

As Per NEP 2020

University of Mumbai



Title of the program

- A- P.G. Diploma in Zoology } 2023-24
B- M.Sc. (Zoology) (Two Year) }
C- M.Sc. (Zoology) (One Year) - 2027-28

Syllabus for

Semester – Sem I & II

Ref: GR dated 16th May, 2023 for Credit Structure of PG

Preamble

1) Introduction

The existing syllabus is re-constructed following the intent and objectives of National Education Policy (NEP) 2020 and National Credit Framework (NCrF). The syllabus has a total of 44 credits (22 credits in semester 1) and (22 credits in semester 2) covering all classroom teaching and practicum. In each semester, the courses (PSZO105M1 & PSZO105M2 for Semester I and PSZO202M1 & PSZO205M2 for Semester II) have been designated as minor courses. PSZO105M1 and PSZO205M1 are subject specific hence will be chosen by postgraduate students of the same zoology department while PSZO105M2 and PSZO205M2 are generic and will be opted by postgraduate students of other unrelated discipline/subject departments. In addition to core courses (Major & Minor), Research Methodology (RM) course (PSZO106) and On Job Training (OJT)/Field Projects (FP) (PSZO206) have been included in Semester I and Semester II respectively. OJT/FP has been kept open and will be decided by the institutions/colleges in their capacity and infrastructures/resources available.

2) Aims and Objectives

The primary aim of the present syllabus is to equip the learners with recent advances in the field of Zoology and related branches. It also aims to encourage and empower the learners to understand the challenges of society and the country that falls into the realms of Zoology, such as Non-Chordates, Chordates, Developmental Biology, Genetics and Evolution, Biochemistry and Biotechnology, Research methodology, etc. The contents incorporated in present syllabus are enough to inculcate with research aptitude and skills that are required to carry out research projects in the field of Zoology. On-Job Training/Field Project kept in second semester will fulfill the gap between academia and industry. Besides above, the present syllabus is enough to ignite the inquisitive minds of learners about the learning.

3) Learning Outcomes

The learners will be able to- i) incorporate critical thinking into their study to carry out scientific investigation objectively ii) differentiate anatomy and physiology of different systems/organs of animals iii) understand genetic analysis, gene, and genome, complex networking of genes in biological systems, altruism, racial distribution, and application of evolutionary principles iv) acquaint with the environmental impact and assessment v) understand processes and techniques used in development of biotechnology products vi) acquaint with special techniques developed for studying animal models vii) equip with skills to analyze problems, formulate a hypothesis, evaluate and validate results, and draw reasonable conclusions thereof viii) prepare for pursuing research or careers in industry in area of animal sciences ix) prepare themselves for teaching in Schools, Colleges and Universities x) continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of issues in animal sciences xi) become an enlightened citizen with commitment to deliver one's responsibilities to the society and the Country at large.

4) Any Other Point (If Any)

For internship/apprenticeship/field work, the credit weightage for equivalent hours will be 50% of that for lectures/tutorials.

5) Credit Structure of the Program (Sem I & II) (Table as per Parishisht 1 with sign of HOD and Dean)

R: _____

Post Graduate Programs in University

Parishisht - 1


Year (2 Yr PG)	Level	Sem. (2 Yr)	Major		RM	OJT / FP	R P	Cum. Cr.	Degree
			Mandatory*	Electives Any one					
I	6.0	Sem I	PSZO101: Non-chordates Credits 4	PSZO106: Frontiers in Zoology Credits 2	PSZO110 : Research Methodology Credits 4			22	PG Diploma (after 3 Year Degree)
		PSZO102: Developmental Biology I Credits 4	PSZO107: Lab Exercises based on PSZO106 Credits 2						
			PSZO103: Genetics and Evolution Credits 2	OR					
			PSZO104: Lab Exercises Credits 2	PSZO108: Instrumentation: Concepts and Applications Credits 2					
			PSZO105: Lab Exercises Credits 2	PSZO109: Lab Exercises based on PSZO108 Credits 2					
		Sem II	PSZO201: Chordates Credits 4	PSZO206: Food, Nutrition and Health Credits 2		PSZO210 OJT/FP Credits 4		22	
			PSZO202: Developmental Biology II Credits 4	PSZO207: Lab Exercises based on PSZO206 Credits 2					
			PSZO203: Biochemistry and	OR					

			Biotechnology Credits 2	PSZO208: Environmental Monitoring and Management Credits 2					
			PSZO204: Lab Exercises: Credits 2	PSZO209: Lab Exercises based on PSZO208 Credits 2					
			PSZO205: Lab Exercises Credits 2						
Cum. Cr. For PG Diploma			28	8	4	4	-	44	

Exit option: PG Diploma (44 Credits) after Three Year UG Degree

Cum. Cr. for 1 Yr PG Degree	26	8				10	44
Cum. Cr. for 2 Yr PG Degree	54	16	4	4		10	88

Note: * The number of courses can vary for totaling 14 Credits for Major Mandatory Courses in a semester as illustrated.



Dr. Ajai Kumar Singh
Head/ Co-ordinator
Department of Zoology



Prof. Shivram Garje
Dean, Science and Technology
University of Mumbai

Title of the program
M.Sc. (Zoology)
(Sem. I & II)

This syllabus is applicable for-

P. G. Diploma in Zoology (Duration 1 Year) (Total Credits: 44)
(Eligibility: After Three-Year UG Degree in Zoology)

P. G. Degree in Zoology (Duration: 2 Years) (Total Credits: 88)
(Eligibility: After Three-Year UG Degree in Zoology)

P. G. Degree in Zoology (Duration 1 Year) (Total Credits: 44)
(Eligibility: After Four-Year UG Degree in Zoology)

M. Sc. (Zoology) Part 1: Semester I (Theory)	
Paper 1: PSZO101: Non-Chordates	
Unit 1: Digestion and Excretion (15Hr)	
Objectives:	<i>To understand functional anatomy, differences and similarities of digestive and excretory systems of non-chordates.</i>
Desired Outcome:	<i>The learner will be able to differentiate anatomical and physiological modifications of digestive and excretory systems of non-chordates like Protostomes and Deuterostomes.</i>
1.1 General organization of digestive systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
1.2 Digestive Systems with Special emphasis on the organs or glands of:	
1.2.1 Annelids	Clamworm – Denticles or Paragnaths, Jaws
1.2.2 Arthropods	Prawn: Buccal cavity, Cardiac and Pyloric stomach, Hepatopancreas
1.2.3 Molluscs	<i>Pila</i> : Odontophore, Sub-radular organ, Radula, Oesophageal pouches, Cardiac and Pyloric chambers, Salivary gland, Hepatopancreas
1.2.4 Echinoderms	Starfish: Cardiac and Pyloric stomach, Intestinal Caeca, Digestive glands
1.2.5 Hemichordates	Balanoglossus: Buccal Diverticulum, Digestive Pharynx, Post-branchial canal, Hepatic and post-hepatic regions
1.3 General organization of excretory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
1.4 Excretory Systems with Special emphasis on the organs/structures or glands of:	
1.4.1 Annelids	Clamworm: Coiled Nephridia
1.4.2 Arthropods	Prawn: Antennal glands or Green glands or Maxillary glands, Bladder, Renal sac
1.4.3 Molluscs	<i>Pila</i> : Organ of Bojanus, anterior Renal chamber, posterior Renal chamber
1.4.4 Echinoderms	Starfish: Water Vascular System, Coelomocytes, Intestinal caeca
1.4.5 Hemichordates	Balanoglossus: Glomerulus or Proboscis gland
Unit 2: Respiration and Circulation (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>To understand anatomical differences and similarities of respiratory and circulatory systems in non-chordates.</i> ● <i>To understand physiological processes in non-chordates.</i>
Desired Outcome:	<i>The learner will be able to differentiate anatomical and physiological modification in respiratory and circulatory systems of non-chordates like Protostomes and Deuterostomes.</i>
2.1 General organization of respiratory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
2.2 Respiratory Systems with Special emphasis on the organs/structures or glands of:	
2.2.1 Annelids	Clamworm: Parapodia, Body wall
2.2.2 Arthropods	Prawn: Branchiostegites, Branchiae, Epipodite
2.2.3 Molluscs	<i>Pila</i> : Ctenidium, Pulmonary sac
2.2.4 Echinoderms	Starfish: Dermal papulae, Tube Feet
2.2.5 Hemichordates	<i>Balanoglossus</i> : Gill slits, Branchial sac, Gill pores
2.3 General organization of circulatory systems of Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
2.4 Circulatory systems with special emphasis on the organs/ structures or glands of:	
2.4.1 Annelids	Clamworm: Dorsal blood vessel, Ventral blood vessel, Transverse

	vessels
2.4.2 Arthropods	Prawn: Heart and Blood lacunae
2.4.3 Molluscs	Pila: Pericardium, Heart
2.4.4 Echinoderms	Starfish: Perihæmal sinuses, Axial gland
2.4.5 Hemichordates	Balanoglossus: Central Sinus (Heart), Dorsal vessel, Ventral vessel
Unit 3: Nervous System, Chemical Co-ordination and Reproductive System (15Hr)	
Objectives:	<ul style="list-style-type: none"> To compare nervous systems and chemical co-ordination in non-chordates. To understand similarities and differences in the reproductive systems of non-chordates.
Desired Outcome:	<ul style="list-style-type: none"> The learner will be able to differentiate anatomical and physiological modifications of nervous systems and chemical co-ordination of non-chordates. The learner will be able to differentiate modifications of reproductive systems of non-chordates.
3.1 General organization of Nervous systems& Chemical Co-ordination in Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
3.2 Nervous system & Chemical Co-ordination with special emphasis on the organs/structures or glands of:	
3.2.1 Annelids	Clamworm: Corpora pedunculata, Giant fibre, Circumpharyngeal ganglion, Peristomal cirri, Nuchal organ, pigmented Retinal cells
3.2.2 Arthropods	Prawn: Brain, Circum-oesophageal commissure, Compound eyes, Chromatophore, Statocysts, Tactile setae, Olfactory setae, Tangoreceptors, Chemoreceptors, Proprioceptors, Sinus gland X organ complex, Y organ
3.2.3 Molluscs	<i>Pila</i> : Cerebral Ganglia, Buccal Ganglia, Pleuro-pedal Ganglionic Mass, Supraintestinal Ganglion, Visceral Ganglion, Osphradium, Tentacles, Statocysts, Eyes, Mechanoreceptors, Photoreceptores, Temperature receptors, Chemoreceptors
3.2.4 Echinoderms	Starfish: Ectoneural nervous system, Langer's nerve, Eyes, Terminal tentacles, Neurosecretory cells
3.2.5 Hemichordates	<i>Balanoglossus</i> : Epidermal Plexus, Preoral ciliary organ, Neurosecretory cells
3.3 General organization of reproductive systems in Protostomes (Annelids, Arthropods and Molluscs) and Deuterostomes (Echinoderms and Hemichordates)	
3.4 Reproductive systems with special emphasis on the organs/structures or glands in:	
3.4.1 Annelids	Clam worm: Gonads – Testes and Ovaries (Temporary)
3.4.2 Arthropods	Prawn: Male – Testes, Vasa deferentia, Vasiculae seminalis; Female – Ovaries, Oviducts
3.4.3 Molluscs	<i>Pila</i> : Male – Testes, Vasa efferentia, Vasa deferens, Vasicula seminalis, Hypobranchial glands; Female – Ovary, Oviduct, Receptaculum seminis, Uterus, Vagina, Hypobranchial gland
3.4.4 Echinoderms	Starfish: Male / Female gonads
3.4.5 Hemichordates	Balanoglossus: Saccular gonads
Unit 4: Paleontology and Phylogeny (15Hr)	
Objectives:	<ul style="list-style-type: none"> To understand evolution of non-chordates by studying their fossils found in Indian subcontinent.

	<ul style="list-style-type: none"> To understand phylogeny of non-chordates.
Desired Outcome:	<i>The learner will be able to understand the evolution of non-chordates and their phylogenetic relationships by means of paleontological evidences.</i>
4.1 Fossils of:	
4.1.1 Annelids	<i>Serpula and Glomerula spp.</i> found in South India
4.1.2 Arthropods	Trilobites found in Kashmir, Insects trapped in amber found in Western India
4.1.3 Molluscs	Molluscs fossils found in Kutchh, Chhattisgarh and Jammu – <i>Palmerella kutchensis, Cimomia forbesi, Lamellidens</i>
4.1.4 Echinodermata	<i>Gongrochanus spp.</i> found in South India, Echnoid fossils found in India.
4.1.5 Hemichordata	Graptolite fossils
4.2 Phylogenetic affinities of Annelida, Arthropoda, Mollusca, Echinodermata and Hemichordata	
4.2.1 Phylogenetic relationships of Trochophore larva	
4.2.2 Similarities and differences between Annelids and Molluscs	
4.2.3 Phylogeny of Arthropods – Monophyletic theory and polyphyletic theory	
4.2.4 Phylogeny of Echinoderms – Asterozoan hypothesis and Cryptosyringid hypothesis	
4.2.5 Affinities of Annelida with Hemichordata	
4.2.6 Affinities of Echinodermata with Hemichordata	
4.3 Construction of Phylogenetic Tree	
4.3.1 Genetic distance	
4.3.2 Rooting trees	
4.4 Phylogenetic Tree Building Methods	
4.4.1 Distance-Based Methods:	<ul style="list-style-type: none"> UPGMA Method Neighbour Joining Method (NJ) Weighted Neighbour-Joining (Weighbour) o Fitch-Margoliash (FM) and Minimum Evolution (ME) Methods
4.4.2 Character-based Methods:	<ul style="list-style-type: none"> Maximum parsimony (MP) Maximum Likelihood (ML)

Paper 2: PSZO102: Developmental Biology – I	
Unit 1: Fertilization and Early Development in Non-chordates (15Hr)	
Objectives:	<ul style="list-style-type: none"> To introduce learners to the concept, mechanism and molecular events of fertilization in non-chordates To introduce the concept of germ layers and coelom formation.
Desired Outcome:	<ul style="list-style-type: none"> The learner will understand the mechanism of fertilization and its molecular events in non-chordates. The learner will appreciate the process of formation of germ layers and coelom in animals and understand the difference in these processes between Protostomes and Deuterostomes.
1.1 Concept and Mechanism of Fertilization	
1.1.1 Types of reproduction – Asexual and sexual	
1.1.2 Fertilization – Concept and types	
1.1.3 Mechanism of fertilization	
	<ul style="list-style-type: none"> Capacitation of sperm Recognition of sperm and egg Acrosome reaction Activation of egg Fusion of egg and sperm cell membrane Amphimixis
1.2 Molecular Events of Fertilization	
1.2.1 Species specific recognition of gametes – Fertilizin and antifertilizin interaction, Binding protein	
1.2.2 Prevention of polyspermy – Fast and slow block	
1.2.3 Calcium as initiator of cortical granule reaction	
1.2.4 Activation of egg metabolism with respect to Sea urchin	
1.3 Formation of Germ Layers and Coelom Formation	
1.3.1 Post Fertilization events: Overall view of Cleavage, Blastulation, Gastrulation	
1.3.2 Formation of Germ layers – Diploblastic, Triploblastic	
1.3.3 Coelom formation in Protostomes and Deuterostomes	
Unit 2: Basic concepts of embryonic development in non-chordates (15Hr)	
Objectives:	<ul style="list-style-type: none"> To introduce basic concepts of embryonic development and embryogenesis. To understand therapeutic applications of stem cells.
Desired Outcome:	Learners would understand basic concepts and aspects of embryogenesis and stem cell therapy.
2.1 Fate map and cell lineages: potency and commitment	
2.2 Competence and induction	
2.3 Mosaic and regulative development	
2.4 Cell specification:	2.4.1 Autonomous specification
	2.4.2 Conditional specification
	2.4.3 Syncytial specification
Unit 3: Early Development in non-chordates (15Hr)	

Objectives:	<ul style="list-style-type: none"> To introduce the learners about the process of early development and differences in the pattern of development in non-chordates. To help learners understand specific gene regulation during development.
Desired Outcome:	<ul style="list-style-type: none"> Learners will understand the mechanism of early development and able to correlate the various differences observed in the pattern of embryonic development in non-chordates. Learners will understand the role of certain genes in early development.
3.1 Development of <i>Caenorhabditis elegans</i>:	
3.1.1 Pattern of cleavage	
3.1.2 Anterior-posterior axis formation	
3.1.3 Dorsal-Ventral axis formation	
3.1.4 Cell specification (Autonomous and Conditional)	
3.1.5 Process of gastrulation	
3.2 Early Development in <i>Drosophila melanogaster</i>:	
3.2.1 Pattern of cleavage	
3.2.2 Blastulation	
3.2.3 Process of gastrulation	
3.2.4 Anterior-posterior pattern formation by morphogenetic protein gradient	
3.2.5 Dorsal-ventral pattern formation by morphogenetic protein gradient	
3.2.6 Patterns of homeotic gene expression: <i>Homeo</i> selector gene complexes (Hom-C, homeotic gene complex) – Antennapedia and bithorax complexes and their functional domains, Realistor genes: <i>distal less</i> and <i>wingless</i> genes	
Unit 4: Special Aspects in Reproduction and Development in non-chordates (15Hr)	
Objectives:	<ul style="list-style-type: none"> To understand diversities in reproduction and development in non-chordates. To understand the mechanism of regeneration. To help learners to relate applications of developmental biology with forensics and IPM.
Desired Outcome:	<ul style="list-style-type: none"> Learners will acquire knowledge about the diversities in reproduction and development in invertebrates and the process of regeneration in lower animals. Learners will understand how principles of developmental biology can be applied in forensics and IPM
4.1 Sexual Reproduction in Protozoa	
	Conjugation in <i>Paramoecium sp.</i>
	Syngamy in flagellates
4.2 Metagenesis in <i>Obelia sp.</i>	
4.3 Polyembryony in <i>Fasciola sp.</i>	
4.4 Regeneration in <i>Hydra</i> (Morphallactic) and <i>Planaria</i> (Totipotency)	
4.5 Parthenogenesis in Aphids	
4.6 Metamorphosis in insects – Indirect Development	
4.6.1 Types of insect metamorphosis	
4.6.2 Eversion and differentiation of imaginal disc	
4.6.3 Hormonal control of insect metamorphosis	
4.6.4 Study of life cycle of Blow fly-applications in forensics	

4.6.5 Larval forms of non-chordates: Amphiblastula larva (Porifera), Planula (Coelenterata), Echinopluteus (Echinodermata) and Tornaria (Hemichordata)

4.7 Pheromones in invertebrates and their role as sex attractants and in Integrated Pest Management (IPM).

Paper 3: PSZO103: Genetics and Evolution	
Unit 1: Introduction to evolutionary genetics and evolution (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● To develop in learners the understanding of genes, genomes in evolution. ● To comprehend the pattern of genetic relatedness between all species. ● To understand the contribution of genetic variation in phenotypic expression.
Desired Outcome:	<ul style="list-style-type: none"> ● The learners will understand the genetic analysis at the gene, genome and population level. ● The learner would realize the flow of genetic information and complex networking of genes in biological system leading to major phenotypic changes.
1.1 Cytochrome ‘c’	
1.1.1 Structure of Cytochrome ‘c’ and couple cytochrome ‘c’	
1.1.2 Cytochrome ‘c’ in eukaryotes. Example Primates	
1.1.3 Cox gene	
1.1.4 Molecular basis of haemoglobin gene structure. Haemoglobin as a model of evolution	
1.2 Sex Determination and Evolution of Sex Chromosome	
1.2.1 Theory of evolution of sex chromosome	
1.2.2 Evolution of sex chromosomes from autosomes	
1.2.3 Biology of Y chromosome	
1.2.4 Molecular level of sex determination in mammals	
1.2.5 Sex based gene expression	
1.2.6 T6sRNA	
1.3 Cytoplasmic Inheritance/Extra-nuclear Inheritance	
1.3.1 Introduction – human mitochondrial genetics	
1.3.2 Paternal and maternal mtDNA inheritance in humans	
1.3.3 mtDNA mutations and human diseases	
1.3.4 Salient feature of cytoplasmic inheritance	
1.4 Selfish Gene	
1.4.1 Introduction and definition	
1.4.2 Individual altruism and genetic egoism	
1.5 Evolution: Concept of neutral evolution, molecular divergence and molecular clock	
1.5.1 Fossil dating	
1.5.2 Geological time scale – Eras, Periods and Epochs	
1.5.3 Major events in evolutionary time scale	
1.5.4 Significance of fossils and fossilization	
1.5.5 Fossil dating – Types: Absolute and Relative Dating	
1.5.6 Process of C-14 Carbon dating	
1.6 Frozen zoo	
1.6.1 Concept of frozen zoo to save endangered species	

1.6.2 Techniques to create offspring from cells of endangered species, nuclear transfer, mixing cells, creating sperms and eggs	
1.6.3 Current status of frozen zoo	
Unit 2: Molecular Genetics (15Hr)	
Objectives:	<ul style="list-style-type: none"> To get acquainted with applications of genes in modern science and population genetics. To give in-depth knowledge of biological processes through molecular mechanisms.
Desired Outcome:	<ul style="list-style-type: none"> The learner will understand the molecular processes that occur in and between the cells. The learner will gain insight in most significant molecular and cell-based methods used to expand the understanding of modern Biology.
2.1 Gene Library	
2.1.1 Molecular analysis of gene and gene products	
2.1.2 Types – Genomic Library, cDNA Library	
2.1.3 Construction of genomic library – human antibody gene library	
2.1.4 Applications of gene library	
2.2 Types of Genes: Definition	
<ul style="list-style-type: none"> Multigenes Repeated genes Single copy gene House-keeping gene (constitutive gene) Luxury gene (non-constitutive gene) Pseudogene Jumping gene (Transposons) Overlapping gene Structural gene Processed gene Split gene Regulatory gene 	
2.2.1 Multi-gene Families and Types:	
a) Split Genes or Interrupted genes	
<ul style="list-style-type: none"> Introduction Structure of split genes Discovery and theory of split genes Evolution of split genes 	
b) Pseudogenes	
c) Selfish gene	
2.2.2 Overlapping Gene	
2.3 Mapping units	
2.3.1 Types –genetic mapping and physical mapping	
2.3.2 Detection of linkages	
2.3.3 Construction of linkage maps in diploids and their characteristics	
2.3.4 Co-efficient of coincidence	
2.3.5 Outline of other types of gene mapping	
2.4 Gene cloning	

2.4.1 Definition and strategies of gene cloning
2.4.2 Techniques in gene cloning
2.4.3 Applications of gene cloning in DNA analysis in research.
2.5 Population genetics
2.5.1 Population genetics in DNA typing.
2.5.2 Mutation – Selection balance.
2.5.3 Parallelism between random drift and inbreeding.

PSZOP104: Lab Exercises	(60 hrs)
1. Study of digestive and excretory systems of clamworm, prawn, <i>Pila</i> , starfish, <i>Balanoglossus</i> .	
2. Study of Fossils of <i>Serpula spp.</i> , <i>Glomerula spp.</i> , Trilobites, Insects trapped in amber, <i>Palmerella kutchensis</i> , <i>Cimomia forbesi</i> , Lamellidens, <i>Gongrochanus spp.</i> , <i>Goniocidaris</i> , Graptolite fossils	
3. Construction of phylogenetic trees based on: Morphological characters.	
4. To culture and observe: <i>Drosophila</i> to study its life cycle.	
5. To study the imaginal discs of <i>Drosophila</i> through temporary mounting.	
6. To study germ layers using permanent slides: <ul style="list-style-type: none"> ● T.S. of body wall of sponges and cnidarians (coelenterates) ● T.S. of body wall of Platyhelminthes ● T.S. of body wall of <i>Ascaris</i> ● T. S. of body wall of earthworm 	
7. To study larvae of non-chordates: <ul style="list-style-type: none"> ● Porifera – Amphiblastula ● Cnidaria (Coelenterata) – Planula ● Annelida and Molluscs– Trochophore ● Mollusca – Glochidium <ul style="list-style-type: none"> ▪ Crustacea ▪ Nauplius ▪ Zoea ▪ Mysis ▪ Megalopa 	
8. Problems on gene mapping.	
9. To study Haemoglobin of domesticated dogs, cats, cattles with the help of comparative protein sequence charts using bioinformatics tools.	
10. Field visit to observe invertebrates in their natural habitat and accordingly the modifications of various systems.	

PSZOP105: Lab Exercises	(60 hrs)
1. Study of nervous and reproductive systems of clamworm, prawn, <i>Pila</i> , starfish, Balanoglossus.	
2. To culture and observe: <i>Tribolium</i> or <i>Sitophilus</i> to study its life cycle.	
3. To study larvae of non-chordates: <ul style="list-style-type: none"> ● Echinodermata <ul style="list-style-type: none"> ▪ Auricularia ▪ Echinopluteus ▪ Bipinnaria ● Hemichordata– Tornaria 	
4. To Isolate DNA from the given blood sample.	
5. Construction of phylogenetic tree based on: Nucleotide sequences.	
6. Problems on mitotic index.	
7. Study of syndromes – Cockeye syndrome (CS), Proteus syndrome, Muenke syndrome.	
8. To culture and observe the life cycle of butterflies/ moths and make a report on it.	
9. To study gemmule in a sponge.	
10. Field visit to study fossils to places such as museums, institutions, quarries, archaeological sites, etc.	

PSZO106: Frontiers in Zoology	
Unit 1: Biological clock, Psychology and Neurobiology of Stress and Emotion (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● To introduce recent interdisciplinary scientific fields to the learners. ● To give learners the basic knowledge of emotions, stress and associated health problems. ● To introduce learners to the brain regions that forms the basis of emotions.
Desired Outcome:	<ul style="list-style-type: none"> ● Learners will get the introductory knowledge of emerging areas correlated with Zoology. ● Learners will understand the different types of biological clocks and their importance. ● Learner will get acquainted with brain regions that form the basis of emotions and stress. ● Learner will also understand the health problems caused due to prolonged emotion and stress on the body.
1.1 Biological rhythms	
1.1.1 Introduction	
1.1.2 Types	
	<ul style="list-style-type: none"> ● Circadian rhythms
	<ul style="list-style-type: none"> ● Tidal rhythms
	<ul style="list-style-type: none"> ● Lunar rhythms
	<ul style="list-style-type: none"> ● Semilunar rhythms
	<ul style="list-style-type: none"> ● Circannual rhythms
1.1.3 Structure of Biological Clock in Insects and Vertebrates; biological clock function	
1.1.4 Molecular mechanisms controlling the circadian rhythm (Noble Prize winning work, 2017)	
1.2.1 Introduction and general features of emotions	
1.2.2 Neuronal basis of emotion	
1.2.3 Types of emotions – Definition and management of Fear, Frustration, Joy / Happiness, Sadness, Embarrassment, Guilt, Anger, Love, Inspiration.	
1.3.1 Concept of Stress, Measurement of stress, Characterizing stress – Signs of stress, Types of stressors	
1.3.2 Stress and the Hypothalamus-Pituitary-Adrenal Axis (HPA Axis)	
1.3.3 Remedial measures to combat psychological stress and negative emotions	
Unit 2: Modern Techniques in Medical Field (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● To provide the basic knowledge of different modern techniques used in medical field. ● To provide information of applications of biomedical techniques.
Desired Outcome:	<ul style="list-style-type: none"> ● Learner would be able to explain the basic principles, applications of the major imaging and DNA bar coding techniques.
2.1 Physical aspects of medical imaging	
2.1.1 Laser beam in Biology and Medical field	
2.1.2 Medical lasers (Carbon Dioxide Laser, Nd: YAG Laser)	
2.1.3 Applications of lasers in therapy and diagnosis.	

2.2 Principle and applications of major medical imaging techniques
2.2.1 Radiography
2.2.2 Echocardiography (2D and 3D Echo)
2.2.3 Computed Tomography Scan (CT scan)
2.2.4 Magnetic Resonance Imaging (MRI)
2.3 Radioisotope Imaging: Introduction and applications
2.4 DNA bar coding technique and its applications
2.5 Molecular Cytogenetic Techniques and their Applications
2.5.1 Fluorescence <i>in situ</i> Hybridization (FISH)
2.5.2 Genomic <i>in situ</i> Hybridization (GISH)
2.5.3 Flow cytometry
2.5.4 Automated karyotyping
2.5.5 Chromosome painting

PSZOP107: Lab Exercises based on PSZO106	(60 hrs)
1. Identification of photographs with respect to chronobiology: <ul style="list-style-type: none"> ● Structure of biological clock in Insects. ● Structure of biological clock in Vertebrates. 	
2. Identification of photographs of different imaging techniques.	
3. Study of gross anatomical regions of brain involved in stress and emotions.	
4. Study of circadian functions in humans (daily eating, sleep and temperature patterns).	
5. Occupational stress index using questionnaire.	
6. Study of MRI scans to diagnose a disease.	
7. Study of DNA barcoding in terms of taxonomy- Generation and usefulness.	
8. Study of human karyotypes to identify the syndromes- Down's, Patau's, Klinefelter's, Turner's.	
9. Assignment/ report on pulse rate after stress.	
10. Visit to DNA barcoding laboratory/ pathology laboratory to prepare a report.	

PSZO108: Instrumentation: Concepts and Applications

Unit 1: Instruments used for physico-chemical parameters and Chromatography (15Hr)

Objectives:

- To skill learners about the instruments used in routine laboratory work.
- To acquaint the learners about the chromatography technique and its application in various fields.

Outcome:

- The learners will know the skills of handling and using the instruments.
- The learners will learn the working and application of different chromatography techniques used in pharmaceutical and life sciences industries.

1.1 Analytical balance

Single pan analytical balance, how to use the balance, methods for weighing, problems encountered and maintenance

1.2 pH and pH Meter:

Acids and bases-Definition, concepts of strong and weak acid and base,

Buffers- Definition, Buffer action and buffer capacity.

pH meter- Working principle, Calomel electrode, glass electrode, standardization method, Factors affecting pH measurement, application and maintenance.

1.3 Digital and Mercury thermometer: Working principle, standardization method, application and maintenance.

1.4 Oven: Working principle, standardization method, application and maintenance

1.5 Rotary shaker Working principle, standardization method, application and maintenance

1.6 Definition, types of chromatography (working principle and application):

- Paper Chromatography,
- Thin Layer Chromatography,
- Column Chromatography,
- Adsorption Chromatography
- Ion- Exchange Chromatography
- Gas Chromatography- Mass Spectrometry (GC-MS)
- High Performance liquid chromatography (HPLC)

Unit 2 Microscopy, Spectroscopy and Electrophoresis

(15Hr)

Objectives:

- To acquaint the learners about the microscopy and its application various disciplines.
- To acquaint the learners about the spectroscopy and electrophoresis technique and their application in analytical research/study.

Outcome:

- The learners will be skilled enough to use of different microscope during routine observation/study.
- The learners will learn the skills of handling, working and uses of spectroscopy and electrophoresis techniques.

Basic Introduction, structural components, working principle, standardization method, application and maintenance of

- Simple and Compound Microscope,
- Dark-Field Microscope,
- Phase Contrast Microscope,
- Transmission Electron Microscope (TEM),
- Scanning Electron Microscope (SEM)

Basic Introduction, Structural components, working principle, Application, SOP and Maintenance of:

- Electromagnetic radiation, Types of spectroscopy,
- Colorimetry
- Ultraviolet and Visible Spectroscopy (UV-VIS)
- Flame Photometry
- Polyacrylamide Gel Electrophoresis (PAGE)
- Agarose Gel Electrophoresis (AGE)

PSZOP109: Lab Exercises based on PSZO108	(60 hrs)
1. To study the pH of water sample/ soil sample using universal indicator/ pH paper/ pH meter.	
2. To study structure, working, use and care of microscopes (dissecting microscope and compound microscope).	
3. Study of Zooplanktons and phytoplanktons from river/pond/lake/estuaries water sample using compound microscope (Temporary mounting).	
4. Separation of lipids in a given sample by TLC.	
5. Separation of pigments from leaves or flowers by adsorption column chromatography.	
6. Separation and identification of amino acids by 2D paper chromatography.	
7. Study of following instruments through photographs: Spectrophotometer, Flame photometer, SEM, TEM, HPLC, GCMS.	
8. Colorimetric estimation of serum/egg protein by Peterson-Lowry method.	
9. Separation of proteins using AGE or PAGE.	
10. Field visit to any instrumentation laboratory/research institute/centralized laboratory	

PSZO110: Research Methodology	
Unit 1: Principles of Scientific Research (15Hr)	
Objectives:	<ul style="list-style-type: none"> To acquaint learners with the principles of scientific research and methods of conducting scientific enquiry. To inculcate scientific temperament and research aptitude among the learners.
Desired Outcome:	<ul style="list-style-type: none"> Learner will be able to formulate research problem and concept research design. Learner will be able to execute the research problem.
1.1 Basic concepts of research	
1.1.1 Definition	
1.1.2 Characteristics of research (controlled, rigorous, systematic, valid and verifiable, empirical and critical)	
1.1.3 Objectives of research	
1.1.4 Types of research:	
a) Pure and applied	
b) Structured and unstructured	
c) Descriptive, correlational, explanatory, exploratory, historical, comparative and experimental	
1.2 Formulating research problem	
1.2.1 Reviewing literature: Using library, computerized searches, evaluating literature	
1.2.2 Developing a research problem: Importance, sources, considerations, steps, defining a problem, formulate objectives	
1.2.3 Identifying variables: Introduction, types of variables, measurement scales	
1.2.4 Hypothesis: Definition, function, characteristics, types (H ₀ , H _A), Principles of hypothesis, framing hypothesis, errors in hypothesis, research question versus research hypothesis, hypothesis versus non-hypothesis research	
1.3 Research design	
1.3.1 Definition and purpose	
1.3.2 Characteristics of good research design	
1.3.3 Sampling strategy and sampling size determination, eliminating extraneous variables	
1.3.4 Types of study design: study designs in quantitative research (cross-sectional, before and after, longitudinal, retrospective, prospective, retrospective-prospective, experimental, non-experimental, quasi-experimental)	
Unit 2: Data Management and Analysis (15Hr)	
Objectives:	<ul style="list-style-type: none"> To introduce learners to various statistical tools for analysis of research data. To familiarize learners with the in-silico approach for data management.
Desired Outcome:	<ul style="list-style-type: none"> The learner will be able to develop skill set for organization and effective presentation of data. The learner will be able to choose correct statistical test.

	<ul style="list-style-type: none"> The learner will be able to perform statistical analysis indifferent fields of research using various computer programs.
2.1 Methods of data collection	
2.1.1 Primary sources	
2.1.2 Secondary sources	
2.2 Data Classification and Presentation	
2.2.1 Classification of data (Geographical, Chronological, Qualitative, Quantitative)	
2.2.2 Tabulation of data (one-way table, two-way table, complex table)	
2.2.3 Type of charts (Line, Column, Scatter plot, Box plot, Heat Map)	
2.3 Concepts of Measurements	
2.3.1 Univariate (standard deviation, variance, quartiles)	
2.3.2 Bivariate (correlation and regression)	
2.3.3 Multivariate (ANOVA: one-way, two-way)	
2.3.4 Level of significance and p-value	
2.3.5 Normal distribution, Skewness, Kurtosis, Outliers	
2.4 Testing of Hypothesis	
2.4.1 Null hypothesis, Alternative hypothesis	
2.4.2 Type 1 and Type 2 Errors	
2.4.3 Testing of Hypothesis (single population mean, two population means)	
2.4.4 One-tailed and Two-tailed tests	
2.5 Parametric and Non-parametric tests	
2.5.1 Parametric tests: t test, z test, F test	
2.5.2 Non-parametric tests: Chi-square test, Mann-Whitney test, Kruskal-Wallis test, Friedman Test, Wilcoxon signed-rank test	
Unit 3: Scientific Communication (15Hr)	
Objectives:	<ul style="list-style-type: none"> To enable learners to develop skills for effective research communication. To enable learners to publish research paper in journals with good impact factors.
Desired Outcome:	The learner will be able to get an insight of scientific communication documentation and will become familiar with good scientific journals.
3.1 Research planning	
3.1.1 Project Proposal and research funding agencies – Research grants, scholarships and funding (CSIR, DBT, DST, DST- INSPIRE Fellowship, ICMR, INSA, BRNS, MoEFCC, UGC-RFSMS, Fulbright Fellowships for Indian students, Lady Tata Memorial Trust, EPA, Bill and Melinda Gates Foundation, Wellcome Trust, Erasmus Mundus)	
3.1.2 Use of reference management software (MS Word / Zotero / Mendeley)	
3.1.3 Scientific writing –Thesis and Dissertation	
3.2 Documentation for approval from Institutional Animal Ethics Committee (IAEC) and Institutional Biosafety Committee (IBSC):	
3.2.1 Documents for registration, renewal and reconstitution of IAEC as per CPCSEA guidelines	
3.2.2 Proposal layout for permission from IAEC for use of animals in research	
3.2.3 Proposal layout based on recombinant DNA safety guidelines from IBSC	
3.2.4 Proposal layout for use of transgenic animals in research	
3.3 Publications and Research Journals	
3.3.1 Types of research journals	
3.3.2 Impact factors of Journals	
3.3.3 Predatory Journals	
3.3.4 Review process - benefits and drawbacks of single blind, double blind and open peer review	

process	
3.3.5 Understanding “h – index” and “i10 – index”	
3.3.6 SCOPUS, Google Scholar, Web of Science	
3.3.7 Process to obtain ISSN and ISBN	
Unit 4: Model organisms and their applications (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● To introduce to learners the key species which are used as model organisms in research. ● To acquaint the learners with special techniques developed for studying these model organisms. ● To make them aware of the contributions of model organisms to basic biology, genetics, development and diseases.
Desired Outcome:	<ul style="list-style-type: none"> ● The learners will be able to understand the special features of different animals that have made them useful as a model system. ● The learners will become familiar with the specific applications of model organisms for various biological processes. ● The learners will be able to appreciate how experimentation with these organisms has enhanced the understanding of the basis of human diseases.
4.1 Introduction: Concept key features and importance of model organisms	
4.2 Earthworm	
4.2.1 Biology and genome	
4.2.2 Model for studies on regeneration	
4.3 <i>Caenorhabditis elegans</i>	
4.3.1 Body plan of the worm, genetics, genome, cultivation, advantages and limitations	
4.3.2 Techniques used for genetic modification, Mutant characterization, discovery of RNAi	
4.4 <i>Daphnia sp.</i>	
4.4.1 Genome, epigenetic phenotypic variation	
4.4.2 Advantage and limitations	
4.4.3 Model for studies in toxicology	
4.5 <i>Drosophila melanogaster</i>	
4.5.1 Genome, advantages and limitations	
4.5.2 Model for cytogenetics, development, neuroscience, human diseases and therapeutic drug discovery	
4.6 <i>Danio rerio</i> (Zebra fish)	
4.6.1 Genome, advantages and limitations	
4.6.2 Insights on embryology, ageing and toxicology	
4.7 <i>Mus musculus</i> (Mouse)	
4.7.1 Genomics, advantages and limitations	
4.7.2 Model for studies on physiology, development, ageing, human diseases (Cancer and Diabetes) and behaviour research	
4.7.3 Transgenic and germ line transgenic mouse models, genetically engineered mouse models (GEMMs): Knock-In and Knock-out mouse models	

M. Sc. Part 1: Semester II (Theory) Paper 1: PSZO201: Chordates	
Unit 1: Protochordates and Agnatha (15Hr)	
Objectives:	<ul style="list-style-type: none"> To equip learners with the knowledge of evolutionary progression of Protochordates. To familiarize learner with the origin, morphology and phylogeny of the Protochordates.
Desired Outcome:	Learners would be equipped with the understanding of morphology and phylogeny of Protochordates.
1.1 Protochordates	
1.1.1 Origin and ancestry of Protochordates, similarities and differences with Invertebrates and Chordates	
1.1.2 Comparison of characteristics between subphyla Urochordates and Cephalochordates	
1.2 Urochordates	
1.2.1 Life history of <i>Herdmania</i> and its phylogenetic affinities	
1.3 Cephalochordates	
1.3.1 General features and phylogenetic affinities	
1.3.2 Life history of <i>Branchiostoma</i>	
1.4 Ostracoderm	
1.4.1 Salient features and biological significance	
1.4.2 Interrelationship and affinities with fish	
1.5 Cyclostomes	
1.5.1 Resemblance with Cephalochordates, Vertebrates and differences from Fishes	
1.5.2 Life history of <i>Petromyzon</i>	
Unit 2: Phylogeny of Chordates (15Hr)	
Objectives:	<ul style="list-style-type: none"> To provide learners with the knowledge of evolutionary progression of Protochordates. To familiarize learner with the origin, morphology and phylogeny of the Protochordates.
Desired Outcome:	Learners would be equipped with the understanding of morphology and phylogeny of Protochordates.
2.1 Ancestry of Chordates	
2.2 Pisces	
2.2.1 General characters of Dipnoi and affinities with Fishes, Elasmobranchs and Amphibia	
2.2.2 Origin of air bladder and its relationship with tetrapod lungs	
2.2.3 Deep sea adaptations of fishes	
2.2.4 Origin of fins	
2.3 Amphibia	
2.3.1 Origin of Tetrapods	
2.3.2 Pedomorphosis	
2.3.3 Adaptive radiation in amphibians Lepspondyli and Lissamphibia	
2.4 Reptilia	
2.4.1 Origin of Reptiles and affinities with Amphibia	
2.4.2 Terrestrial adaptations in Reptiles	
2.5 Aves	
2.5.1 Origin of Birds and affinities with Reptiles	
2.5.2 Adaptive radiation in Birds – Ratitae (Flightless Birds) and Carinatae (Flying Birds)	

2.5.3 Origin of Flight – Theory of Cursorial and Arboreal origin	
2.6 Mammalia	
2.6.1 Origin of Mammals	
2.6.2 Phylogeny of terrestrial and aquatic mammals	
Unit 3: Functional and Comparative Anatomy of Chordates (15Hr)	
Objectives:	<ul style="list-style-type: none"> To equip learners with the knowledge of evolutionary progression of chordates. To familiarize learner with the origin, morphology and phylogeny of the chordates.
Desired Outcome:	Learners would understand evolution, morphology and phylogeny of chordates.
3.1 Comparative Anatomy of:	
3.1.1 Chondrocranium	
3.1.2 Splanchnocranium	
3.1.3 Skull in different Vertebrates	
3.2 Evolution and Comparative Anatomy of Excretory System of Chordates	
3.2.1 Evolutionary development of Kidney	
<ul style="list-style-type: none"> Archinephros Pronephros Mesonephros Metanephros 	
3.3 Comparative Anatomy of Nervous System in Vertebrates	
3.3.1 Brain	
3.3.2 Sense organs – Eyes and Ears	
3.4 Comparative Anatomy of Respiration	
3.4.1 Gills, Skin and Lungs	
3.5 Circulation: Heart and Aortic Arches	
3.6 Male and female reproductive and urinary ducts of Vertebrates (Cyclostomes, Teleost, Elasmobranchs, Amphibia, Reptilia, Aves and Mammalia)	
Unit 4: Assorted Topics on Chordates (15Hr)	
Objectives:	To introduce learners with some interesting topics of the chordates.
Desired Outcome:	Learners would obtain additional knowledge of diverse characteristics of various chordates
4.1 Retrogressive metamorphosis in Ascidians	
4.2 Pisces	
<ul style="list-style-type: none"> Evolutionary significance Crossopterygians, Placoderms Migration Lateral line sense organ and electric organs 	
4.3 Amphibia – Evolutionary significance of Labyrinthodonts	
4.4 Reptilia	
<ul style="list-style-type: none"> Evolutionary significance of Dinosaurs Venom apparatus and biting mechanism in snakes 	
4.5 Aves	
<ul style="list-style-type: none"> Migration Flight adaptations 	
4.6 Mammalia	
<ul style="list-style-type: none"> Dentition in mammals Habitat diversification 	

<ul style="list-style-type: none"> • Walking gait: Plantigrade, Digitigrade and Unguligrade
<ul style="list-style-type: none"> • Comparative account of Jaw suspension

Paper 2: PSZO202 Developmental Biology – II	
Unit 1: Generalized Account of Reproductive Systems in Chordates (15Hr)	
Objectives:	<i>To introduce to the learner the generalized account of reproductive systems and accessory structures in chordates.</i>
Desired Outcome:	<i>The learner will gain knowledge of reproductive systems in chordates.</i>
1.1 Reproductive system	
<ul style="list-style-type: none"> • Urochordata – Tunicate 	
<ul style="list-style-type: none"> • Cephalochordata – <i>Amphioxus</i> 	
<ul style="list-style-type: none"> • Cyclostomata – <i>Petromyzon</i> 	
<ul style="list-style-type: none"> • Pisces – Catfish 	
<ul style="list-style-type: none"> • Amphibia – Frog 	
<ul style="list-style-type: none"> • Reptilia – Lizard 	
<ul style="list-style-type: none"> • Aves – Pigeon 	
<ul style="list-style-type: none"> • Mammalia – Human 	
1.2 Accessory Reproductive Glands – Human	
Unit 2: Physiology of Reproduction (15Hr)	
Objectives:	<i>To acquaint the learner with the physiology of reproduction in chordates.</i>
Desired Outcome:	<i>The learners will get an idea of reproductive physiology in chordates.</i>
2.1 Biochemistry of semen – Fish, Frog, Snake, Human.	
2.1.1 Sperm capacitation, decapacitation – molecular mechanism and significance	
2.2 Ovarian leuteinization and mammary gland differentiation – human	
2.3 Pheromones – Pisces, Amphibia, Reptilia, Aves and Mammalia	
2.4 Courtship behaviour in – Pisces, Amphibia, Reptilia, Aves, Mammalia	
Unit 3: Developmental Biology – Germ Cells, Stem Cells and Induced Breeding (15Hr)	
Objectives:	<ul style="list-style-type: none"> • <i>To introduce to the learner the germ cell migration in chordates.</i> • <i>To acquaint the learner with details of stem cells.</i>
Desired Outcome:	<ul style="list-style-type: none"> • <i>The learner shall comprehend details of germ cell migration and understand the importance of stem cells.</i>
3.1 Introduction to germ cells	
Germ cell migration in Zebrafish, Frogs, Lizard, Chick and Mouse	
3.2 Stem cells –	
3.2.1 Embryonic stem cells, Induced Pluripotent stem cells, Adult stem cells	

3.2.2 Regeneration Therapy – Cardiac, bone and neuronal regeneration	
3.2.3 Cryopreservation of stem cells – Concept, tools, techniques and application	
3.3 Induced breeding in fish – technique and applications	
Unit 4: Animal Development – Impact of Environment and Evolution (15Hr)	
Objectives:	<i>To introduce to the learner the impact of environment on development and its evolutionary aspects.</i>
Desired Outcome:	<i>The learner will be acquainted with environmental impact on development and evolution of animals.</i>
4.1 Environmental Cues and Impact on Development	
<ul style="list-style-type: none"> ● Predator Induced Polyphenisms – Amphibian 	
<ul style="list-style-type: none"> ● Temperature and Sex – Fish, Turtle and Alligator 	
4.2 Teratogenesis	
Alcohol, Retinoic acid, Endocrine disruptors – Diethylstilbestrol, Plastics –	
Nonylphenol, Bisphenol A and Heavy metals as teratogens	
4.3 Developmental constraints on evolution – physical, morphogenetic and phyletic	
4.3.1 Modularity of development – Example – Duffy blood group substance and Stickleback fish	
4.4 Aging and Senescence – Causes, Consequences, and Therapeutics	
4.4.1 Environmental and epigenetic causes of aging – Plastics, Pesticides, Heavy metals	
4.5 Promoting Longevity: Role of telomerase: an overview	

Paper 3: PSZO203: Biochemistry and Biotechnology	
Unit 1: Fundamentals of Biochemistry and Metabolism (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>To provide learners an in-depth knowledge of the fundamentals of chemical foundations of biomolecules and their interactions.</i> ● <i>To provide the learners knowledge of the metabolism of various biomolecules and the importance and interrelationships of metabolic pathways in the biological systems.</i>
Desired Outcome:	<ul style="list-style-type: none"> ● <i>Learners will have an in-depth understanding of the fundamentals of the chemical basis of life.</i> ● <i>Learners will have knowledge of the structures, interactions, and importance of complex biomolecules and their significance in the living system.</i> ● <i>Learners' will have in-depth understanding of the bioenergetics and metabolic pathways of various biomolecules.</i> ● <i>Learners will gain knowledge of the regulatory mechanisms underlying various metabolic pathways.</i>
1.1 Water as the Basic Molecule of Life	
1.1.1 Molecular structure and solvent properties of water, tetrahedral geometry, hydrogen bond, thermal properties of water and their biological significance	
1.1.2 Ionization of water, Ion product of water (K_w), Concept of pH , Dissociation of weak acids and weak bases, Henderson-Hasselbalch Equation, Titration curves of strong and weak acids, concept of buffer, buffers in biological systems.	
1.2 Biological Macromolecules	
1.2.1 Central role of Carbon	
1.2.2 Common ring structure, Chirality, and Isomerization in biomolecules	
1.2.3 Composition, structure of monomers and polymers, functions of carbohydrates, lipids, proteins, nucleic acids and vitamins	
1.3 Interactions of Macromolecules	
1.3.1 Stability of Proteins and Nucleic Acids; Stabilizing Interactions such as <i>Vander Waals</i> , Electrostatic, Hydrogen Bonding, Hydrophobic Interactions	
1.3.2 Conformation of proteins: Ramachandran plot, secondary structure, domains, motif and folds, hydropathy index of amino acids, isoelectric point (p_i) of proteins	
1.4 Complex biomolecules	
1.4.1 Glycoproteins: blood group determinants	
1.4.2 Complex Lipids: Phospholipids, Sphingolipids, Gangliosides, Sterols and Waxes	
1.4.3 Lipoproteins: classification and functions of chylomicrons, VLDL, LDL, HDL, and free fatty acid-albumin complex	
1.5 Carbohydrate and Lipid Metabolism	
1.5.1 Glycolysis, Krebs's cycle, ETC and its energetics.	
1.5.2 Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate and lactate.	
1.5.3 Glycogen metabolism: Glycogenesis, Glycogenolysis	
1.5.4 Significance of the pathways: Hexose Monophosphate (HMP) Shunt as a multifunctional pathway; uronic acid pathway; glyoxalate cycle	
1.5.5 Fatty acid metabolism: Oxidation of saturated even and odd carbon atom, and unsaturated fatty acids, metabolism of cholesterol	
Unit 2: Processes, Techniques and Applications of Biotechnology (15Hr)	

Objectives:	<ul style="list-style-type: none"> ● To provide the learners thorough knowledge on the genome organization, gene expression and its control in prokaryotes and eukaryotes. ● To acquaint learners with the basic tools and techniques used in Biotechnology. ● To provide learners the knowledge on the applications of biotechnology in various fields.
Desired Outcome:	<ul style="list-style-type: none"> ● Learners will be able to understand the processes for harnessing the potentials of living systems for betterment of mankind. ● Learners will have an understanding of the processes and techniques used in development of biotechnology products. ● Learners will gain knowledge on the application of biotechnology in industries, medicines, agriculture and environment.
2.1 Genome Organization	
2.1.1 Organization of genome in prokaryotes and eukaryotes, C-value paradox and genome size.	
2.1.2 Complexity of viral, bacterial and eukaryotic genomes, Cot curves, repetitive and non-repetitive DNA sequences.	
2.2 DNA replication, Gene expression in prokaryotes and eukaryotes	
2.2.1 Molecular model of DNA replication.	
2.2.2 Transcription and translation in prokaryotes.	
2.2.3 Transcription and translation in eukaryotes.	
2.3 Control of gene expression in Prokaryotes & Eukaryotes	
2.3.1 Small regulatory RNAs, small nuclear ribonucleoproteins (snRNPs), Transcription level control, RNA processing, Translational level control, post-translational control.	
2.3.2 Gene silencing, miRNA, RNA silencing pathways and DNA methylation.	
2.4 Methods in Biotechnology	
2.4.1 Cloning using plasmid pUC18, pUC19, detection of recombinants by blue-white screening, cloning in bacteriophage, cosmid, BAC and YAC vectors.	
2.4.2 Chromosome walking, RAPD, AFLP, Microarrays.	
2.5.1 Microbial fermentation, Microbial growth kinetics, Design of a fermenter, Organisms used in large scale fermentation.	
2.5.2 Monoclonal antibodies (mAbs) and their therapeutic applications.	
2.5.3 HIV therapeutic agents.	
2.5.4 Production of biopharmaceuticals from transgenic animals – Human Tissue Plasminogen Activator (hTPA) and α -1Antitrypsin (AAT).	
2.5.5 Environmental biotechnology: Effluent treatment, Bioremediation, phytoremediation, Biosensors, Biofuels.	

PSZOP 204: Lab Exercises	(60Hr)
1. Museum specimens / Photographs / Pictures / Slides:	
i. Protochordates: Study of <i>Doliolum</i> , <i>Herdmania</i> , <i>Ascidia</i> , <i>Botryllus</i>	
ii. Adaptive radiation in Reptiles-Turtles, Crocodile, Tuatara, Snakes and Lizards	
iii. Adaptive radiation in Mammals – Talpa (mole), Tarsius, Armadillo, Camel and Sperm whale	
2. Types of jaw suspension in vertebrates- Autodiastylis, Holostylic, Amphistylis and Autostylic.	
3. Types of vertebrae – Acoelous, Procoelus, Opisthocoelus, Amphicoelus, Amphiplatins, Heterocoelus, Axis and atlas vertebrae.	
4. Measurement of fish ova diameter using an oculometer.	
5. Titration curve of weak acid.	
6. Titration curve of strong acid.	
7. Estimation of the number of bacteria in the given culture by nephelometry.	
8. Preparation of beads by immobilization of yeast cells in calcium alginate.	
9. Analysis of testicular extract/ semen- Fish/ Chicken/ Goat.	
a) pH, Viscosity, Agglutination	
b) Sperm count and Motility	
c) Hypoosmotic swelling of Sperm- Normal/ Abnormal	
10. Field visit to National park / Sanctuary / Museum / Zoo or any other suitable ecosystem to study vertebrates.	

PSZOP 205: Lab Exercises	(60Hr)
1. Pigeon – Study / Virtual dissection of <ul style="list-style-type: none"> i. Flight muscles ii. Digestive system iii. Respiratory system iv. Circulatory system v. Excretory system vi. Reproductive system – male and female 	
2. Histology of male and female accessory reproductive glands – Human – Prostate gland, Bulbourethral gland and placenta [Permanent slides].	
3. Preparation of histological slides for histomorphology and histochemistry (PAS staining) study of fish ovary/testis.	
4. Titration curve of weak acid.	
5. Titration curve of strong acid.	
6. Restriction digestion of the given DNA sample and separation of the fragments by agarose gel electrophoresis.	
7. Monitoring of Invertase activity in the bioreactor column of immobilized yeast cells by DNSA method.	
8. Isolation and determination of glycogen in the given tissue (liver/ skeletal muscles/ kidney) by anthrone method.	
9. Determination of effect of minimal media and enriched media on growth curves of <i>E. coli</i> .	
10. Field visit to National park / Sanctuary / Museum / Zoo or any other suitable ecosystem to study animal adaptations/ choice of habitat.	

PSZO206: Food, Nutrition and Health	
Unit 1: Nutrition and its importance (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>To update students about the role of nutrition in growth and development.</i> ● <i>Educate students about nutritional diversity of India and dietary recommendations</i> ● <i>To enable students to understand advances in clinical nutrition.</i> ● <i>To emphasize the role of nutrition in prevention of chronic diseases.</i>
Desired Outcome:	<ul style="list-style-type: none"> ● <i>The learner will be able to understand the importance of nutrition in maintaining good health and wellbeing.</i> ● <i>The learner will be able to differentiate between healthy and unhealthy lifestyle based on nutrition.</i>
Nutritional diversity of India, Nutritional deficiencies and Digestive disorders	
Nutrition and its importance in Human Health Nutrition and General aspects of Growth: 1.1 Types of nutrients, their role in mental and physical growth and development. 1.2 Critical Periods of growth and development. 1.3 Food pyramid and its benefits in planning diet for different age groups. 1.4 Nutritional diversity of India: Nutrient enrichments of cereals, pulses, oilseeds, grains, millets, vegetables and fruits in India. 1.5 Concept of dietary nutrient recommendations: RDAs, DRI and TUL 1.6 Sources of fibers and their importance in food. 1.7 Concept of BMI and its use in determining health status. 1.8 Nutritional deficiencies disorders (Causes, Symptoms and Remedies)-Anemia (B12 and Iron deficiency), Rickets, Marasmus, Goitre, Kwashiorkor 1.9 Digestive system Disorders (Causes, Symptoms and Remedies)- Dental issues, Constipation, Diverticulitis and Haemorrhoids, Starvation, Acidity and Flatulence, Gastritis and Peptic Ulcers. 1.10 Gluten induced enteropathy, Lactose intolerance 1.11 Inflammatory bowel disease, irritable bowel syndrome	
Unit 2: Nutrition and Health: Changing trends of food choices and eating habits, National Health Policies and Goals (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>To understand the changing trend in food choices in society and its effect on the health of humans especially youth and children.</i> ● <i>To understand dietary planning during disease conditions.</i> ● <i>To understand national health policies and goals of our country to achieve the goal of fit and healthy India</i>

Desired Outcome:	<ul style="list-style-type: none"> ● <i>To educate students about the importance of physical fitness and health.</i> ● <i>The learner will be able to differentiate the effect of changing trends in food choices and its ill effects.</i> ● <i>The learner will be able to understand health policies and goals of our nation.</i> ● <i>The learner will try to adopt a healthy lifestyle in order to stay fit and disease free.</i>
<p>2.1 Food choices before and after modernization. 2.2 Role of family and peers in food choices. 2.3 Influence of culture on selection of food. 2.4 Impact of mood and emotions on food choice. 2.5 Fast food, food cravings and food addiction. 2.6 Influence of Media on food choice. 2.7 Effect of electronic gadgets on food choice. 2.8 Dietician and its role in combating common diseases (Obesity, cardiac patients, diabetes, liver and kidney disorders, allergies, cancer) by suggesting healthy eating and life style. 3.1 National Health Policies and Goals in reference to India 2.9 United Nation Millennium Development Goals (MDGs): Perspective on Nutrition and Health. 2.10 National Rural Health Mission-Vision, objectives, strategies and outcomes of the mission. 2.11 Definition of health, the need for health education and health goal. Universal Immunization Programme. 2.12 An overview of plans and services (local, state, national and international) related to Public Health Nutrition. 2.13 Initiatives for prevention of disease e. g. Water, air and vector borne diseases. 2.14 Physical Fitness, Components of physical fitness, Factors influencing Physical fitness and precautions to be followed (with special referent to nutrients used in gyms). 2.15 Psychological Fitness- Stress (causes, consequences & strategies of management) 2.16 Role of Yoga and Meditation in maintaining active and healthy life.</p>	

PSZOP 207: Lab Exercises based on PSZO206	(60Hr)
1. Study nutritional diversity in day today food in and compare it with balance diet	
2. Preparation of essential macro (protein, fiber) and micronutrient (calcium, iron vitamin C, A and B) rich recipe, calculation of nutritive value and cost per serving.	
3. Identification of clinical signs and symptoms of various deficiency diseases.	
4. To study and detect various adulterants in food stuff.	
5. Planning and calculating nutritive value for a Sports person.	
6. Estimation of total sugar content, reducing and non-reducing sugars in given food samples.	
7. Estimation of vitamins: Ascorbic acid, thiamine, beta-carotene.	
8. Estimation of starch content of cereals.	
9. Planning of diets for following disease conditions: <ul style="list-style-type: none"> ● Fever, Malabsorption disease, Lactose intolerance. ● Hypertension and Chronic heart diseases, ● Liver diseases, Cholecystitis and Pancreatitis 	
10. Assessment of nutritional status of an individual/community using anthropometry and dietary survey. A) Preparation of schedule B) Survey work C) Analysis of data D) Writing of report	

PSZO208: Environmental Monitoring and Management	
Unit 1: Environment and its quality monitoring (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>The learners will learn the basic concepts of the environment and their role in making life sustainable.</i> ● <i>To acquaint learners about the quality parameters of air, water and soil and their monitoring.</i>
Desired Outcome:	<ul style="list-style-type: none"> ● <i>The learners will be more aware about the environmental issues and environment protection.</i> ● <i>The learners will learn the various monitoring systems used for air, water and soil quality check</i>
1.1 Concept, Scope and Approaches of environmental studies	
1.2 Global concerns about environment, environmental protection and sustainability: principles of sustainability.	
1.3 Structure of natural systems, causes of land degradation and environmental pollution.	
1.4 Population growth and environment Monitoring, Legal and institutional status of environment.	
1.5 Causes and effects of air pollution, water pollution and soil pollution	
1.6 Ambient and indoor air quality monitoring; Methods of collection and analyses of gaseous and particulate pollutants, air pollution standards.	
1.7 Monitoring of agricultural systems and aquatic habitats: understanding the degradation processes.	
1.8 Steps of environment monitoring: indices and indicators.	
Unit 2: Environmental Management System and Ethics (15Hr)	
Objectives:	<ul style="list-style-type: none"> ● <i>To acquaint learners about the environmental management strategies and ethics involved in managing the environment.</i> ● <i>To educate learners about the environmental audits and their significance in environment management.</i>
Desired Outcome:	<ul style="list-style-type: none"> ● <i>Learners will learn the skills of how to manage the environment by using regulatory guidelines and ethics.</i> ● <i>Learners will be skilled enough to i) do the audits of the environment and ii) take steps towards improving the environment.</i>
2.1 Environmental management system (EMS): ISO-14000; Environmental audit; Environmental clearance for establishing industries and buildings.	
2.2 Environmental Impact Assessment (EIA); EIA guidelines.	
2.3 Environmental taxes international trade and environment; Trade Related Intellectual Properties (TRIPs), Intellectual Property Rights (IPRs).	
2.4 Environmental education, public awareness, peoples participation in resource conservation and environmental protection.	
3.5 Concept of green buildings.	
2.5 Environmental audit- Definition, types and benefits	
2.6 Tools for environmental auditing- environmental risk assessment, strategic environmental assessment, green accounting, life cycle analysis	
2.7 Audit activities-Pre and post audit activities	
2.8 Audit report- Compiling data, Organizing data, writing report	
2.9 Factors of successful audit, thoroughness of the audit, voluntary and mandatory reports	

PSZOP 209: Lab Exercises based on PSZO208	(60Hr)
1. Study of a simple ecosystem (Suggested habitats: pond, river, estuarine, grassland, forest and desert) and description of the biotic and abiotic components of the ecosystem.	
2. Study of physical properties of soil: Temperature, moisture, & texture of soil.	
3. Study of chemical properties of soil: pH and Organic matter.	
4. Study of Physico-chemical properties of sewage/ effluent water: conductivity, turbidity, dissolved oxygen, salinity & total hardness.	
5. Estimation of Water Pollution: BOD & COD.	
6. Study of air microflora.	
7. Measurement of intensity of light by Lux meter.	
8. Measurement of sound by Sound meter.	
9. Study of application of alternative energy resources (Solar panel, Biogas plant, Photovoltaic cell, Windmill, Nuclear reactor, Harnessing tidal energy)	
10. Observation & study of indicator species.	
11. Environment Audit report (Environmental Compliance Audits, Environmental Management Audits, Functional Environmental Audits).	
12. Preparation/drafting of EIA Report (Chemical Industry, Fertilizer Industry, hydropower station).	
13. Field visit: Students should undertake fieldwork and survey. The Students should visit different places to collect data to make surveys and analyse. At least one place should be visited. The Places of visit could be: Lakes, rivers, estuary and marine, nature parks, water/ sewage/ Industrial effluent treatment plant, Solid waste dump, meteorological centre, mangrove vegetation, industries – food, pharmaceutical, petrochemical, fertilizer, paper, sugar, distillery etc.	

PSZO210 OJT/FP
OJT/FP has been kept open and will be decided by the institutions/colleges in their capacity and infrastructures/resources available.
(60Hrs)

Note: For internship/apprenticeship/field work, the credit weightage for equivalent hours is 50% of that for lectures/ tutorials.

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Modality of Assessment

The examination pattern for all courses (Theory and Practical) offered in this syllabus will be 50% internal and 50% external (semester end).

A) Internal Assessment (Theory)- 50%

Sr. No.	Evaluation type	Total Marks (50)	Total Marks (25)
1	One Assignments/ Case study	20	10
2	Active participation in routine class instructional deliveries (Seminar)	20	10
3	Group discussion/ quiz/ test	10	05

B) External examination (Semester End Theory Examination)- 50%

Semester end theory examination (for both semester I and II) shall be conducted as per the following pattern:

1. Core courses (Theory):
 - Course I and II of 50 Marks each.
 - i. Duration – These examinations shall be of two hours duration for each paper.
 - ii. Theory Question Paper Pattern:
 - There shall be five questions each of 10 marks. For each unit there will be one question and the first one will be based on entire paper.
 - All questions shall be compulsory with internal choice within the question. Each question will be of 15 to 20 marks with options.
 - Question may be subdivided into sub-questions a, b, c... and the allocation of marks depend on the weightage of the topic.
2. Core courses (Theory):
 - Course III of 25 Marks.
 - i. Duration – These examinations shall be of one hour duration for each paper.
 - ii. Theory Question Paper Pattern:
 - There shall be three questions of 8,8 and 9 marks. On each unit there will be one question of 08 marks and the first one (with 09 marks) will be based on entire paper.

- All questions shall be compulsory with internal choice within the questions. Each question will be of 12 to 18 marks with options.
- Question may be subdivided into sub-questions a, b, c... and the allocation of marks depend on the weightage of the topic.

3. Minor courses (Theory): 25 Marks each

iii. Duration – These examinations shall be of one hour duration for each paper.

iv. Theory Question Paper Pattern:

- There shall be three questions of 8,8 and 9 marks. On each unit there will be one question of 08 marks and the first one (with 09 marks) will be based on entire paper.
- All questions shall be compulsory with internal choice within the questions. Each question will be of 12 to 18 marks with options.
- Question may be subdivided into sub-questions a, b, c... and the allocation of marks depend on the weightage of the topic.

4. Research Methodology course (Theory): 50 Marks

i. Duration – This examination shall be of two hours duration.

ii. Theory Question Paper Pattern:

- There shall be five questions each of 10 marks. On each unit there will be one question and the first one will be based on entire paper.
- All questions shall be compulsory with internal choice within the questions. Each question will be of 15 to 20 marks with options.
- Question may be subdivided into sub-questions a, b, c... and the allocation of marks depend on the weightage of the topic.

b) Practicals (For both Core and Minor courses)

25 Marks

A) Internal Assessment (Practical)- 50%

Sr. No.	Evaluation type	Total Marks (25)
1	Activity based report from the practical paper	10
2	Overall conduct as a responsible student, manners, skills in performing practical, data compilation and analysis/ interpretation	10
3	Attendance (0-25%= 0 Mark, 25-50%= 1 Marks, 50-75%=3 Marks, 75-100%=5 Marks.)	05

B) External Assessment (Practical)- 50%

25 Marks

Semester End Practical Examination shall be based on the practical conducted (course wise) and shall be decided by the Chairperson concerned covering all the practical mentioned in the syllabus and without affecting integrity of the practical course.

University of Mumbai
M.Sc. (ZOOLOGY)
Semester I / Semester II EXAMINATION
Course PSZO (For 50 Marks Papers)
Maximum Marks: 50 Duration: 2.0 Hours Marks Option: 80

Question 1: Based on Unit I to IV (Mixed Questions)

Question 2: Based on Unit I

Question 3: Based on Unit II

Question 4: Based on Unit III

Question 5: Based on Unit IV

Instructions:

- i. All questions are compulsory.
- ii. All questions carry equal marks.
- iii. Draw neat and labelled diagrams wherever necessary.

1. Answer any four questions from the following (Based on all 4 units). (10 Marks)

- A)
- B)
- C)
- D)
- E)
- F)
- G)
- H)

2. Answer any two questions from the following. (Based on Unit1). (10 Marks)

- A)
- B)
- C)

3. Answer any two questions from the following. (Based on Unit 2). (10 Marks)

- A)
- B)
- C)

4. Answer any two questions from the following. (Based on Unit 3). (10 Marks)

- A)
- B)
- C)

5. Answer any two questions from the following. (Based on Unit 4). (10 Marks)

- A)
- B)
- C)

University of Mumbai
M.Sc. (ZOOLOGY)
Semester I / Semester II EXAMINATION
Course PSZO (For 25 Marks Papers)
Maximum Marks: 25 Duration: 1.0 Hours Marks Option: 42

Question 1: Based on Unit I to II (Mixed Questions)

Question 2: Based on Unit I

Question 3: Based on Unit II

Instructions:

- i. All questions are compulsory.
- ii. All questions carry equal marks.
- iii. Draw neat and labelled diagrams wherever necessary.

1. Answer any four questions from the following (Based on all 2 units). (9 Marks)

- A)
- B)
- C)
- D)
- E)
- F)

2. Answer any two questions from the following. (Based on Unit1). (08 Marks)

- A)
- B)
- C)

3. Answer any two questions from the following. (Based on Unit 2). (08 Marks)

- A)
- B)
- C)

Letter Grades and Grade Points:

Semester GPA / Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result
9.00 - 10.00	90.0 - 100	O (Outstanding)
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)
5.00 - < 5.50	50.0 - < 55.0	C (Average)
4.00 - < 5.00	40.0 - < 50.0	P (Pass)
Below 4.00	Below 40.0	F (Fail)
Ab (Absent)	-	Absent





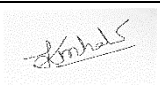


Dr. Ajai Kumar Singh
Head/ Co-ordinator
Department of Zoology




Prof. Shivram Garje
Dean, Science and Technology
University of Mumbai

Team for Creation of Syllabus

Name	College Name	Sign
Dr. Ajai Kumar Singh	R K Talreja College of Arts, Science and Commerce, Ulhasnagar	
Dr. Vikrant Berde	NES's Arts, Commerce and Science college, Lanja	
Dr. Tejali Ayare	B.N.N. College, Bhiwandi	
Dr. Kamran Abbas	G.M. Momin Women's College, Bhiwandi	
Mr. Kuldeep Mhatre	R K Talreja College of Arts, Science and Commerce, Ulhasnagar	

Justification for M.Sc. (Zoology)

1.	Necessity for starting the course:	As per the provisions of NEP 2020 accepted by Maharashtra Government, It is necessary to start this course.
2.	Whether the UGC has recommended the course:	Yes
3.	Whether all the courses have commenced from the academic year 2023-24	Yes
4.	The courses started by the University are self-financed, whether adequate number of eligible permanent faculties are available?	In some colleges/institutes, this course is run under self-finance scheme while in others it is aided and grantable. Yes, adequate number of PG recognized teachers are available for this course.
5.	To give details regarding the duration of the Course and is it possible to compress the course?	P. G. Diploma in Zoology (Duration 1 Year) (Total Credits: 44) (Eligibility: After Three-Year UG Degree in Zoology) P. G. Degree in Zoology (Duration: 2 Years) (Total Credits: 88) (Eligibility: After Three-Year UG Degree in Zoology) P. G. Degree in Zoology (Duration 1 Year) (Total Credits: 44) (Eligibility: After Four-Year UG Degree in Zoology) The course cannot be compressed further.
6.	The intake capacity of each course and no. of admissions given in the current academic year:	Either 10 or 12 Admission is under process
7.	Opportunities of Employability / Employment available after undertaking these courses:	Lots of opportunities are available in both Government and Private sectors. The course is also useful for self-employments and startups creation



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