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 2019-20

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	ZOO: 4101	Theory	Biochemistry and Bioenergetics	4	I / E	40 + 60
2	ZOO: 4102	Theory	Cell Biology and Genetics	4	I / E	40 + 60
3	ZOO: 4103	Theory	Fresh Water Zoology and Ichthyology	4	I / E	40 + 60
4	ZOO: 4104	Theory	Skills in Scientific Communication & Writing and Biostatistics	4	I / E	40 + 60
5	ZOO: 4105	Zoology Practical-I	Practicals Corresponding to: ZOO:4101 and ZOO:4102	4	I / E	40 + 60
6	ZOO: 4106	Zoology Practical-II	Practicals Corresponding to: ZOO:4103 and ZOO:4104	4	I / E	40 + 60
7	CC-23		Certificate Course	2	-	-
	SD-24		Skill Development II	2	-	-

IA* - Internal Assessment

EA*- External Assessment

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)

Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology

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

Course Name: Biochemistry and Bioenergetics **Course Code: ZOO: 4101**

Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Explain the fundamental building blocks of life (biomolecules) and their diverse functions through understanding different classes like carbohydrates, lipids, proteins, vitamins, and coenzymes.
- Analyze the stabilizing interactions and key properties of biomolecules with focus on water's role, pH and buffers, protein structure, and denaturation processes.
- Apply the principles of bioenergetics to metabolic pathways by interpreting concepts like free energy, redox potential, and high-energy compounds like ATP.
- Dissect the intricate pathways of carbohydrate metabolism including glycolysis, citric acid cycle, and HMP pathway, understanding their regulation and energetic significance.
- Delve into the breakdown and synthesis of amino acids by exploring transamination, urea cycle, and their connection to ammonia excretion.
- Unravel the intricacies of nucleic acid metabolism by tracing the pathways for both purine and pyrimidine degradation and biosynthesis.
- Master the science of enzyme action through classification, understanding enzyme kinetics (Michelis-Menten equation), specific activity, and factors influencing their activity and inhibition.

Course Outcomes:-

After completion of this course students will be able to -

CO1: identify and characterize the fundamental biomolecules (carbohydrates, lipids, proteins, vitamins, and coenzymes) and their diverse roles in living organisms. (Focuses on knowledge and understanding)

CO2: explain the stabilizing interactions (e.g., hydrogen bonding) and key properties of biomolecules, with emphasis on the influence of water, pH & buffers, protein structure, and denaturation processes. (Analyses relationships and factors affecting stability)

CO3: apply the principles of bioenergetics (free energy, redox potential, ATP) to analyze and interpret metabolic pathways, including their energetic significance. (Develops problem-solving skills using bioenergetics concepts)

CO4: master the details and regulatory mechanisms of key carbohydrate metabolism pathways (glycolysis, citric acid cycle, HMP pathway) and their contribution to cellular energy production. (Requires in-depth analysis and comprehension of specific pathways)

CO5: evaluate the processes of amino acid breakdown (transamination) and synthesis (urea cycle) and their connection to ammonia excretion in various organisms. (Focuses on understanding interconnected metabolic processes)

CO6: demystify the intricacies of nucleic acid metabolism by tracing the pathways for both purine and pyrimidine degradation and biosynthesis, considering their regulation and significance. (Develops a comprehensive understanding of nucleotide metabolism)

CO7: become proficient in enzyme knowledge, including classification, reaction kinetics (Michaelis-Menten equation), specific activity, and factors influencing enzyme activity and inhibition. (Requires mastery of enzyme concepts and their practical applications)

TOPICS:

1.	**Biomolecules: - Classification, Structure and Function.**	**20 L**
	1.1 Stabilizing Interactions in Biomolecules.	**1**
	1.2 Water: Structure and Function, pH and Buffers, Biological Buffer System	**2**

	1.3 Carbohydrates: Classification, basic Chemical Structures, GeneralReactions and properties, Biological Significance.	**3**
	1.4 Lipids: Classification, structure and function of major lipid subclasses.Formation of micelles, monolayers, bilayer	**3**
	1.5 Vitamins and Coenzymes: Classification, water-soluble and fat-solublevitamins, coenzyme forms and their significance	**3**
	1.6 Proteins: A. Amino acids: Classification, properties and reactions, ninhydrin reaction B. Peptide bond, formation, End group analysis and sequencing, Ramachandranplot. C. Denaturation of Protein D. Protein structure: i. Primary structure and its importance ii. Secondary structure- X ray diffraction, alpha-helix, beta-helix iii. Tertiary structure: Myoglobin, Forces stabilizing, unfolding and refolding. iv. Quaternary structure- haemoglobin. E. Biological Roles of Proteins	**8**
2.	**Bioenergetics: - Metabolic Pathways and its energetics**	**32 L**
	2.1 Basic law of thermodynamics: internal energy, enthalpy, entropy, concept of free energy, redox potentials, high energy compounds, structure and function of ATP.	**3**
	2.2 Concepts of metabolism: Metabolic Pathways-Catabolic and anabolic,regulation of metabolic pathways.	**2**
	2.3. Glycogen Biosynthesis and its regulation: Role of enzymes in synthesis &degradation of glycogen, role of cAMP, gluconeogenesis.	**4**
	2.4. Carbohydrate metabolisms: Glycolysis- Detailed study, energetic and its regulation, PFK, Citric acid cycle- Detailed study, energetics, regulation and significance, Role of PDH, HMP pathway, Electron transport chain andoxidative phosphorylation.	**8**
	2.5. Oxidative degradation of amino acids: transamination, oxidative deamination, urea cycle, Ammonia excretion.	**4**
	2.6. Purine and Pyrimidine degradation, biosynthesis of purine and pyrimidine nucleotides	**5**
	2.7. Lipid metabolism: Introduction, Biosynthesis of palmitic acid, Beta oxidation of fatty acid, Lipogenesis and lipolysis, Ketogenesis, Transport of Fatty Acids.	**6**
3.	Enzymology: - Classification and Kinetics 3.1 Classification: Types, Nomenclature and Properties 3.2 Enzyme Kinetics -One Substrate Reaction (Michaelis-Menten Equation) 3.3 Specific Activity 3.4 Factors affecting enzyme activity 3.5 Enzyme inhibition 3.6 Allosteric Enzymes 3.7 Isozymes (LDH)	**8 L**

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H. Freeman, New York.
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5. Harper's Illustrated Biochemistry 26th Ed. (2003) Robert Murray et. Al.
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Course Articulation Matrix of ZOO: 4101 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	2	1	3	2	2	1	3
CO2	3	3	2	2	2	3	2	2	3
CO3	2	3	2	2	2	2	3	2	3
CO4	3	3	2	3	2	3	2	2	3
CO5	3	2	2	3	1	2	2	1	2
CO6	3	3	2	3	3	3	2	2	3
CO7	2	3	2	2	2	2	3	2	3

PO1: Disciplinary Knowledge

All Course Outcomes (COs) contribute to building a strong foundation in the discipline of biochemistry.
CO1-6 delve into different biomolecules and their metabolic pathways, providing in-depth knowledge of this field.
CO7 focuses on enzymes, key players in biochemical reactions, solidifying understanding of the mechanisms powering various processes.

PO2: Critical Thinking and Problem Solving

CO3 requires applying bioenergetic principles to analyze metabolic pathways, demonstrating problem-solving skills within the context of biochemistry.
CO4 demands in-depth analysis of specific pathways, such as glycolysis, to understand their energetic significance and troubleshoot potential disruptions.
CO5 and CO6 involve evaluating interconnected metabolic processes like amino acid metabolism and nucleic acid metabolism, showcasing the ability to think critically about complex systems.

PO3: Social Competence

CO1 and CO3 require explaining biomolecular properties and applying bioenergetic concepts, both of which can involve effective communication in group discussions or explaining these concepts to others.
CO7 emphasizes enzyme classification and factors influencing activity, which could be presented in group projects or discussions, further developing social and communication skills.

PO4: Research-related skills and Scientific temper

CO2 analyses factors affecting biomolecule stability, encouraging an investigative approach and critical evaluation of scientific data.
CO5 and CO6 delve into interconnected metabolic processes and complex pathways, respectively, fostering a research-oriented mindset and the ability to interpret intricate results.

PO5: Trans-disciplinary knowledge

CO4's focus on the energetic significance of specific pathways allows for connections to other disciplines like biophysics or evolutionary biology.

CO6's exploration of nucleic acid metabolism has connections to genetics and molecular biology, promoting trans-disciplinary understanding.

PO6: Personal and professional competence

CO7's emphasis on enzyme kinetics, specific activity, and factors influencing enzyme activity equips students with professional skills relevant to biopharmaceutical research or clinical studies.

PO7: Effective Citizenship and Ethics

CO2's exploration of water's role in biomolecule stability raises awareness of environmental factors influencing biochemical processes.

CO5's focus on ammonia excretion connects biochemistry to ecological considerations and potential environmental implications.

PO8: Environment and Sustainability

CO2's analysis of factors affecting biomolecule stability can be linked to environmental concerns like pollution and its impact on biochemical processes.

CO5's exploration of ammonia excretion has connections to agricultural practices and their potential environmental impact.

PO9: Self-directed and Life-long learning

All COs require independent learning, critical thinking, and the ability to analyze and interpret complex information, laying the foundation for lifelong learning in biochemistry and related fields.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)
Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology

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

Course Name: Cell Biology and Genetics **Course Code: ZOO: 4102**

Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Gain a fundamental understanding of the chemical building blocks of life.
- Master the structure and function of the plasma membrane..
- Unravel the secrets of the endomembrane system and peroxisomes.
- Appreciate the critical role of the nucleus in cellular control.
- Decipher the mechanisms of cell signaling and transduction.
- Gain insights into the intricate regulation of the cell cycle.
- Develop a holistic understanding of cancer biology.

Learning Outcomes:-

After completion of this course students will be able to -

CO1: build molecular models of biomolecules and explain their functions in living systems.
CO2: explain the structure and function of the plasma membrane using various models.
CO3: describe the roles of the endomembrane system and peroxisomes in cellular processes.
CO4: analyze the structure and function of the nucleus and its role in cell division.
CO5: design a signal transduction pathway based on a specific stimulus and receptor.
CO6: create a cell cycle checkpoint simulation to illustrate the regulation of cell division.
CO7: develop a research proposal to investigate a specific aspect of cancer biology.

TOPICS:

Section -A Cell Biology	
1. Overview of Chemical Nature of the Cell:	**2 L**
1.1 Carbon as backbone of biologically important molecules. 1.2 Macromolecules and their role in form and function of living systems.	
2. Plasma Membrane:	**4 L**
2.1 Models of plasma membrane structure. 2.2 Transport across membrane and Active and passive transport; Voltage andtransmitter gated ion channels; energetics of transport. 2.3 Membrane potential and synaptic transmission.	
3. The Endomembrane System and Peroxisomes:	**3 L**
3.1 Endoplasmic reticulum, protein folding, processing and secretion; lipid synthesis. 3.2 Golgi complex: Protein glycosylation and proteolytic processing 3.3 Lysosomes and intracellular digestion. 3.4 Structure and functions of Peroxisomes and glyoxysomes. 3.5 Intracellular Transport and protein trafficking.	
4. Nucleus	**4 L**
4.1 Ultrastructure, Nuclear pore complex, Nucleo - Cytoplasmic Interactions 4.2 Nucleolus, Nuclear lamina and its role in Cell Division	
5. Mitochondria and Chloroplast	**2 L**

5.1 Structure, Genetic system, Functions, Protein Import	
6. Extracellular Matrix, Cell-Cell Junction and Adhesion	**3 L**
6.1 Polarity proteins 6.2 Adhesion junctions 6.3 Tight junctions (Desmosomes) 6.4 Claudins 6.5 Gap junctions 6.6 Extracellular matrix of animal and plant cell surface 6.7 Plasmodesmata	
7. Cell Signaling and Transduction	**3 L**
7.1 Chemical Signals and Cellular Receptors, Role of Sec. messengers. 7.2 G Protein-Linked Receptors 7.3 Protein Kinase-Associated Receptor 7.4 Hormonal Signaling	
8. Cell Cycle and its regulation	**3 L**
8.1 Check points of cell cycle. 8.2 Regulation of Cyclin and Cyclin dependent kinases, p538.3Inhibitors of cell cycle.	
9. Cytoskeleton and Motor Proteins	**3 L**
9.1 Microtubules: Structure, MTOC's and functions of microtubules 9.2 Intermediate filaments: Structure and functions of intermediate filaments. 9.3 Microfilaments: Actin polymerization, role in cell movement. 9.4 Dynein, Kinesin and Myosin 9.5 Inhibitors of cytoskeleton organization	

10. Cancer Biology	**3 L**
10.1 Characteristics of Cancer Cell **10.2 Metastasis** 10.3 Types and classification of Cancer 10.4 **Causes of cancer**: Physical, Chemical and biological agents; 10.5 **Tumor viruses** -Hepatitis B viruses, Adenoviruses, SV40, Polyoma virus,Herpes viruses, Papillomaviruses and Retroviruses, Oncogenes and Tumor suppressor genes 10.6 Diagnosis, Screening and treatment of cancer	
Section -B Genetics	
1. Recapitulation of Mendelian Principles:	**2 L**
Practical applications of genetics in brief.	
2. Gene Interactions	**4 L**
Incomplete and co-dominance, Dominant Epistasis, Recessive Epistasis, Duplicate Dominant Epistasis, Duplicate recessive epistasis, Polymeric gene interaction.	
3. Multiple alleles:	**2 L**
Blood groups and its significance, coat colour in mice	
4. Linkage and crossing over:	**4 L**
Linkage, linkage groups, types of crossing over, Models of molecular basis of recombination, maps in diploids for 3-point test cross (determination of gene order and distance with suitable examples)	
5. Inheritance of qualitative and quantitative traits:	**4 L**
QTL Mapping, heritability, genetic basis and influence of environment on quantitative inheritance.	
6. Principles of Population Genetics:	**4 L**
Hardy-Weinberg law and its application.	

7. Somatic Cell Genetics:	**2 L**
Its applications, Gene Therapy, Gene transfer technology	
8. Human genetics:	**4 L**
Dominant and recessive disorders, Pedigree Analysis, physical and physiological traits.	
9. Gene Mutation:	**3 L**
Types, Causes and Detection	
10. Introduction to epigenetics.	**1 L**

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Course Articulation Matrix of ZOO: 4102 Cell Biology and Genetics
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

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

PO1: Disciplinary Knowledge:

CO1, CO2, CO3, CO4: These COs require understanding the key biomolecules, structures, and functions within a cell, demonstrating disciplinary knowledge of cell biology.

CO5, CO6, CO7: Analyzing signal transduction pathways, designing cell cycle simulations, and proposing research illustrate deeper application of cell biology concepts.

PO2: Critical Thinking and Problem Solving:

CO1, CO2, CO3: Building molecular models and explaining functions involves analyzing complex structures and their interactions, demonstrating critical thinking.

CO4, CO5, CO6: Analyzing cell division, designing signal transduction pathways, and simulating cell cycle checkpoints require complex problem-solving skills.

CO7: Developing a research proposal necessitates critical questioning, hypothesis formulation, and problem-solving skills in a real-world context.

PO3: Social Competence:

CO5, CO6, CO7: Presenting research findings, collaborating on the cell cycle simulation, and discussing research proposals in a group setting develop effective communication and teamwork skills.

PO4: Research-related skills and Scientific temper:

CO5, CO6, CO7: Designing a signal transduction pathway, simulating cell cycle checkpoints, and developing a research proposal all involve research skills like data analysis, interpretation, and hypothesis testing.

CO4: Analyzing the role of the nucleus in cell division requires a critical and skeptical approach to scientific findings.

PO5: Trans-disciplinary knowledge:

CO5, CO6, CO7: Understanding signal transduction pathways, designing cell cycle simulations, and proposing cancer research require integrating knowledge from related fields like biochemistry, genetics, and medicine.

PO6: Personal and professional competence:

CO1, CO2, CO3, CO4: Building molecular models, explaining functions, and analyzing structures hone independent research and learning skills.

CO5, CO6, CO7: Designing experiments, simulating processes, and proposing research demonstrate project management, time management, and communication skills needed for professional settings.

PO7: Effective Citizenship and Ethics:

CO7: Investigating cancer biology emphasizes the ethical implications of research and its potential benefit to society.

PO8: Environment and Sustainability:

CO7: Exploring cancer research could potentially lead to solutions for reducing environmental pollutants linked to cancer incidence

PO9: Self-directed and Life-long learning:

CO1, CO2, CO3, CO4: Building models, explaining functions, and analyzing structures encourage further exploration and lifelong learning in cell biology.

CO5, CO6, CO7: Designing experiments, simulating processes, and proposing research foster independent learning and critical thinking skills for continual knowledge acquisition

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)
Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology
Class: M.Sc. - I **Semester: I**
Course Name: Fresh Water Zoology and Ichthyology **Course Code: ZOO: 4103**
Number of Credits: 04 **Number of Lectures: 60**

Course Objectives:-

- Understand the different types of aquatic environments and their characteristics: This includes learning about lotic (flowing) and lentic (still) habitats, as well as ephemeral water bodies.
- Analyze the physical and chemical conditions of water and their impact on aquatic life: This involves studying factors like water movement, depth, temperature, light, dissolved oxygen, pH, and nutrient levels.
- Examine the physiological and protective adaptations of various aquatic organisms: This section focuses on how different groups like protozoa, rotifers, crustaceans, and fishes have adapted to their specific environments.
- Study the diagnostic features and life cycles of temporary rainwater pool animals: This objective delves into the unique characteristics and lifecycle stages of creatures like fairy shrimps, tadpole shrimps, and clam shrimps.
- Investigate respiratory and locomotor adaptations, particularly in freshwater insects and their larvae: This section explores how insects and their larvae have adjusted their breathing and movement mechanisms to thrive in aquatic environments.
- Explore the relationship between amphibians and water, with a focus on the frog's life cycle and the tadpole's ecological role: This objective focuses on how amphibians like frogs rely on water and the important role tadpoles play as herbivores.
- Analyze the adaptations of freshwater reptiles and their economic importance: This section examines how reptiles like turtles and crocodiles have adapted to freshwater environments and explores their economic value.

Learning Outcomes:-

After completion of this course students will be able to -

CO1: explain the diversity and complexity of aquatic environments.
CO2: analyze and interpret environmental data.
CO3: enhanced problem-solving skills related to aquatic conservation challenges.
CO4: think and develop new research ideas.
CO5: explore the relationship between amphibians and water.
CO6: explain the diagnostic features and life cycles of temporary rainwater pool animals.
CO7: analyze the adaptations of freshwater reptiles and their economic importance.

TOPICS:

	Section A: Fresh Water Zoology	
1.	**Types of Aquatic Environment.** 1.1 Lotic Habitat: Major river systems in India / rapid and slow-moving rivers. 1.2 Lentic Habitat: Lakes, Ponds and Swamps, Bogs lakes and succession of lakes. 1.3 Ephemeral water bodies (Temporary habitat).	**4 L**

2.	**Physical Conditions of Water:** 2.1 Movement of water, depth, viscosity, density, buoyancy, temperature, light,transparency and turbidity.	**4 L**
3.	**Chemical Conditions of Water:** 3.1 Dissolved oxygen and carbon di-oxide, phosphates, sulphate content, nitrates 3.2 Nitrate-nitrite ratio, acidity, alkalinity, Mg-hardness, Ca-hardness, dissolved solids 3.3 Organic matter, primary productivity 3.4 Importance of chemical conditions to aquatic life.	**4 L**
4.	**Physiological and protective adaptations of the following.** 4.1 Protozoa, Rotifera, Crustaceans, Fishes.	**2 L**
5.	**Diagnostic features and life cycle of temporary rainwater pool animals:** 5.1 Fairy shrimps 5.2 Tadpole shrimps. 5.3 Clam shrimps.	**3 L**
6.	**Respiratory and locomotory adaptations:** 3.1 Adaptations in freshwater insects and their larvae.	**3 L**
7.	**Amphibia and water:** 7.1 General life cycle of frog. 7.2 Tadpole as important herbivore of freshwater habitat.	**2 L**
8.	**Adaptations in fresh water reptiles:** 8.1 Turtles and crocodiles, economic importance of reptiles.	**3 L**
9.	**Economic importance:** 9.1 Economic importance of freshwater molluscs (snails and bivalves) as a food and medicine:	**2 L**
10.	Biological changes in freshwater due to sewage pollution (with reference to rivers) and its effect on freshwater animals.	**3 L**
	SECTION B: Ichthyology	
1.	**Classification and Diagnostic Characters (up to orders):** Extant Cyclostomata, Chondrichthyes and Osteichthyes (9 major orders of fishes)	**4 L**
2.	**Phylogeny of Fishes**	**1 L**
3.	**External morphology:** Body form, appendages, pigmentation, skin and scales, principles of morphometry and locomotion	**2 L**
4.	**Endoskeleton:** Skull, axial and appendicular skeleton.	**2 L**
5.	**Digestion:** Food and feeding habits, digestive system and its anatomical modifications.	**3 L**
6.	**Respiration:** Structure and functions of gills; adaptations for air breathing; role of air bladder. Respiratory functions of food.	**2 L**
7.	**Buoyancy Mechanisms:** Role of fat and swim bladder.	**2 L**
8.	**Excretion and Osmoregulation:** Glomerular and aglomerular kidneys; Nitrogen (Ammonia, Urea and TMAO) excretions; water and salt and balance in steno and euryhaline fishes. Role of skin and gills	**3 L**

9.	**Catadromous and Anadromous fishes**	**1 L**
10.	**Reproduction:** Structure of gonads, gametogenic cycles; spawning and parental care.	**4 L**
11.	**Nervous System and Sense Organs:** Organization of the central and peripheral nervous systems. Eye, lateral line organs and chemoreceptors	**3 L**
12.	**Endocrine Organs:** Functions of the pituitary, thyroid, inter-renal and chromaffin tissues, ultimobranchial and corpuscles of Stannous	**3 L**

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Course Articulation Matrix of ZOO: 4103 Fresh Water Zoology and Ichthyology
Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related

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

PO1: Disciplinary Knowledge
CO1 & CO2 directly contribute to deepening disciplinary knowledge of aquatic environments.
CO3 & CO4 demonstrate comprehension of specific and advanced concepts in aquatic conservation challenges and research avenues.

PO2: Critical Thinking and Problem Solving
CO2 & CO3 require analyzing and interpreting complex data, forming hypotheses, and designing solutions.
CO4 demands critical evaluation of existing knowledge and generating innovative research questions.

PO3: Social Competence
CO5 encourages creative expression and communication, potentially involving collaboration with others.

CO7 emphasizes effective communication and advocacy towards stakeholders and the public.

PO4: Research-related skills and Scientific temper
CO2 & CO4 directly involve data analysis, research question formulation, and hypothesis testing.
CO7 showcases responsible citizenship within scientific exploration and environmental advocacy.

PO5: Trans-disciplinary knowledge
CO3 & CO4 may involve integrating knowledge from various disciplines like ecology, chemistry, sociology, etc., when addressing conservation challenges.
CO7 promotes informed advocacy that considers the broader economic, social, and political context of environmental issues.

PO6: Personal and professional competence
CO1 & CO2 require independent study and engagement with complex material.
CO3 & CO4 demonstrate initiative and proactive engagement in research and problem-solving.
CO6 indicates potential for career development and professional skills acquisition in aquatic science or conservation.

PO7: Effective Citizenship and Ethics
CO5 encourages responsible and creative expression that can raise awareness and influence positive change.
CO7 emphasizes responsible citizenship through informed advocacy for healthy aquatic ecosystems.

PO8: Environment and Sustainability
CO1 & CO7 cultivate understanding and appreciation for the environment, specifically aquatic ecosystems.
CO3 & CO4 foster skills and knowledge relevant to addressing environmental challenges and promoting sustainable practices.

PO9: Self-directed and Life-long learning
CO1 & CO2 stimulate intellectual curiosity and motivation to acquire new knowledge.
CO3 & CO4 require independent investigation, critical evaluation, and formulation of new research questions, fostering the spirit of lifelong learning.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)
Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology

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

Course Name: Skills in Scientific Communication Writing and Biostatistics

Course Code: ZOO: 4104

Number of Credits: 04 **Number of Lectures: 60**

Course Objectives: -

- **Develop strong communication skills:** Emphasis on reading, writing, listening, and speaking, along with understanding synonyms and antonyms, aims to build clear and effective communication.
- **Master the fundamentals of English grammar and syntax:** Focus on sentence structure, basic grammar rules, paragraph writing, paraphrasing, and précis writing hones in on accurate and precise written and spoken English.
- **Eliminate common errors in written and spoken language:** Learning to identify and avoid tautology, double negatives, superfluous words, incorrect sequence of tenses, and other common errors leads to polished and professional communication.
- **Become a confident and effective oral presenter:** Gaining knowledge on preparation, using presentation tools, communication techniques, voice control, and addressing obstacles equips one for delivering impactful presentations.
- **Differentiate between hypotheses, theories, and concepts:** Understanding these key scientific terms fosters critical thinking and accurate representation of knowledge.
- **Grasp the concept of intellectual property rights (IPR) and patents:** Introduction to IPR and its international conventions provides awareness of protecting innovative ideas and inventions.
- **Gain skills in research project preparation and funding:** Learning about project planning, funding avenues and effective proposal writing prepares one for successful research endeavours.

Learning Outcomes:-

After completion of this course students will be able to -

CO1: communicate with clarity and confidence: Participants will be able to: Express themselves clearly and concisely in writing and speech.
CO2: grammatically correct sentences and paragraphs. Paraphrase and write concise summaries.
CO3: identify and avoid common errors like tautology, double negatives, and incorrect tenses. Produce polished and professional communication materials.
CO4: utilize presentation tools effectively and confidently. Employ impactful communication techniques, including body language and voice control.
CO5: differentiate between hypotheses, theories, and concepts.
CO6: explain the concept of intellectual property rights (IPR) and protect their own innovative ideas and inventions through appropriate legal means.
CO7: develop research projects addressing well-defined research questions and write effective research proposals that secure funding.

TOPICS:

Topic	Section A: Skills in Scientific Communication and Writing	No. of lectures
1.	**Language as a Communication Tool:** Relationship among reading, writing, hearing and speaking, synonyms and antonyms	3 L
2.	**Organization of English Language:** Sentence structure, basic grammar, Syntax, paragraphs, paraphrases and preciserecognizing important statements and key words	4 L

3.	**Common Error in Written and Spoken Presentation:** Tautology, double negative, doubles positive superfluous words, sequence and tenses.	**3 L**
4.	**Oral presentation:** How to prepare presentation, power point slides use of communication and it, voice,speed of delivery, obstacles in effective communication.	**4 L**
5.	**Hypothesis, Theory and Concept**	**2 L**
6.	**Concept of IPR and patent:** General introduction to IP and IPR; Introduction, History and role of internationalconventions.	**3 L**
7.	**Research project preparation and funding**	**3 L**
8.	**Outline of a Scientific Paper:** 8.1 Introduction: Survey of Literature, defining the problem and justification 8.2 Materials and Methods: Contents, importance of measurements, reproducibility etc. 8.3 Observations and Results: Text and data presentation, tables, graphs, histograms,diagrams, photographic plates, legends and captions.	**8 L**
	Section B: Biostatistics	
1.	**Introduction:** 1.1 Applications and Uses of Statistics 1.2 Population and sample, Different types of Sample 1.3 Exercise and Problems.	**2 L**
2.	**Data Classification:** 2.1 Some important terms (Class frequency, class- limits, Class-width, class – mark) 2.2 Frequency distribution, Cumulative frequency, Graphical representation of data (Histogram, Pie-Diagram, Ogive-Curve.) 2.3 Exercise and Problems.	**3 L**
3.	**Measures of central tendency:** 3.1 Concept of central tendency, Types of central tendency (Arithmatic mean, Median and mode) combined mean. 3.2 Partition values (Quartiles, Deciles, and Percentiles) 3.3 Exercise and Problems.	**4 L**
4.	**Measures of dispersion:** 4.1 Concept of dispersion, absolute and relative measure of dispersion. 4.2 Different measures of dispersion (Range, Quartile- Deviation, Variance 4.3 Exercise and Problems.	**3 L**
5.	**Correlation and Regression:** 5.1 Bivariate data, concept of correlation, Types of Correlation, Scatter diagram, 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.	**5 L**
6.	**Probability and probability distribution**: 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	**5 L**

	these distribution. 65 Exercise and Problems.	
7.	**Test of hypothesis:** 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.	**8 L**

REFERENCES:

1 O'Conner, M and Woodford, F.P.(1975). Writing scientific papers in English. Elsevier-Excerpta Medica-North Holland pul., Amsterdam.
2 Trelease, S.F. (1958). How to write Scientific and Technical papers. Williams and Wilkins Co. Baltimore, USA
3 Robert Day (1996). How to write and publish a Scientific Paper. Cambridge University Press
4 McMillan, V (1997). Writing Papers in the Biological Sciences. Edn. 2, W.H. Freeman. New York.
5 Vijayalakshmi and C. Sivapragasam. (2008) Research Methods –Tip and Techniques, MJP Publishers, Chennai. WWW.mjppublishers.com
6 Principles And Practice of Biostatistics : Dr J.V. Dixit
7 Statistical Methods: Snedecor G.W. and Cochran W.G.
8 Statistical Methods : Dixon W.S. and Massey

Course Articulation Matrix of ZOO: 4104 Skills in Scientific Communication & Writing and Biostatistics

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

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

PO1: Disciplinary Knowledge

Mapped to CO1, CO2, CO3, CO5: These COs focus on mastering the use of English language, both written and spoken, with accuracy and clarity. This is foundational to understanding and communicating disciplinary knowledge effectively.

Mapped to CO6: Understanding and protecting intellectual property relates to knowledge within specific disciplines and the importance of its ownership and dissemination.

PO2: Critical Thinking and Problem Solving

Mapped to CO1, CO2, CO5: Effective communication skills are essential for analyzing information, developing arguments, and presenting solutions. These COs emphasize the ability to express complex ideas clearly and concisely.

Mapped to CO7: Conducting successful research projects requires critical thinking for defining research questions, data analysis and draw conclusions.

PO3: Social Competence

Mapped to CO1, CO2, CO4: These COs focus on effective communication and engagement in conversations and presentations. This includes skills like active listening, understanding audience needs, and delivering impactful messages.

PO4: Research-related skills and Scientific temper

Mapped to CO5, CO7: The ability to think critically and present knowledge accurately is crucial for research. CO5 emphasizes differentiating between concepts and avoiding oversimplification, while CO7 focuses on conducting research projects with defined questions and effective methodologies.

PO5: Trans-disciplinary knowledge

Mapped to CO1, CO2, CO5: Mastering language enables communication and understanding across different disciplines. These COs emphasize clear and concise expression, which facilitates the transfer of knowledge between fields.

PO6: Personal and professional competence

Mapped to all COs: All of the COs contribute to personal and professional competence by equipping individuals with effective communication skills, critical thinking abilities, and research expertise. These skills are valuable in various professional settings and enhance personal development.

PO7: Effective Citizenship and Ethics

Mapped to CO1, CO2, CO5: Clear and ethical communication is essential for responsible citizenship. These COs focus on using language accurately and avoiding misrepresentation of information, which are crucial for effective and ethical social engagement.

PO8: Environment and Sustainability

Mapped to CO5, CO7: Research and communication play a vital role in addressing environmental issues and promoting sustainability. CO5 emphasizes accurate knowledge representation, while CO7 focuses on conducting research that supports sustainable practices.

PO9: Self-directed and Life-long learning

Mapped to all COs: The skills developed through these COs, such as critical thinking, research, and communication, empower individuals to be self-directed learners and continue acquiring knowledge throughout their lives.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)
Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology

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

Course Name: Title of paper: Zoology Practical-I
(Practicals Corresponding to ZOO: 4101, ZOO: 4102)

Course Code: ZOO: 4105

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

Learning Objectives:-

- Understand and perform basic laboratory techniques: This includes preparing standard solutions, buffers, and conducting titrations. You'll also learn how to measure pH and estimate the concentration of various biochemicals.
- Isolate and characterize enzymes: You'll gain hands-on experience in isolating enzymes like amylase or invertase, determining their specific activity, and studying their activity under different conditions (pH, temperature, substrate concentration, inhibitors, activators).
- Analyze cellular components: You'll learn how to use light microscopy to measure cell size, study cell division (meiosis) in detail, and observe organelles like nuclei and mitochondria.
- Investigate chromosome structure and *behaviour*: You'll prepare chromosome spreads, analyze their morphology, and study the effects of treatments like colchicine on mitosis. Additionally, you'll explore banding techniques like G-banding and C-banding to visualize specific chromosome regions.
- Apply genetic principles: You'll delve into sex-linked inheritance in *Drosophila*, calculate gene distances and order, and analyze human population genetics. This involves understanding concepts like allelic frequencies and heterozygosity.
- Explore the impact of environmental factors: You'll investigate the effects of toxicants on the regeneration ability of *Hydra*, providing insights into environmental stress responses.
- Develop quantitative skills: Throughout the course, you'll hone your skills in data analysis, interpretation, and drawing conclusions from experimental results.

Learning Outcomes:-

After completion of this course students will be able to -

CO1: independently prepare standard solutions, buffers, conduct titrations, measure pH, and estimate the concentration of various chemicals using established protocols.

CO2: isolate and purify enzymes, determine their specific activity under varied conditions (pH, temperature, substrate concentration, etc.), and analyze the effects of inhibitors and activators.

CO3: gain proficiency in using light microscopy to measure cell size, study cell division processes (meiosis), and identify and characterize organelles such as nuclei and mitochondria.

CO4: prepare and analyze chromosome spreads, interpret their morphology, study the effects of treatments like colchicine on mitosis, and apply banding techniques like G-banding and C-banding to visualize specific chromosome regions.

CO5: analyze sex-linked inheritance patterns in *Drosophila*, calculate gene distances and order, and apply concepts like allelic frequencies and heterozygosity to analyze human population genetics.

CO6: investigate and interpret the effects of environmental stressors (e.g., toxicants) on organisms (e.g., *Hydra*) and gain insights into environmental stress responses.

CO7: effectively analyze and interpret experimental data, draw sound conclusions from results, and communicate findings in a clear and concise manner.

PRACTICALS:

	Section I – ZOO 4101: Biochemistry and Bioenergetics (Any 10)
1	Preparation of standard Acid and Alkali solutions and acid-base titration.
2	Preparation of Buffers of known pH and molarity and measurement of pH of Various samples, Buffering capacity
3	Estimation of Inorganic Phosphate.
4	Estimation of Sugar (Glucose) by O-toludine method.
5	Estimation of Tyrosine by FCR.
6	Estimation of vitamin 'C' by iodine method.
7	Isolation of amylase/ invertase, to find specific activity and progress curve
8	Estimation of protein by Lowry et.al method.
9	Units and specific activity of enzymes.
10	Effect of substrate concentration pH temperature inhibitor and activator on enzyme activity
11	Estimation of cholesterol
12	Estimation of Starch
	Section II- ZOO 4102: Cell Biology and Genetics (Any 10)
1	Measurements of cell size using light microscope.
2	Study of meiosis in Grasshopper testes / Onion flower buds / Aloe vera with
3	emphasis on all stages of prophase.
4	Cell fractionation- Nuclei, mitochondria observation, nuclear count.
5	Study of metaphase spreads chromosomes from any suitable material.
6	Effect of Colchicine treatment on Mitosis from any suitable material.
7	Demonstration of collagen by Van Gueson's Stain in Liver/Tissue Sections.
8	Study of sex linked inheritance in *Drosophila* sp.
9	Determination of gene distances and gene order for a given three point test cross
10	Polytene chromosomes of *Drosophila*/ Chironomous-examination of puff and bands
11	Study of Banding Pattern in Chromosome (G- Banding and/or C- Banding)
12	Estimation of allelic frequencies, heterozygote frequencies in human populations
13	Effect of toxicant on Hydra regeneration.

Course Articulation Matrix of ZOO: 4105 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	2	3	1	2	3	1	3
CO2	3	3	2	3	2	3	3	2	3
CO3	2	2	2	2	1	2	2	2	2
CO4	2	3	2	3	2	2	3	2	3
CO5	3	3	2	3	3	3	3	2	3
CO6	2	3	3	2	3	2	2	3	3
CO7	2	3	3	3	2	3	3	2	3

PO1: Disciplinary Knowledge

CO1, CO2, CO3, CO4, CO5: These COs directly involve acquiring and applying knowledge in core biological concepts like laboratory techniques, enzymes, cellular components, chromosomes, and genetics.

CO6, CO7: Understanding the impact of environmental factors and analyzing experimental data requires strong disciplinary knowledge in ecology and biostatistics.

PO2: Critical Thinking and Problem Solving

CO1, CO2, CO3, CO4, CO5: Isolating enzymes, analyzing chromosome spreads, calculating gene distances, and interpreting inheritance patterns all require critical thinking and problem-solving skills.

CO6, CO7: Investigating environmental effects and drawing conclusions from data involve analyzing complex information and formulating solutions.

PO3: Social Competence

CO1, CO2, CO3, CO4, CO5: Collaborating with peers in laboratory experiments, discussing results, and presenting findings in reports and presentations foster social competence.

CO6, CO7: Interpreting environmental issues and communicating scientific findings effectively to a broader audience require strong communication and collaboration skills.

PO4: Research-related skills and Scientific temper

CO1, CO2, CO3, CO4, CO5: Designing experiments, following protocols, collecting data, and drawing conclusions based on evidence all contribute to developing research-related skills and a scientific temper.

CO6, CO7: Analyzing environmental data, interpreting results critically, and forming hypotheses based on observations further enhance research skills and scientific thinking.

PO5: Trans-disciplinary knowledge

CO2, CO3, CO4, CO5: Understanding enzymes in cellular processes, analyzing chromosome *behaviour* during cell division, and studying genetic principles in human populations involve applying biological knowledge to other disciplines like medicine and agriculture.

CO6, CO7: Analyzing the impact of environmental factors on organisms bridges biology with environmental science and ecology.

PO6: Personal and professional competence

CO1, CO2, CO3, CO4, CO5: Planning and executing experiments, managing time effectively, and working independently in the laboratory contribute to personal and professional development.

CO6, CO7: Analyzing data, drawing conclusions, and presenting findings confidently enhance communication and critical thinking skills, valuable for personal and professional growth.

PO7: Effective Citizenship and Ethics

CO6: Understanding the impact of environmental factors and responsible conduct of scientific research foster awareness of ethical considerations in environmental issues.

CO7: Communicating scientific findings accurately and objectively to the public promotes responsible citizenship and ethical scientific practices.

PO8: Environment and Sustainability

CO6: Investigating the effects of environmental stressors on organisms directly relates to understanding environmental issues and promoting sustainable practices.

CO7: Analyzing environmental data and advocating for responsible environmental actions contribute to environmental awareness and sustainability.

PO9: Self-directed and Life-long learning

CO1, CO2, CO3, CO4, CO5: Designing experiments, interpreting data, and seeking new knowledge in various biological fields encourage self-directed learning and a lifelong curiosity about science.

CO6, CO7: Analyzing complex environmental issues, staying updated on scientific advancements, and adapting to new technologies promote lifelong learning and intellectual curiosity.

SYLLABUS (CBCS) FOR M.Sc. ZOOLOGY (w. e. f. June, 2019)
Academic Year 2019 – 2020

Name of the Program: M.Sc. Zoology

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

Course Name: Title of paper: Zoology Practical-II
(Practicals Corresponding to ZOO: 4103, ZOO: 4104)

Course Code: ZOO: 4106

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

Learning Objectives:-

- Preparation and maintenance of a culture of *Paramecium*, *Daphnia* and *Hydra*.
- Study of locomotory and respiratory adaptations in aquatic insects and their larvae.
- Estimation of chlorides in given sample of water.
- Study of bioindicators of pollution by insects, rotifers, algae, diatoms.
- Determinations of LC50 using fish/insect larvae for known pollutant like heavy metal/any pesticide/industrial effluent.
- Compulsory Visit to freshwater body for the study of aquatic ecosystem.
- Visit to fish farm to study breeding *behaviour* of fish

Learning Outcomes:-

After completion of this course students will be able to -

CO1: develop and maintain cultures of diverse aquatic organisms (*Paramecium*, *Daphnia*, *Hydra*) in a controlled laboratory environment. (Skills: Aseptic technique, observation, data recording, maintenance of water quality)

CO2: analyze and compare locomotory and respiratory adaptations in various aquatic insects and their larvae. (Knowledge: Aquatic insect diversity, adaptation to different aquatic environments, functional morphology)

CO3: accurately quantify chloride concentration in water samples using established analytical techniques. (Skills: Chemical analysis, titration, calibration, data interpretation)

CO4: evaluate the suitability of different bioindicators (insects, rotifers, algae, diatoms) for assessing water pollution levels. (Knowledge: Bioindicatory organisms, pollution tolerance levels, ecological monitoring)

CO5: determine the LC50 (lethal concentration at 50%) of a known pollutant (heavy metal, pesticide, industrial effluent) using fish or insect larvae in controlled bioassays. (Skills: Bioassay design, data analysis, dose-response relationships, toxicity assessment)

CO6: gain first-hand experience of aquatic ecosystem dynamics and water purification technology through a visit to a Zoological Survey of India (ZSI) center and a freshwater body. (Knowledge: Ecosystem components, water treatment processes, conservation importance)

CO7: observe and document the breeding behaviour of different fish farm. (Knowledge: Fish reproductive strategies, parental care, environmental influences on spawning)

PRACTICALS:

Sr. No.	Section I -ZOO 4103: Fresh Water Zoology (Any 05)
1	A qualitative and quantitative analysis of Zooplankton from a given sample ofwater using Sedgwick rafter counting cell.
2	To prepare and maintain a culture of *Paramecium*, *Daphnia* and *Hydra*.
3	Study of locomotory and respiratory adaptations in aquatic insects and theirlarvae. (*Ranatra*, *Notonecta*, *Gerris*, *Bellostoma*, *Dytiscus*).
4	Estimation of Chlorides in given sample of water.
5	Study of Bioindicators of pollution by insects, rotifers, algae, diatoms.

6	Determinations of LC_{50} using fish/insect larvae for known pollutant like Heavymetal/any Pesticide/industrial effluent.
7	Water analysis with regards to hardness (Total and Calcium).
8	Compulsory Visit to ZSI and freshwater body for the study of aquatic ecosystemand water purification plant and submission of tour report.
	Section II - ZOO 4103: Ichthyology (Any 05)
1	General external characters, fins and scales (permanent slides and temporary preparations);morphometric measurements Length-weight relationship, conditionsfactors, gonosomatic and hepatosomatic indices
2	Classification of fishes (12-18 representatives of different orders); use ofdiagnostic keys
3	Adaptations of fishes (adhesive organs, accessory respiratory organs, stomachlessfishes, spiral valve, electric organs etc.
4	Digestive system, Cranial nerves (V, VII, IX and X) and eye ball musculature,innervations and reproductive systems of carp/catfish/Tilapia
5	Histology of digestive, respiratory, excretory, reproductive and endocrine organs.
6	Satiation index (e.g. Gambusia-mosquito larvae system)
7	Visit to fish farm/fish market or any aquarium to study breeding *behaviour* ofgourami, Siamese fighter, swordtail/tilapia
	Section III - ZOO 4104: Skills in Scientific Communication (Any 05)
1	Syntax, paraphrasing and précis writing, synonyms, antonyms, abbreviations.
2	Outline of a scientific paper; preparation of a project and writing Introduction
3	Writing abstracts, conclusion/ summary and acknowledgements, key words and tosuggest a title to the given abstract/paper
4	Assigning legends to given graphs, figures and captions to given tables,Deciphering the given pictorals.
5	Study of proof correction symbols; proof- reading the given text and correcting theProofs
6	How to write materials and methods, observation and discussion section for thegiven research paper.
	Section IV - ZOO 4104: Biostatistics (Any 05)
1	Construction of frequency distribution and its graphical representation.
2	Measures of Central Tendency and Dispersion.
3	Correlation and Regression.
4	Computation and application of normal, binomial and Poisson probabilities.
5	Test for means and proportions.
6	Chi-square test of goodness of fit, Paired and unpaired t- test, F-test
7	Statistical analysis with Computer software packages.

Course Articulation Matrix of ZOO: 4106 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	2	3	2	3	3	2	3
CO2	3	3	2	3	3	3	2	2	3
CO3	3	3	2	3	2	3	3	3	2
CO4	3	3	3	3	3	3	3	2	3
CO5	3	3	2	3	2	3	3	3	3
CO6	3	3	2	3	2	3	3	3	3
CO7	3	3	3	3	3	3	2	3	3

PO1: Disciplinary Knowledge
Mapped with CO1, CO2, CO3, CO4, CO5, CO6: These COs directly involve acquiring and applying knowledge in aquatic biology, including diversity of organisms, adaptations, analytical techniques, pollution indicators, toxicity assessment, and ecosystem dynamics.
Mapped with CO7: Understanding fish reproductive strategies requires knowledge of fish biology, physiology, and behaviour.

PO2: Critical Thinking and Problem Solving
Mapped with CO1, CO2, CO3, CO4, CO5, CO6: These COs require analyzing data, interpreting results, identifying patterns, and drawing conclusions about aquatic systems and water quality. Designing bioassays (CO5) and evaluating bioindicators (CO4) involve problem-solving in specific contexts.
Mapped with CO7: Documenting breeding behaviour involves observation, identification of factors influencing spawning, and making connections between environmental cues and reproductive responses.

PO3: Social Competence
Mapped with CO6: Visiting a ZSI center and interacting with professionals might involve teamwork, communication, and collaboration skills.
Mapped with CO7: Observing breeding behaviour in a fish farm might involve interacting with farmers and understanding their practices, requiring social awareness and communication skills.

PO4: Research-related skills and Scientific temper
Mapped with CO1, CO2, CO3, CO4, CO5, CO6: These COs involve data collection, recording, analysis, and interpretation, which are fundamental research skills. Maintaining scientific temper through careful observation, objective recording, and unbiased analysis is crucial in all these COs.

PO5: Trans-disciplinary knowledge
Mapped with CO3: Chemical analysis in CO3 might involve knowledge from chemistry, applying principles of titration and calibration to assess water quality.
Mapped with CO6: Understanding water purification technology in CO6 might involve knowledge from engineering and environmental science, connecting ecological principles with technological solutions.

PO6: Personal and professional competence
Mapped with all COs: Each CO requires developing skills like time management, organization, accuracy, and responsibility in carrying out laboratory work, fieldwork, and data analysis. These skills contribute to personal and professional competence.

PO7: Effective Citizenship and Ethics
Mapped with CO4, CO6: Understanding bioindicators and water pollution in CO4 and visiting a ZSI center in CO6 raise awareness about environmental issues and the importance of sustainable practices. This fosters responsible citizenship and ethical behaviour towards the environment.
Mapped with CO7: Observing breeding behaviour might involve understanding ethical considerations in fish breeding and conservation practices.

PO8: Environment and Sustainability
Mapped with CO1, CO4, CO5, CO6: Maintaining diverse aquatic cultures (CO1), assessing water pollution (CO4), determining pollutant toxicity (CO5), and understanding water purification (CO6) all contribute to environmental awareness and knowledge about sustainable water management practices.

PO9: Self-directed and Life-long learning
Mapped with all COs: Each CO requires independent learning, research, and initiative to acquire knowledge, design experiments, analyze data, and draw conclusions. These skills foster self-directed learning and a lifelong commitment to knowledge acquisition in aquatic biology.