3**

PO1: Disciplinary Knowledge
All of the COs are directly mapped to PO1 because analysing zooplankton, understanding insect adaptations, assessing water quality, fish morphology, and conducting genetic analysis require deep knowledge of aquatic ecology and fish biology concepts.

PO2: Critical Thinking and Problem Solving
All of the COs are directly mapped to PO2 because categorizing zooplankton, interpreting adaptations, evaluating pollution indicators, analysing water hardness and productivity, and understanding morphometric data require critical thinking and problem-solving skills.

PO3: Social Competence
All of the COs are directly mapped to PO3 because they primarily focus on individual knowledge and technical skills in aquatic ecology and fish biology. Social interaction or collaboration might be involved in group work or data sharing.

PO4: Research-related skills and Scientific temper
All of the COs are indirectly mapped to PO4 because, designing and conducting genetic experiments, analysing data statistically, and interpreting results directly contribute to research skills and scientific methodology.

PO5: Trans-disciplinary knowledge
All of the COs are directly mapped to PO5 Applying statistical analysis skills and interpreting data are relevant across various scientific disciplines and research fields.

PO6: Personal and professional competence
All of the COs are directly mapped to PO6 because designing and conducting complex experiments, mastering statistical software, and independently interpreting data contribute significantly to developing personal and professional competence.

PO7: Effective Citizenship and Ethics
All of the COs are indirectly mapped to PO7 because analysing data objectively, reporting results accurately, and interpreting them responsibly are crucial for upholding scientific integrity and contributing to effective citizenship.

PO8: Environment and Sustainability
All of the COs are indirectly mapped to PO8 because understanding fish biology and applying statistical analysis for environmental data can contribute to research in areas like fish conservation, water quality monitoring, and sustainable resource management.

PO9: Self-directed and Life-long learning
All of the COs are directly mapped to PO9 because mastering different zooplankton identification, analysing complex adaptations, understanding water quality parameters, and studying fish morphology encourage self-directed learning and adapting to new challenges.