ST JOSEPH'S UNIVERSITY

BENGALURU-27

Conferred the status of a Public-Private-Partnership University by the Ministry of Human Resource Development (now MoE), GoI,
under *Rashtriya Uchchatar Shiksha Abhiyan* (RUSA) 2.0 and established by the St Joseph's University Act no.24 of 2021

DEPARTMENT OF ZOOLOGY

SYLLABUS FOR POSTGRADUATE PROGRAMME

COURSE CONTENT AND COURSE OUTCOMES

DEPARTMENT OF ZOOLOGY

FIRST SEMESTER

Semester	**I**
Paper code	**ZO 7124**
Paper Title	**SYSTEMATICS, PHYLOGENY AND BIOLOGY OF NON-CHORDATES**
Number of teaching hours per Week	**4**
Number of teaching hours per Semester	**60 (52 hours+8 hours of self- study)**
Number of credits	**4**

Learning outcome:

Learner should be able to

- Get acquainted with the origin of invertebrate animals
- Outline the fundamentals of organism's organization
- Outline the historical and modern methods of animal classification and systematics.
- Identify organisms using taxonomic keys.
- Understand the phylogenetic relationships among the different groups of invertebrate animals

Units	Description	Hrs
I	**Origin and organization of Invertebrate animals** ● **Origin**: Different hypothesis of metazoan origin – Gastraea hypothesis, Planula hypothesis. ● **Levels of organization –** Germ layers (diploblastic and triploblastic condition) **(Self-study)** - Development of coelom - Radial and bilateral symmetry - Segmentation and cephalization. Evolutionary advantages of Symmetry, Metamerism and Coelom.	7

II	**Introduction to Systematics** ● **Biological Classification**: Principle of taxonomy, Taxonomic hierarchy, Nomenclature – Binomial, Trinomial nomenclature **(Self-study),** Zoological collections, identification and description, Concepts of Taxon, holotype, paratype, topotype etc. International code of Zoological Nomenclature.	**8**

	● **Taxonomic Keys:** dichotomous and polytomous keys. Taxonomic keys presentation, Merits and demerits of keys. AI in taxonomic studies.	
III	**Invertebrate Phylogeny** ● Phylogenetic relationships among Porifera, Placozoa, Mesozoans; Cnidaria and Ctenophora; Platyhelminthes and other acoelomates. Phylogenetic relationships among the protostome lineage – Mollusca, Annelida and Arthropoda. Adaptive radiation in Mollusca and Annelida. ● Cladistic and phenetic approaches. ● **Phylogenetic position** of the phyla Onychophora and Tardigrada. Trilobites **(Self-study).** Minor Phyla: Structure affinities and life history of the following minor Phyla – Rotifera, Entoprocta **(Self-study),** Phoronida and Ectoprocta.	**10**
IV	**Invertebrate - Comparative functional biology - I** ● **Mechanics and Movement:** Amoeboid, Flagellar and Ciliary movement in protozoa. Skeletal adaptations of sponges to marine and freshwater environments. Hydrostatic movements in Coelenterates, Mollusca and Echinodermata. ● **Nutrition and Digestion**: Canal systems, Patterns of Feeding and digestion in lower Metazoa. Feeding ecology in polychaeta, Mollusca and Echinodermata. ● **Circulation and Gas exchange:** Organs of respiration: Gills, lungs and trachea. Respiratory pigments **(Self-study)**, Mechanism of respiration. **Invertebrate - Comparative functional biology - II** ● **Excretion, Ionic and Osmotic regulation:** Excretion in invertebrates. Mechanisms of Osmoregulation. ● **Control Systems:** Primitive Nervous systems: Coelenterata and Echinodermata. Advanced nervous system- Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda). Sense organs and their importance. Hormones and pheromones (**Self-study).**	15 10

V	**Invertebrate development and Life Histories** ● Polymorphism in Cnidarians, Coral ecosystems **(Self-study)**. ● Patterns of reproduction in invertebrates: Asexual, sexual and parthenogenesis. ● Invertebrate larval forms : Trematoda, Cestoda, Crustacea, Mollusca and Echinodermata, and their evolutionary significance	**10**

Blue print
Course Code: ZO 7124
Course Title: SYSTEMATICS, PHYLOGENY AND BIOLOGY OF NON-CHORDATES

Unit Number	**Number of Hours**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	7	8
Unit II	8	9
Unit III	10	12
Unit IV	25	29
Unit V	10	12
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN SYSTEMATICS, PHYLOGENY AND BIOLOGY OF NON-CHORDATES

Semester	**I**
Paper code	**ZO 7P1**
Paper Title	**SYSTEMATICS, PHYLOGENY AND BIOLOGY OF NON-CHORDATES**
Number of teaching hours per semester	**44**

Sl. No	Description	Units
1	Collection and Preservation of Invertebrates.	
2	**Animal-like protists:** *Balantidium, Noctiluca, Amoeba, Vorticella, Volvox, Euglena, Paramecium* w/m and Conjugation, Foraminifera and Radiolaria, *Nyctotherus*. Pathogenic protist: *Trypanosoma, Plasmodium*, Monocystis, *Entamoeba histolytica*. **Experiment**: Observation of fresh water protozoans	1
3	**Porifera:** *Leucosolenia, Euplectella, Hyalonema, Sycon* w/m and L.S, sponge gemmules and spicules. **Experiment:** Taxonomy of museum sponges (morphological observation, and classification of museum specimens)	1
4	**Cnidaria:** *Hydra,* Coral types (*Tubipora, Alcyonium, Fungia, Astrea, Meandrina*), *Physalia, Pennatula, Velella, Porpita, Aurelia, Obelia*, Sea Anemone, Ephyra larva. **Experiment:** Taxonomy of museum corals (morphological observation, and classification of museum specimens)	1
5	**Helminthes:** Tapeworm, T.S of tapeworm and *Scolex*, Liver fluke, T.S of liver fluke, *Ascaris* male and female, T.S of *Ascaris*. **Experiment:** Taxonomy of parasitic worms (morphological observation, and classification of museum specimens)	1
6	**Annelida:** *Nereis, Aphrodite, Hirudinaria, Arenicola, Sabella,* Earthworm, *Chaetopterus*. Trochophore larva, Parapodium of *Neries* **Experiment:** On campus vermiculture practice.	1
7	**Arthropoda:** *Peripatus, Lepas, Balanus* (Acorn barnacle), Lucifer, Centipede, Millipede, *Limulus*, tick. Crustacean larval forms: *Nauplius, Mysis, Zoea, Metazoea*, Lucifer. Mouth parts of Insects - Honey bee, Housefly, Mosquito, Butterfly. Book lung of scorpion. **Experiment:** Arthropods – Collection and identification of Drosophila/Bactrocera/ Mosquito) from different localities.	1
8	**Mollusca:** *Sepia, Patella, Chiton, Loligo, Dentalium, Murex xanchus*. Larval forms (*Glochidium* larva, *Velliger* larva). Conchology (*Unio* and *Achatina fulica*) **Experiment:** Mating behaviour, mode of reproduction, Fecundity, clutch size studies on edible/ornamental molluscs.	1

9	**Echinodermata:** *Ophiothrix*, *Sea urchin*, *Heart urchin*, *Starfish*, *Sea cucumber*, *Sea lily*, *Pedicellaria*, *Sea urchin*. Larval forms (*Gluteus* larva, *Echinopluteus* larva, *Ophiopluteus* larva, *Bipinnaria* larva). **Experiment:** To make a working model of water vascular system.	1
10	**Experiment:** Phylogeny tree construction using PHYLIP online tool	1

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14. Simson G. G. 2012. Principles of animal taxonomy. Scientific publishers, India.
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COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Explain the principles of taxonomy and classification of non-chordates. (Understand)	*	*	*								(Understand)
2. CO 2: Apply systematic tools for identification of invertebrate species			*	*	*						(Apply)
3. CO 3: Analyze phylogenetic relationships among invertebrate phyla					*	*	*				(Analyze)
4. CO 4: Evaluate structural and functional adaptations of non-chordates to diverse habitats.							*	*	*		(Evaluate)
5. CO 5: Create a comparative report on the biodiversity of selected invertebrates.								*	*	*	(Create)

ZO 7224 ADVANCED CELL BIOLOGY AND GENETICS

Semester	**I**
Paper code	**ZO 7224**
Paper title	**ADVANCED CELL BIOLOGY AND GENETICS**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**4**

Learning outcome:

Learner should be able to

- Describe the dynamic nature of plasma membrane and its functional capabilities.
- Demonstrate the role of endomembrane system in protein processing, sorting, targeting and transport through vesicular trafficking.
- Elucidate the phases of cell cycle, its checkpoints, and the process of regulation.
- Distinguish between Apoptosis and Necrosis, Mechanism of Intrinsic and Extrinsic pathway, and the Role of Bcl2 and Bax in Apoptosis.
- Explain the nature of signal, distinguish between various signals, and the mode of transmission of signals between cells, amplify the signal by (second messengers) and transmit the information inside the cell (hormones, receptors, signal transduction).
- Understand how genes and chromosome's function.
- Interpret how genetic disorders develop and the role genetic testing and counselling in identifying, preventing and treating these disorders.
- Analyse the patterns of inheritance and their expressions.
- Distinguish between maternal effect, sex-linked, formulate a pedigree chart and discern the mode of inheritance.

Units	Description	Hrs
I	**Cell Membranes - Structure and Function** ● Plasma Membrane characteristics and its function – Structural composition and dynamic nature of plasma membrane, Solute movement across membrane- Diffusion, facilitated diffusion, Formation of electrochemical gradient, Ion transport, Mechanism of Na+ and K+ pump, co-transport, symport and antiport **(self-study)**. ● Cytoplasmic Membrane system and Membrane Trafficking: Endoplasmic Reticulum structure and its functions in synthesis,	**12**
	processing and transporting of proteins. Structure and functions of Golgi apparatus in protein sorting and targeting from cis to trans Golgi Network. Types of Vesicular transport: COPI, COPII and Clathrin coated vesicles. Transport of Soluble Lysosomal Resident Proteins, Endocytic Pathway: Phagocytosis, Autophagy, Receptor mediated Endocytosis (LDL) and Exocytosis. ● Structural organization of Cytoskeleton: Actin filaments, Micro tubulins and Intermediate filaments.	
II	**Cell cycle, its regulation and Apoptosis** ● Phases of Cell cycle: Interphase, Mitosis and Cytokinesis, Control of cell cycle: Cell cycle check points MPF, APC's. Role of Protein Kinases and Phosphatases as cell cycle regulators (Cyclins and CDKs), CDK inhibitors in cell cycle regulation (Molecular mechanism of inhibition by Rb, P53 dependent and independent inhibition). ● Apoptosis: Role of caspases, Mechanism of activation of caspases, Extrinsic and Intrinsic pathways of Apoptosis, Role of Bcl2 and Bax gene in apoptosis, inhibition of apoptosis by extracellular factors; Necrosis **(self-study)**.	**8**
	Cell – Cell Interaction and Cell Signaling ● Cell-Cell Interaction: Cell adhesion molecules - Integrins, Selectins, Cadherins (Self-study). Cell communication through Cellular Junctions - Tight junctions, Desmosomes, Hemidesmosomes(Self- study) and gap junctions. ● Cell signalling and Signal Transduction: Elements of cell signaling - Extracellular messengers (ligands, hormones) and their receptors (cell surface receptor, receptor associated kinases), signal transduction through G-protein coupled receptors (Epinephrine) and Receptor-Tyrosine Kinase (Insulin), Role of Cyclic AMP in signal amplification, second messengers (Role of Calcium as intracellular messenger), signal Integration.	**10**

IV	**Mendelian and Non Mendelian Genetics** ● Mendelism – basic principles (brief study) Mendel's Laws of Inheritance with examples from Drosophila and human. ● Extensions of Mendelism, Multiple allele: ABO blood groups in humans, Rh blood group incompatibility, Dominance: co-dominance and incomplete dominance. lethal alleles, Genetic interaction: Epistatic interactions, Non-Epistatic inter-allelic genetic interactions, Atavism, Penetrance and expressivity of genes. ● Nonmendelian inheritance – Maternal effects – Pigmentation in Lymnaea peregra, b) Organelle heredity – Mutations in Chlamydomonas, Mitochondria-Petite in, Saccharomyces, c) Infectious heredity–Kappa in Paramecium, Drosophila, d) Mitochondrial diseases in Man **(Self study).**	**4** **4**

V	**Human Genetics and Sex determination in animals** ● Inheritance of traits in Humans, Patterns of Inheritance- Autosomal dominant, Autosomal recessive, X - linked recessive, X - linked dominant and Y-linked. Pedigree analysis, determination of human genetic diseases by pedigree analysis. Heterochromatization in human beings, Human karyotype, Banding techniques, Eugenics – positive and negative eugenics **(Self study).** ● Dosage Compensation, Hyperactivation and inactivation of X-linked genes, Genes involved in sex determination and the hormonal control of Sex determination in mammals, *Drosophila* and *C. elegans*. ● The Chromosome theory of heredity Concept of linkage, Experiments of Bateson and Punnet **(Self study)**, Morgan's experiment; Construction of linkage maps in Drosophila. ● Genetic recombination and Crossing over - Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, interference and co-efficient of coincidence. ● Chromosomal aberrations: mutations and their types, rearrangements – Duplications, Deletions, Inversions and translocations.	**3** **2** **2** **6**
VI	**Quantitative Genetics** Polygenic inheritance, Statistics of Quantitative Genetics: Frequency distributions, the mean and the modal class, the variance and the standard deviation, Analysis of quantitative traits: The multiple factor hypothesis, Partitioning the phenotypic variance.	**4**

VII	**Molecular Genetics** Fundamentals of Viral and Bacterial Genetics: Genetic Transduction, Transformation and Conjugation (Bacteriophage and *Escherichia coli*) Genetics and Society **(Self-study).**	**5**

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BLUEPRINT:

Course Code: ZO 7224

Course Title: Advanced cell biology and genetics

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	12	14
Unit II	8	9
Unit III	10	12
Unit IV	8	9
Unit V	13	15
Unit VI	4	5
Unit VII	5	6
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN ADVANCED CELL BIOLOGY AND GENETICS

Semester	**I**
Paper code	**ZO 7 P2**
Paper title	**ADVANCED CELL BIOLOGY AND GENETICS**
Number of teaching hours per semester	**44**

Sl.No	Description	Units
1	Micrometry- Stage and Ocular	1
2	Preparation of Meiotic stages- *Poecilocerus pictus*.	1
3	Drosophila culture - Media preparation, Life history, Morphology and its significance as model organism.	1
4	Vital staining of mitochondria from Yeast cells using Giemsa stain.	1
5	Study and identification of *Drosophila melanogaster* mutants.	1
6	Preparation of polytene chromosome from salivary gland of *Drosophila melanogaster*.	1
7	Study of tonicity in RBC's.	1
8	Mounting of sex comb and genital plate of *Drosophila melanogaster*.	1
9	Genetic problems in Recombination and linkage.	1

10	Genetic problems related to Quantitative genetics.	1

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Explain advanced concepts of cell structure, function, and signaling pathways.	*	*	*								(Understand)
2. CO 2: Apply genetic principles to analyze inheritance patterns and molecular mechanisms.			*	*	*						(Apply)
3. CO 3: Analyze interactions between cellular organelles in various physiological processes.					*	*	*				(Analyze)
4. CO 4: : Evaluate the impact of mutations and chromosomal aberrations on genetic stability.							*	*	*		(Evaluate)
5. CO 5: Design genetic experiments using model organisms to study gene function.								*	*	*	(Create)

ZO 7324 DEVELOPMENTAL BIOLOGY AND EVOLUTIONARY BIOLOGY

Semester	**I**
Paper code	**ZO 7324**
Paper title	**DEVELOPMENTAL BIOLOGY AND EVOLUTIONARY BIOLOGY**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**4**

Learning outcome:

Learner should be able to

- Appreciate and trace the history of evolutionary and developmental philosophy.
- Trace and describe the origins and history of life on earth.
- Define, describe and explain the fundamental principles governing early development of organisms.
- Describe and explain what evolution is, how it works, and integrate evolutionary principles to all fields of biology.
- Define, describe, explain and illustrate early developmental patterns and processes in vertebrates.
- Demonstrate and examine how variation and heritability is fundamental to the evolutionary process.
- Describe, enumerate, and explain the genetic underpinnings controlling early development in vertebrates.
- Explain, describe, and critically evaluate natural selection and sexual selection.
- Investigate and design experiments to demonstrate and measure natural and sexual selection.
- Investigate and examine mutations that cause major developmental disorders in animals and in humans.
- Design experiments to visualize early developmental processes.
- Explain, critically analyze, and evaluate the interaction and relative importance of drift and selection, natural selection and sexual selection.
- Define, critically analyze, investigate, and evaluate the various theories of speciation.
- Describe, explain, and examine early human development.

- Define, describe, explain and evaluate theories of molecular evolution.
- Use basic computational methods to test for selection or neutrality at the molecular level.

Units	Description	Hrs
I	**DEVELOPMENTAL BIOLOGY** ● Brief introduction to the history of Developmental biology. Key concepts and questions in development. ● Mechanisms of Development, morphogenesis, induction and competence, transgenic cells and organisms.	8
II	**Pattern formation** ● Axes formation: anterior – gene expression and development, *Drosophila* posterior polarity, dorso-ventral polarity. (*research article discussion, virtual videos*). ● Introduction to homeotic genes, organization and arrangement, expression and segmentation. Segmentation in Drosophila **(self- study)**. ● Comparative development – comparative analyses of homeobox gene organization, arrangement, and segment formation in Drosophila, Xenopus, and Mouse. (*link to evolution mutation and selection*). Vertebrate hox code hypotheses.	8
	Morphogenesis ● Vertebrate neurulation, neural tube patterning. ● Limb bud formation and specification (FGF, Hox, Tbx, retinoic acid). Digit formation – A/P axis specification and ZPA, Cell death in digit formation. (*link to evolution, morphological adaptations*). ● Metamorphosis and Regeneration: Molecular mechanism of ecdysone action-cellular choice between apoptosis and differentiation. Molecular responses to thyroid hormone during metamorphosis (Amphibians). Blastema formation and differentiation during regeneration. (Morphollaxis in Hydra and Epimorphosis in Salamander) ● Comparison of early development in Early development of vertebrates- a) Fish b) Birds c) Mammals. Early development of Invertebrates- a) Sea urchin b) Snails c) Tunicates d) Nematodes ● Overview of developmental mutations: examples, Limb bud formation and loss, Antennae, etc. (*link with evolution loss and gain of traits*).	10
IV	**Human Embryonic Development** Development of Foetal membranes. Foetal development from conception to Parturition (Three trimesters). Human embryo- Prenatal diagnosis-Medical implication of developmental biology (self study).	4

V	**<u>EVOLUTIONARY BIOLOGY</u>** ● History of life on earth. History of evolutionary thought. ● Darwin and Wallace's discovery of evolution by natural selection. ● Micro and Macroevolution	**3**
VII	**<u>Processes of evolution and tracking evolutionary change</u>** ● Variation in populations (molecular, physiological, phenotypes). Overview of mutations, types and levels **(self-study)**. Frequency of mutation types found in individuals and populations. Genetic variation in human populations (*summary/discussion of research articles, analyses of data*). ● Natural Selection. Types and modes of selection - Stabilizing, Directional, Disruptive **(self-study)**. Genetic models of selection. Critical analyses of evolution by drift and selection - the importance of balancing and frequency dependent selection in maintaining genetic variation. ● Random Genetic Drift, molecular clocks, neutral and nearly neutral theory of molecular evolution. ● Fundamental population genetics: Hardy –Weinberg equilibrium and estimating allele frequency in populations. Analyses of population divergence and isolation by distance – Sewall Wright's Fixation index (FST, GST) and Nei's Genetic Distance (D) to estimate population divergence. Redundancy in genetic code and resulting variation of synonymous and nonsynonymous substitutions and codon bias in genes. ● Sexual selection – direct and indirect male competition, female choice, Fisher's runaway process, cryptic female choice, male choice, other male strategies (e.g., sneaker males, etc.). Critical analyses of female choice theories. Alternatives to female choice. Sexual conflict and sexual antagonistic arms race.	
VIII	**<u>Fundamentals of Molecular evolution</u>** ● Fundamentals of molecular evolution. Substitutions and substitution models. Construction of phylogenetic tree, overview of phylogenetic models - Distance method, Neighbor Joining, K2P, Parsimony method, Maximum likelihood, Bayesian models. Inferring molecular clock, neutrality vs. adaptive evolution in phylogenetic and sequence data.	**8**
XI	**<u>The origins of species</u>** ● Speciation concepts and models – biological, ecological, phylogenetic, species recognition, alternative theories. Occurrence of hybrids and	**6**

	critical analyses of speciation theories. Current status of taxonomy – morphological vs. molecular classification of species **(self-study, interactive debate,** *link to chordates and non-chordates***)**. ● Reproductive isolation and reproductive barriers - Allopatric vs. sympatric speciation. Pre mating isolation - Climatic, Seasonal, Habitat, Ethological, etc. Post-mating prezygotic isolation, Post mating isolation – gametic incompatibility (**self-study**), Dobzhanski- Muller model. Hybrid inviability, sterility, and reinforcement. Genetics of speciation (*research paper reviews drosophila and cichlids*). Human evolution. Critical analyses of the speed of speciation – gradual vs. punctuated equilibrium models, current status and evidence. Domestication and artificial selection. **Applications of Evolutionary Biology:** ● Evolutionary medicine, Evolutionary psychology. Antibiotic resistance, etc.	

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BLUEPRINT:

Course Code: ZO7324

Course Title: Developmental and Evolutionary Biology

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	8	10
Unit II	8	10
Unit III	10	10
Unit IV	4	5
Unit V	4	5
Unit VI	8	9
Unit VII	6	6
Unit VIII	6	6
Unit IX	6	7
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN DEVELOPMENTAL BIOLOGY AND EVOLUTIONARY BIOLOGY

Semester	**I**
Paper code	**ZO 7 P3**
Paper Title	**Developmental and Evolutionary Biology**
Number of Practical teaching hours	**44**

Sl. No	Description	Units
1	Study of developmental stages in frog/chick embryos.	**1**
2	Observation and study of early embryonic development in Drosophila.	**1**
3	Observation of segment formation in Drosophila larvae.	**1**
4	Study of imaginal discs in Drosophila larvae and pre-pupa (brain, leg/wing).	**1**
5	Identification of first, second, and third instar larvae of *D. melanogaster* using morphological traits.	**1**

6	Analyses of sex comb/bristle number variation in cultured and wild Drosophila populations.	**1**
7	Identification of Drosophila species (melanogaster subgroup).	**1**
8	Investigation of courtship behavior and female choice in guppies/ mollies/Drosophila.	**1**
9	Phylogenetic analyses: tree construction, inference.	**1**
10	Analyses of neutrality and selection in genes.	**1**

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Explain key concepts of embryonic development and evolutionary theory.	*	*	*								(Understand)
2. CO 2: Apply developmental principles to interpret morphogenetic changes.			*	*	*						(Apply)
3. CO 3: Analyze evolutionary patterns and molecular evidence supporting phylogenetic relationships.					*	*	*				(Analyze)
4. CO 4: Evaluate comparative embryological data to infer evolutionary links.							*	*	*		(Evaluate)
5. CO 5: Create integrative models connecting developmental and evolutionary mechanisms.								*	*	*	(Create)

ZO 7424: HISTOLOGY, HISTOCHEMISTRY AND HISTOPATHOLOGY

Semester	**I**
Paper Code	**ZO 7424**
Paper Title	**HISTOLOGY, HISTOCHEMISTRY AND HISTOPATHOLOGY**
Number of teaching hours per week	**04**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**04**

Learning outcome:

Learner should be able to

- Comprehend the logic behind tissue fixation and learn the technique of staining.
- Understand the microscopic organization and relationships of cells, tissues and organs of the human body.
- Identify cells and tissues and describe their functions.
- Develop problem solving skills to evaluate both normal and pathological structure and function of cells and tissues that comprise the organs of the human body.
- Demonstrate critical thinking skills to describe possible pathological outcomes of dysfunctional cells and tissues.

Units	Description	Hrs
I	**Tissue fixation and staining** ● **Introduction:** Histology – Historical account, Histochemistry and Histopathology. Objectives of histology and its applications. ● **Tissue fixation:** Objectives and types of tissue fixation: ➢ Chemical fixatives: features and groups of chemical fixative ➢ Utility and chemistry of fixation of aldehyde, glutaraldehyde, alcohol, acetic acid **(self-study)**, mercury, picric acid and potassium dichromate. ➢ Physical method of fixation - freezing and microwave fixation. ➢ Factors affecting fixation and fixation artefacts. ● **Dyes:** ➢ Differences between stain and dye, chemical properties of dyes**.** ➢ Acidic dyes and basic dyes **(self-study).** ➢ Natural dyes: Source, chemical properties and utility of colchineal, carmine and haematoxylin. ➢ Synthetic dyes: Chemical properties and utility of eosin, Giemsa**,** Mallory's trichome stain. ➢ Dyes used in medical procedure (fluorescein, gadolinum contrast an methylene blue).	**15**
II	**Histology** ● **Epithelium:** Types and modifications (cilia, stereocilia, **(self-study)**. microvilli, flagella, junctional complexes). Cell adhesion molecules ● **Functional histo-morphology (human tissue)**: lung, kidney, spleen, thymus, brain, adipose tissue **(self-study)**, testis and ovary.	**15**
III	**Histochemistry** ● **Classical histochemistry:** Principle, method and application of classical histochemical techniques: ➢ Localization of glycoproteins (PAS) ➢ Nucleic acids (Feulgen) **(self-study)** ➢ Steroid dehydrogenase activity ● **Enzyme histochemistry:** Principle and methods ● **Immunohistochemistry:** Principles, methods (direct, indirect, PAP and ABC) and application of immunohistochemistry. ➢ Immunofluorescence technique **(self-study)**. ➢ Localization of proteins in endocrine cells in pituitary cell types and islet of Langerhans ➢ Biomarkers for malnutrition and mechanism of autophagy ➢ *In situ* hybridization of nucleic acids (principle, method and applications)	**15**

IV	**Histopathology** ● Morphological alterations in cells due to disease. ● Types of degeneration- clouding, hyaline, hydropic and fatty degeneration. ● Etiology, pathogenesis and histopathology of liver cirrhosis and atherosclerosis. ● Neuropathology of alcoholism ● Pathophysiology of obesity ● Neurodegenerative disorders, demyelination – Alzheimer's disease, Parkinson's disease and Multiple sclerosis. ● Histopathology of tumors - malignant and non-malignant. Types of carcinoma **(self-study).** ● Histopathology of breast and prostate tumors. ● Histopathology of testicular and ovarian cancer.	**15**

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BLUEPRINT:

Course Code: ZO7424

Course Title: Histology, histochemistry and Histopathology

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	15	18
Unit II	15	18
Unit III	15	17
Unit IV	15	17
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN HISTOLOGY, HISTOCHEMISTRY AND HISTOPATHOLOGY

Semester	**I**
Paper Code	**ZO 7P4**
Paper Title	**HISTOLOGY, HISTOCHEMISTRY AND HISTOPATHOLOGY**
Number of practical teaching hours per semester	**44**

Sl.No.	Description	Units
01	Preparation of paraffin tissue blocks for histology (tissue processing: dehydration, clearing, infiltration)	**01**
02	Sectioning of tissue blocks using microtome and spreading of tissue on slide	**01**
03	Staining of tissue sections (Haematoxylin and Eosin)	**01**
04	Preparation of Giemsa stain, Differential staining and examining of blood cells, granules and cell types.	**01**
05	Isolation of hepatocytes and determination of cell viability by Trypan blue staining assay	**01**
06	**Histopathology:** Observation of permanent slides of fatty liver, breast tumours, cystic follicles of ovary, diabetic pancreas, seminoma of testis and malignant melanoma (in comparison with healthy tissues)	**02**
07	**Micrometry:** Measurement of different follicles of ovary, diameter of seminiferous tubules, diameter of thyroid follicles and zonation of adrenal gland	**01**
08	**Histochemistry:** a) Alcian blue method to localize acidic glycoproteins (mucopolysaccharides) b) Localization of proteins and lipids (adipose tissue) in the tissue sections by mercury bromophenol blue method and Sudan Black-B method respectively.	**02**

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Describe the structure and organization of tissues in various organ systems.	*	*	*								(Understand)
2. CO 2: Apply histological techniques to prepare and stain tissue sections.			*	*	*						(Apply)
3. CO 3: Analyze histological and histochemical characteristics under microscopy.					*	*	*				(Analyze)
4. CO 4: Evaluate pathological alterations in tissues and organs.							*	*	*		(Evaluate)
5. CO 5: Develop histological case reports demonstrating structure–function relationships.								*	*	*	(Create)

SC- ZO 7524: ANIMAL BEHAVIOUR

Semester	**I**
Paper code	**ZO 7524**
Paper Title	**ANIMAL BEHAVIOUR**
Number of teaching hours per week	**3**
Number of teaching hours per semester	**45 (39 hours + 6 hours Self-study)**
Number of credits	**3**

Learning outcome:

Learner should be able to

- Understand types of animal behaviour and their importance to the organisms.
- Relate animal behaviour with other subjects such as Animal biodiversity, Evolutionary biology, Ecology, Conservation biology and Genetics.
- Learn about the biological rhythm and their application in pharmacology and modern medicine
- Describe the role of natural and sexual selection in the evolution of behaviour.
- Understand human behaviour.

Units	Description	Hrs
I	**Introduction** • Aims and objectives • Trends in animal behaviour studies: Historical perspective, Modern approaches. Methods and recording of a behaviour, AI in animal behaviour studies in conservation • Classical ethology: Innate and learned behaviour ➢ Characteristics, taxis, kinesis, motivation, tropism, reflexes and instincts with suitable examples. **(Self-study)** ➢ Learning behaviour types: Sensitization and habituation, imprinting, associative learning, latent and insight learning. ➢ Innate behaviour vs learned behaviours ➢ Case studies: Domestication and behavioural changes. Cognition in cephalopods, temple elephants	**6**
II	**Interactions between gene, neuron, hormone and environment** • Phylogeny of behaviour, Evolution of behaviour – cells to society, Individual vs. group selection **(Self-study)** • Genetics of behaviour: Single gene, multiple genes, methods in behavioural genetics • Approaches with case studies: Behavioural endocrinology, behavioural ecology and conservation. Scope of research and applications.	**5**

III	**Chronobiology** ● Historical account, Chronobiology in India, **(Self-study)** Biorhythms. Types of Biorhythms. Clock diversity, Clock genes, Circadian rhythm in prokaryotes. ● The biological clock and how it works w.r.t circadian rhythm (Neural, molecular, hormonal) Endogenous, Exogenous, Zeitegebers. ● Recent trends in chronobiology: Phase response, Chronotherapy: Chronopharmocology, actigraphy devices and actogram.	**5**
IV	**Foraging** ● Optimal foraging theory ● Cooperative hunting: Group foraging with special reference to birds, fishes and mammals. ● Comparative aspects of intelligence. Use of tools by animals. Cultural aspects of behaviour. ● Prey-predator strategies with examples, Red Queen hypothesis	**6**
V	**Migration** ● Migration (fishes, birds, mammals) **(Self-study)** ● Orientation and navigation. Movement and ranging	**3**
VI	**Animal Communication** • Meaning and components of communication. • Types of signals: Chemical, auditory, visual, tactile. Multimodal communication (Features with examples).	**4**
VII	**Sexual behaviour and parental care** • Anisogamy, sexual dimorphism, parental investment – offspring conflict and trade offs in males and females • Sexual selection: Discussion on sex and sexual selection, Bateman's principle, Mate choice, Intra-sexual selection (male rivalry), Inter-sexual selection (female choice) • Mating systems in sexual animals: Polyandry, polygyny, harems, leks, promiscuity. • Effect of parasitic adaptations on reproductive behaviour (Barnacles - Rhizocephalans) on crustacean biology, Wolbachia on *Drosophila*). • Parental care in animals with suitable examples **(Self-study)**	**7**
VIII	**Socio-biology and Social behaviour** • Origin and roots to sociality, Types of social groups. • Altruism and Hamilton's rule. Advantages and disadvantages of social grouping. Cost and benefits of sociality. • Social organization- insects (honey bees, termites) and primates. Discussion on evolution of eusocial behaviour. • Bird Socio-biology: Cooperative breeding in birds. Ecology of avian brood parasitism **(Self-study)** Case studies, scope of research and applications.	**6**
IX	**Human behaviour** ● Memory: basic concepts and types, emotions, learning (language), non-verbal human communication, family relations and altruism. Territorial behaviour and aggression.	**3**

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BLUEPRINT:

Course Code: ZO 7524

Course title: : Animal behaviour

Unit Number	**Number of Hours**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	**8**	**9**
Unit II	**7**	**7**
Unit III	**7**	**7**
Unit IV	**8**	**10**
Unit V	**4**	**5**
Unit VI	**5**	**6**
Unit VII	**10**	**11**
Unit VIII	**8**	**10**
Unit IX	**4**	**5**
Total	**Mention total hours 45**	**Mention total marks 70**
Maximum marks for the course (Excluding bonus questions) = 50		

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

Course code: Course title :

(COs can be written for Theory and Practical together)

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Recall key concepts, terminology, and historical developments in animal behaviour studies	*	*	*								Remember
2. CO 2: Explain mechanisms underlying instinctive and learned behaviours, communication, and social organization in animals			*	*	*						Understand
3. CO 3: Apply ethological methods to observe, record, and interpret behavioural patterns in selected species.					*	*	*				Apply
4. CO 4: Analyze environmental, physiological, and genetic influences on animal behaviour.							*	*	*		Analyze
5. CO 5: Evaluate behavioural adaptations and design experimental approaches to study behavioural ecology and evolution.								*	*	*	Evaluate/Create

SECOND SEMESTER

ZO 8124: SYSTEMATICS, PHYLOGENY AND BIOLOGY OF CHORDATES

Semester	**II Semester**
Paper code	**ZO 8124**
Paper title	**Systematics, phylogeny and biology of Chordates**
Teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours Self study)**
Number of Credits	**4**

Learning outcome:

Learner should be able to

- Understand organisation and functions of various chordate systems.
- Comprehend and explain evolutionary relationship with other phyla
- Examine the environmental opportunity and innovations resulting in adaptive radiation
- Differentiate orders in different classes
- Learn the comparative account of integument, skeletal components, their functions and modifications in different vertebrates.
- Understand the evolution of heart, modification in aortic arches, structure of respiratory organs used in aquatic, terrestrial and aerial vertebrates.
- Learn the evolution of brain, sense organs and excretory organs among vertebrates
- Analyse and critically evaluate the structure and functions of vertebrate systems, which helps them to understand the developmental, functional and evolutionary history of vertebrate species.

Units	Description	Hrs
I	**Origin of Chordates and Protochordates** ● Introduction to Chordates: Salient features of Urochordata and Cephalochordata. ● Study of larval forms in Protochordates, retrogressive metamorphosis in Urochordata. **(Self study)** ● Origin of Chordates: Theories on the origin of chordates	7

II	**Agnatha and Pisces** ● Agnatha: General characteristics and classification of cyclostomes up to Class ● Ostracoderms and Placoderms: Phylogeny and fossil record ● Pisces: General characteristics, classification and phylogeny of Chondrichthyes and Osteichthyes. ● Chondrichthyes: Fossil history, tendencies in Elasmobranch evolution ● Actinopterygii: Origin and evolution, Adaptive radiation of bony fishes. ● Specialized organs: Electric organs, sound producing organs, light producing organs, Poison glands **(Self study)**	**10**
III	**Herpatofauna** ● Amphibia: General characteristics, classification and phylogeny. Origin of Tetrapoda (Evolution of terrestrial ectotherms); Adaptive radiation Specialized organs: Poison glands eg: Toad. ● Reptilia: General characters, classification and Phylogeny. Temporal fossae and its significance. ● Evolution and adaptive radiation of Reptilia. ● Extinct reptiles: Saurischian and Ornithischian Dinosaurs. ● Specialized organs: Poison gland, Poison apparatus and Biting mechanism. Venom types and Venom banks. **(Self study)**	**10**
IV	**Aves** ● Fossil history of birds, General characters, classification and Phylogeny. Palate in birds. ● Adaptive radiation in birds. **(Self study)** ● Anatomical and physiological adaptations for flight in birds.	**5**
V	**Mammals** ● Evolution of Mammals, Diversity and Phylogeny. ● Interesting features of Prototherians, Metatherians and Eutherians ● Dentition in Mammals. (S**elf study)** ● Gut microbiota as an adaptation in mammals. ● Adaptive radiation in mammals.	**6**

VI	**Comparative anatomy** ● Locomotory structures: Fins and limbs. ● Circulatory system: Heart and aortic arches. ● Respiratory organs: Skin, gills, lungs and air sacs ● Urinogenital system: Kidney and reproductive ducts. ● Nervous system: Brain ● Integumentary system in the vertebrates **(Self study)**	**12**
VII	**Descriptive anatomy** ● Jaw suspensorium in vertebrates ● Receptors: visual and auditory receptors in humans. ● Skeletal system: Overview of axial and appendicular skeleton in humans Vertebrae, Girdles and limb skeleton in humans	**10**

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BLUEPRINT:

Course Code: ZO 8124

Course Title: Systematics, phylogeny and biology of Chordates

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	7	8
Unit II	10	12
Unit III	10	12
Unit IV	5	6
Unit V	6	7
Unit VI	12	14
Unit VII	10	11
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN SYSTEMATICS, PHYLOGENY AND BIOLOGY OF CHORDATES

Semester	**II Semester**
Paper code	**ZO 8P1**
Paper title	**Systematics, phylogeny and biology of chordates**
Number of teaching hours per semester	**44**

Sl. no	Description	Unit
1	Protochordata: *Balanoglossus*, T.S of proboscis, *Ascidia*, Tadpole larva, Amphioxus w/m, T.S of pharynx, Ammocoetus larva **Experiment:** Protochordates and vertebrate phylogeny - (Phylogenetic tree construction)	**1**
2	Pisces: Shark, *Trygon*, *Clarias*, *Arius*, *Ostracion*, *Oreochromis*, Channa, *Hippocampus*, *Tetradon*, *Echeneis*. **Experiment:** Observation of Weberian ossicles, swim bladder and Gill apparatus of commercially available fish.	**1**

3	Amphibia: *Triton, Gegenophis, Amblystoma*, *Siren, Hyla, Ichthyophis, Dattaphrynus melanostictus* **Experiment:** Morphometrics as a tool for classification (studies on preserved specimen of toad, frog and tadpole)	**1**
4	Reptilia: *Chamaeleon*, *Phrynosoma*, *Varanus*, King cobra, Krait, Turtle, Crocodile. Extinct reptiles (Dinosaurs) models: *Ichthyosaurs*, *Brontosaurs, Stegosaurs, T. rex, Pteranodon.* Key for Identification of venomous and non-venomous snakes. **Experiment: S**tudy on the scale/shield types and morphometric indices (study from preserved specimens/photographs)	**1**
5	Aves: Morphological characters and sexual dimorphism in Cuckoo, Black kite, Jungle fowl, Indian roller, Horn bill, Owl. Beak and feet modifications. **Experiment:** Study of Pecten from Fowl head and feather types	**1**
6	Mammalia: Loris, Bat, Squirrel, Platypus, Porcupine, Pangolin. **Experiment:** Curation of vertebrate specimens (Videos, Taxidermy, Online portals)	**1**

7	Study of skull: Aves (Skull and modifications in palate region – Desmognathous and Schizognathous type. e.g. duck and pigeon), reptiles (turtle and crocodile), mammals (goat and cat). **Experiment:** Online Tools and its application: (OsteoID, Idaho Virtual Museum, BoneID, Avian Osteology, Russell Bone Atlas)	**1**
8	Study of dermal derivatives in vertebrates (Carapace and plastron of turtle /tortoise) **Experiment:** Applications of feathers, hooves, horn in various fields (protocols and patents - Online sources)	**1**
9	Overview of human skeletal system (axial)	**1**
10	Introduction to culture media and microbial techniques (Plating and streaking techniques) and its applications	**1**
	Field exposure visit/ Visit to aquarium / Zoo / Research institute / to understand the diversity of extant animals (2 visits)	

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

Course code: Course title :

(COs can be written for Theory and Practical together)

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: : Explain the taxonomy, morphology, and evolutionary trends in chordates.	*	*	*								(Understand)
2. CO 2: Apply comparative anatomy to identify distinguishing chordate features.			*	*	*						(Apply)
3. CO 3: Analyze the adaptive radiation and phylogenetic divergence within vertebrates.					*	*	*				(Analyze)
4. CO 4: Evaluate evolutionary significance of chordate organ systems.							*	*	*		(Evaluate)
5. CO 5: Create phylogenetic trees depicting evolutionary relationships among chordates.								*	*	*	(Create)

ZO8224: PHYSIOLOGY AND BIOCHEMISTRY

Semester	**II**
Paper code	**ZO 8224**
Paper Title	**Physiology and Biochemistry**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**4**

Learning outcome:

Learner should be able to

- Explain and reason on the fundamental Physiological and Biochemical process that are vital for life sustenance.
- Define, describe, and explain homeostatic and osmoregulatory mechanisms.
- Examine and evaluate the pathological consequences due to dysfunction in biochemical pathways.
- Develop scientific enquiry skills to design experiments in physiology and biochemistry.
- Develop spectro-photometrical and analytical skills

Unit	Description	Hrs
I	**Cellular Physiology** ● **Homeostasis:** Positive and negative feedback, General patterns of acclimation and acclimatization **(Self study).** ● **Osmoregulation:** Concepts of osmoregulation, Osmoregulation in animals of aquatic and terrestrial environments. Excretory patterns and osmoregulation. Role of renal and extra renal tissues in osmoregulation	6
II	**Environmental and integrative physiology** ● High altitude, Space and deep sea diving physiology: Effect of low oxygen pressure on the body, effects of acceleratory forces on the body in aviation and space physiology, effect of high partial pressure of gases on the body. ● Concept of temperature tolerance: mechanisms of body temperature regulation, temperature regulation in animals living in high and low temperatures, Role of brown fat in temperature regulation **(Self study)** ● Exercise Physiology: Acute adaptations of exercise - Metabolic, respiratory, musculoskeletal and cardiovascular adaptations and effects of exercise. Resistance exercise and endurance training.	8

III	**Integrative Neurophysiology** ● Neuronal Physiology: CNS synapses - special characteristics of synaptic transmission, Axonal transmission of nerve impulses, Synaptic integrity, synaptic plasticity, electrochemical gradients – Nernest and Goldman equations. ● Sensory Physiology: Somatic sensations - Tactile and position senses. Sensory receptors and pathways for transmission of somatic signals into the central nervous system. Median leminiscal system. ● Physiology of Pain*:* Referred and Visceral pain, Headache; Pain receptors and their stimulation, Dual transmission of pain signals into the central nervous system, Thermal sensations. ● Organs of special senses: Physiology of vision, hearing, taste, smell and touch **(Self study).**	**8**
IV	**Gastrointestinal physiology** ● General principles of gastrointestinal function - motility, nervous control, and blood circulation, Transport and mixing of food in the alimentary tract, Ingestion of food. ● Motor functions of stomach. Movements of small intestine. Movements of colon. Action of enteric neurons. ● Secretary functions of alimentary tract: Secretion of saliva, Gastric secretion, Pancreatic secretion, Secretion of bile by liver **(Self study)**, Secretions of small and large intestine. ● Digestion and absorption in gastrointestinal tract: Digestion of various foods, Absorption in small intestine.	**8**
V	**Chemical and Physical Foundations of Biochemistry** ● Chemical Bonds – stabilizing interactions (Ionic, Covalent, Hydrogen bonds, Van der Waals and metallic bonds, Electrostatic and hydrophobic interactions). ● Biophysical chemistry - pH, buffer [**Self study**], reaction kinetics, Entropy, Enthalpy, Free-energy). ● Biochemical Reactions – Group transfer reaction (transfer of an amine functional group); Formation/Removal of carbon-carbon double bonds (hydrogenation reaction); Isomerization reaction; Ligation reaction; Hydrolysis reaction; oxidation-reduction reaction and Phosphorylation .	**8**
VI	**Metabolism and Bioenergetics** ● ***Carbohydrate metabolism:*** mechanisms and regulation and significance of Glycolysis, gluconeogenesis, Glucogenolysis, Tricarboxylic acid cycle, role of vitamins in TCA cycle, Hexose monophosphate shunt. Diseases associated with carbohydrate metabolism*:* Galactosuria, Fructosuria and Hunter's Syndrome. ● ***Protein Metabolism:*** biosynthesis of amino acids – transamination, deamination, catabolisms of aromatic and sulphur containing amino	**15**

	acids and urea cycle **(Self study)**. Diseases associated with amino	

	acid metabolism: Phenylketonuria, Maple-Syrup Urine Disease (MSUD). ● ***Lipid Metabolism:*** biosynthesis of fatty acid, Oxidation of fatty acids (alpha and beta), Ketogenesis and ketolysis. Cholesterol biosynthesis and its regulation. Diseases associated with lipid metabolism: Gaucher's disease and Tay-Sacch's disease. ● ***Nucleotide Metabolism:*** Biosynthesis and metabolism of purine, and pyrimidines. ▪ *Diseases associated with nucleotide metabolism:* Von-Gierke's disease and Gout.	
VII	**<u>Enzymes and Vitamins</u>** ● General characteristics of enzymes, definition of coenzyme, holoenzyme, prosthetic groups and classification. ● Enzyme Kinetics: Substrate, active site, transition state, activation energy, equilibrium constant Km, Vmax, specificity, Michaelis-Menten equation. ● Reaction Mechanism: Acid-base catalysis and covalent catalysis; Regulation of enzyme activity: Reversible and irreversible inhibition (non-competitive, uncompetitive) and their effects on Km and Vmax, ● Effect of pH, <u>heat</u>, **(Self study)** serene protease inhibitors on enzyme activity and Allosteric enzymes. ● Vitamins: Fat soluble (A, D, E, K); water soluble (Group B vitamins and C) Biological significance and physiological consequences of vitamin deficiency.	**7**

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BLUEPRINT:

Course Code: ZO 8224

Course Title: Physiology and Biochemistry

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	6	7
Unit II	8	9
Unit III	8	10
Unit IV	8	10
Unit V	8	9
Unit VI	15	18
Unit VII	7	7
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50 marks		

PRACTICALS IN PHYSIOLOGY AND BIOCHEMISTRY

Semester	**II**
Paper code	**ZO 8P2**
Paper Title	**PHYSIOLOGY AND BIOCHEMISTY**
Number of teaching hours per semester	**44**

Sl. no	Description	Unit
1	Preparation of Osazone's and identification of carbohydrates.	**1**
2	Determination of absorption maxima using dye solutions and Beer-Lambert's law.	**1**
3	Estimation of protein by Lowry's method.	**1**
4	Estimation of serum lactate dehydrogenase (LDH) activity.	**1**
5	Estimation of blood glucose content.	**1**
6	Estimation of glycogen in liver.	**1**
7	Determination of blood cholesterol content.	**1**
8	Preparation and identification of bone marrow cells.	**1**
9	Estimation of blood urea content.	**1**
10	Determination of arterial blood pressure using sphygmomanometer.	**1**
	Visit to NIMHANS (neurophysiology study).	

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

Course code: Course title :

(COs can be written for Theory and Practical together)

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Explain physiological mechanisms in relation to biochemical pathways.	*	*	*								(Understand)
2. CO 2: Apply biochemical principles to analyze metabolic regulation.			*	*	*						(Apply)
3. CO 3: Analyze interrelationships between organ systems in maintaining homeostasis.					*	*	*				(Analyze)
4. CO 4: Evaluate effects of biochemical imbalances on physiological functions.							*	*	*		(Evaluate)
5. CO 5: Design experimental approaches to assess physiological responses under stress.								*	*	*	(Create)

ZO8324: MOLECULAR BIOLOGY AND IMMUNOLOGY

Semester	**II**
Paper code	**ZO 8324**
Paper title	**MOLECULAR BIOLOGY AND IMMUNOLOGY**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**4**

Learning outcome:

Learner should be able to

- Describe the molecular structure, characteristics of Nucleic acids its different forms and types and their functional abilities.
- Demonstrate different models of replication, process of replication, enzymes involved and their functions in both prokaryotes and eukaryotes.
- Explain the molecular mechanism of mutation causing DNA damage and decipher the role of different types of DNA repair mechanism.
- Elucidate the process of Gene transcription, distinguish the enzymes, transcription factors and apparatus involved in prokaryotes and eukaryotes and explain the molecular mechanism of post transcriptional modification in eukaryotes.
- Explain the characteristics of genetic code, process of protein synthesis, enzymes and factors involved in prokaryotes and eukaryotes.
- Describe the role of chaperons in post translational modification and explain the molecular mechanism of protein ubiquitination.
- Elucidate the immunological processes at cellular and molecular level.
- Understand how the immune system develops, how the body defends itself against disease.
- Outline, compare and contrast the key mechanisms and cellular players of innate and adaptive immunity and their functions.
- Understand the principles of immunological tolerance, autoimmunity and transplantation.
- Explain the concepts of immune system in cancer and the principles of immunotherapy.

Unit	Description	Hrs
I	**MOLECULAR BIOLOGY** **Molecular basis of life** ● Introduction to Nucleic acids, experimental proof of DNA as genetic material. Structure, forms (A, B and Z) and characteristics of DNA. ● RNA structure, characteristics and their functions in different types of RNA (coding, housekeeping and non-coding regulatory RNAs) in prokaryotes and eukaryotes.	**4**
II	**DNA Replication, Damage and Repair** ● Models of replication (Theta and Rolling circle model) in prokaryotes and (Linear model) in eukaryotes, fidelity of replication, Unit of replication, enzymes involved replication origin, replication fork, steps involved in activation, unwinding, formation of RNA primers, Okazaki fragments, mechanism of end replication in eukaryotes- concept of telomeres. ● DNA damage and repair: Molecular mechanism of mutation: Depurination, Base analogs- alkylating agents, deaminating agents, oxidation, UV radiation. Repair mechanism: Basic pathway, Types of DNA repair- Direct repair, Mismatch repair, Base excision repair, Nucleotide excision repair and SOS repair.	**8**
III	**Gene transcription and control** ● Mechanism of transcription in Prokaryotes and Eukaryotes- Types of RNA polymerases, transcriptional unit, transcription apparatus and factors involved. post transcriptional modifications: pre-mRNA processing- Process of 5' CAP formation and 3' poly adenylation, concept of introns ad exons, types of introns, molecular mechanism of splicing- spliceosome's, Types of splicing – alternative splicing (Calcitonin in humans) and multiple 3' cleavage site. ● Gene regulation, Operon model-Inducible and repressible systems, lac, trp operon; (Attenuation, positive and negative regulation). Regulation of eukaryotic gene expression, transcriptional control, cis control elements, promoters, enhancers, transacting factors.	**10**
IV	**Protein synthesis and ubiquitination** ● Genetic code Characteristics, Wobble's hypothesis, process of translation- Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, Ribosome complex formation, formation of initiation complex, initiation factors, peptidyl transferase, elongation factors, termination factors and their regulation. ● Post- translational modification of proteins- Molecular chaperons, and their mechanism of protein folding and processing. Protein ubiquitination- molecular mechanism of ubiquitination and the role of proteosomes in protein degradation.	**8**

V	**IMMUNOLOGY** ● Introduction to Immunology, Historical background of Immunology ● Ontogeny and Physiology of immune system: Primary and Secondary lymphoid organs. ● Adaptive and innate immunity system, differences with the cells involved, Hematopoiesis. ● Self and non-self-recognition, immunological memory and specificity. ● Antigens: Essential features of Ag, haptens, Carrier molecule, Antigenic determinants. **(Self - study)**	**4**
	Immunity ● Types: Active and passive immunity. ● Cell mediated immunity, humoral immunity, immune response; primary and secondary response. ● Phagocytosis, mechanism of phagocytosis. Null cells: Natural Killer cells. TLR ● Complement system - Pathways: Classical pathway.	**3**
VI	**Antibodies** ● Nature, Primary structure of immunoglobulins, Enzymatic fragmentation of Ig. Classification of Immunoglobulins: Types –IgG (G1, G2, G3 & G4), IgM, IgA, IgD and IgE (Origin, structure and functions). ● Monoclonal – Hybridoma technology ● Antigen processing and presentation to T- lymphocytes. MHC – types and importance- distribution and function.	**5**
	Recognition and response actions ● Cytokines and its types; Cytokine storms and interferons. ● lymphokines and chemokines and its responses **(Self - study)**	**2**
	Hypersensitivity ● Type I: Allergies and anaphylaxis – IgE, Mast cell degranulation, biologically active agents released in reactions, Clinical manifestations. ● Type II: Antibody mediated HS reactions; Mechanism, pathogencity and cases of type II reactions; Hemolytic-disease of new born (HDN). ● Type III: Immune complex mediated HS reactions: Mechanism & pathogenecity of type III reactions. Soluble immune complexes and insoluble immune complex mediated reactions. Arthus reaction, Serum sickness. ● Type IV: Delayed type (or) cell-mediated HS reactions; Mechanisms and pathogenecity, Tuberculin reaction. ● Type V: Stimulatory HS reactions. Mechanism and pathogenecity, Grave's disease. Blood groups: AB, Rh system, Lewis-Luthern systems, significance, practical application of immuno methodology in blood transfusions, Erythoblastosis faetalis.	**5**

VII	**Auto immunity, Infectious diseases and human health** ● Introduction, Auto recognition, classes of auto immuno diseases. Transplantation: Terminology, Auto graft, Isograft, Allograft, Xenograft. ● Immunological basis of transplantation reactions, GVH reaction, Immune suppression **(Self - study)** ● Immune Deficiencies: Introduction, primary and secondary deficiencies. T-cell, B-cell deficiencies. Acquired immuno deficiency syndrome. ● Host-symbiont interaction, Mucosal immunity and role of gut microbiota, Viral immunity, Fungal immunity, Parasite immunity, Evasion strategies of microbes and parasites. **(Self - study)**	**2** **2** **3**
VIII	**Immuno engineering** ● Passive and Active immunization. Types of Vaccines-Live, attenuated vaccines, Inactivated vaccines, Subunit vaccines, Toxoid vaccines, Conjugate vaccines, DNA vaccines, Recombinant vector vaccines ● Types of immunotherapies - Adoptive Cell Therapies, Cell Therapy, NK Cell Therapy, Cancer Vaccines, Immune System Modulators. Nanotechnology based therapies.	**4**

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BLUEPRINT:

Course Code: ZO8324

Course Title: Molecular Biology and Immunology

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	4	5
Unit II	8	10
Unit III	10	11
Unit IV	8	9
Unit V	7	8
Unit VI	12	14
Unit VII	7	8
Unit VIII	4	5
Total	60	70
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN MOLECULAR BIOLOGY AND IMMUNOLOGY

Semester	**II**
Paper code	**ZO 8 P3**
Paper title	**MOLECULAR BIOLOGY AND IMMUNOLOGY**
Number of teaching hours per semester	**44**

Sl. no	Description	Unit
1	Extraction of genomic DNA from liver tissue and its analysis by UV spectrophotometer.	**1**
2	Extraction of total RNA from animal tissue by TRIZOL method.	**1**
3	Estimation of the concentration of RNA by Orcinol method.	**1**
4	*In vitro* amplification of DNA by PCR.	**1**
5	Analysis of amplified DNA by agarose gel electrophoresis.	**1**
6	Separation of Proteins by SDS- Polyacrylamide Gel Electrophoresis.	**1**
7	Study of immunodiffusion by Mancini Radial immune diffusion method and Ouchterlony double immunodiffusion method.	**1**
8	Study of Enzyme-linked immunosorbent assay: Sandwich ELISA.	**1**

9	Analyzing proteins and nucleic acids sequences and their three-dimensional structures using RASMOL and EXPASY Bioinformatics tools.	**1**
10	Estimation of erythrocyte sedimentation rate in Blood samples.	**1**

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

Course code: Course title :

(COs can be written for Theory and Practical together)

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Describe the structure and function of nucleic acids and proteins.	*	*	*								(Understand)
2. CO 2: Apply molecular techniques for gene expression and analysis.			*	*	*						(Apply)
3. CO 3: Analyze mechanisms of immune response and antigen–antibody interactions.					*	*	*				(Analyze)
4. CO 4: Evaluate molecular pathways regulating immune system function.							*	*	*		(Evaluate)
5. CO 5: Design molecular assays for disease diagnosis or immune profiling.								*	*	*	(Create)

ZO 8424 AQUATIC BIOLOGY AND FISHERIES

Semester	**II**
Paper code	**ZO 8424**
Paper Title	**AQUATIC BIOLOGY AND FISHERIES**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours + 8 hours self study)**
Number of credits	**4**

Learning outcome:

Learner should be able to:

- Define, examine, and categorize freshwater and marine water bodies.
- Describe and explain the general structure of freshwater and marine water bodies.
- Enumerate, explain, and examine physicochemical parameters of aquatic systems.
- Define, describe, explain, and investigate the role of physic-chemical parameters on freshwater and marine water quality.
- Examine and evaluate how aquatic morphology influence physicochemical parameters.
- Describe, examine, and explain the major biotic components of freshwater and marine systems.
- Examine and evaluate how freshwater or marine structure and physicochemical parameters influence distribution and diversity of biotic components.
- Categorize, describe and explore freshwater and marine ecosystem structure, community, and ecosystem services.
- Examine and evaluate the threats faced by aquatic systems, examine conservation strategies and challenges in implementation of management systems.
- Describe diversity and distribution of freshwater and marine fish in Indian waters.
- Identify major economically important fish of India.
- Describe fisheries practices and culture in India.
- Evaluate and link aquatic ecosystem services to food security and global health.

Unit	Description	Hrs
I	**<u>The freshwater aquatic environment</u>** ● Classification of aquatic water bodies-Ponds, lakes, freshwater swamps, estuaries, and marshes. ● Biological zonations - Structure and characters of Lotic and lentic ecosystems. ● Characteristics of Ponds, lakes, freshwater swamps, and marshes. ● Physico-chemical parameters and their influence on lentic and lotic ecosystems. ● Overview of biodiversity, ecological communities, and special adaptations in lentic and lotic systems. ● Distribution and hydrology of major lakes and rivers in India**. (Self-Study)**	**14**
II	**<u>Lentic and lotic ecology, management and conservation</u>** ● Hydrological cycles (rainfall, runoff, drainage, depletion). ● Eutrophication – natural and anthropogenic. ● Nutrients, nutrient cycling and primary productivity in aquatic ecosystems. ● Plankton ecology – overview of plankton classification, seasonal dynamics. ● Ecosystem services, pollution, and threats to freshwater systems, conservation, management, and challenges. **(self-study)** ● River management and restoration strategies. ● Climate change threats to lotic systems, scale and sustainability. ● **Field learning:** Field techniques. Analyses of water quality parameters in Bangalore lakes in labs.	**14**
	Wetlands and Estuaries. ● Origins, classification, hydrology, physico-chemical properties of Estuaries and salt marshes. Salinity, temperature fluctuation dynamics - tidal and seasonal (case studies). Habitat heterogeneity. ● Community ecology- flora fauna. Tidal and seasonal dynamics of communities. Threats to wetlands and conservation strategies.	**6**

III	**<u>Marine biology and Oceanography</u>** ● Brief overview of oceanography –oceans and seas, categories, distributions. Overview of submarine topography, general features of the ocean floor, Bathymetry and recent advances in ocean topography mapping, submarine volcanoes and vents, global distribution. ● Overview of ocean circulations, waves, tides, currents, and upwelling. Marine zonations and changes in physico-chemical properties. Global variation in oceanographic parameters (**Self-study**). ● Marine Ecosystems: Inter-tidal ecosystems, rocky, sandy shores, characteristics, coastal oceanographic influences on intertidal structure, recruitment, and community. (*review/summary of research paper, field learning*). ● Sea grass ecosystems -. Characteristics and global distribution, brief overview of origins and evolution, types of seagrasses, factors influencing seagrass ecosystem dynamics. Overview of seagrass community ecology.	**16**

	Ecosystem services. (*review/summary of research papers*). ● Coral reef ecosystems: characteristics and global distribution, brief overview of origins and evolution, shallow and deep coral community ecology, threats to coral reefs and conservation and management strategies, ecosystem services, current status of coral reefs (*review/summary of research papers on reef recruitment, community ecology, threats and management*). ● Deep sea ecosystem: Characteristics, physico-chemical properties, fauna, special adaptations, recent discoveries (*review/summary of research paper*). ● Mangrove ecosystems: Characteristics and global distribution. Types of mangroves, adaptations, factors influencing ecosystem dynamics, community ecology, ecosystem services. (*review/summary of research papers, field learning*). ● Ocean migrations –factors influencing freshwater/marine animal migration. (**Self study**). **Field learning:** Visit to coastal zone, survey of landscape dynamics and community structure differences in sandy and rocky intertidal zones, survey of mangrove/seagrass types and mangrove community. Survey of anthropological activity and coastal erosion.	
IV	**<u>Fisheries: Fish diversity in India</u>** ● Overview of diversity and distribution of major freshwater and marine fishes of India. ● Overview of major food fish (freshwater, marine) and Lacustrine fish culture (ornamental) practices. **(self-study)** ● Overview of fish diseases, symptoms and prevention. Overview of fishing gears and crafts. ● **Field learning:** Visit to coastal/local fisheries institutes.	**10**

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BLUEPRINT:

Course Code: ZO8424

Course Title: Aquatic Biology and Fisheries

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	14	15
Unit II	20	22
Unit III	16	20
Unit IV	10	13
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN AQUATIC BIOLOGY AND FISHERIES

Semester	**II**
Paper code	**ZO 8 P4**
Paper Title	**AQUATIC BIOLOGY AND FISHERIES**
Number of Practical teaching hours per semester	**44**

Sl. no	Description	Unit
1	Overview of water and aquatic sediment sampling equipment, techniques, and standard operating procedures - Ekman's dredge/grab and Niskin's water sampler (*videos*), surface water collection, Secchi's disk for turbidity estimation (*demonstration/fieldwork*).	**1**
2	Estimate diversity of aquatic macrofauna: Collection and analyses of aquatic plants/insects.	**1**
3	Estimate diversity/abundance of aquatic zooplankton: Collection, identification and count (if sedgewick counter is available) of common aquatic zooplankton.	**1**
4	Water quality analyses: temperature, salinity, pH, alkalinity, TDS, Phosphate/Nitrates (any 3 using titration/calorimetric methods in lab, all parameters for lake/river samples using analyzer kit).	**1**
5	Observation of life cycle and maintenance of guppies/mollies (ornamental fish) (semester-long activity).	**1**
6	Identification of major freshwater and marine food fish in India.	**1**
7	Estimation of primary productivity in aquatic bodies.	**1**
8	Anatomy and morphometry of selected fish species (Length-weight, std and total length, fin lengths – pectoral, pelvic, and caudal).	**1**
9	Estimation of nutritional content (protein/lipids/carbohydrate) of different fish.	**1**
10	Estimating Gonadosomatic index fish	

	RBPT: Analyses of water quality of lakes around Bangalore. Visit to Govt. Aquarium/fisheries market, field report on aquarium maintenance and local fisheries economics.	**1**

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Explain the physical, chemical, and biological properties of aquatic ecosystems.	*	*	*								(Understand)
2. CO 2: Apply limnological and oceanographic methods to assess water quality.			*	*	*						(Apply)
3. CO 3: Analyze population dynamics and productivity in aquatic organisms.					*	*	*				(Analyze)
4. CO 4: Evaluate sustainable fishery practices and aquatic resource management.							*	*	*		(Evaluate)
5. CO 5: Design aquaculture or conservation models to enhance aquatic biodiversity.								*	*	*	(Create)

SC - ZO8524: ENTOMOLOGY

Semester	**II**
Paper code	**ZO 8524**
Paper Title	**ENTOMOLOGY**
Number of teaching hours per week	**3**
Number of teaching hours per semester	**45 (39 + 6)**
Number of credits	**3**

Learning outcome:

Learner should be able to

- Understand the relationships and evolutionary advancements of insects over their other arthropod relatives and why are insects more successful.
- Apply knowledge in plant health management- agriculture and horticulture.
- Have an assertive outlook on positive and negative interactions between insects and humans.
- Evaluate Human-insect interactions, positive, negative and symbolic roles in the society.
- Rationalise the need for insect conservation.
- To build an evaluative understanding of insect occurrences in an ecosystem- trophic level.

Unit	Description	Hrs
I	**Introduction and Basic Biology** ● Traits that distinguish insects from other terrestrial arthropods. Evolutionary traits that have contributed to insect success and diversity. Inventory: major groups of insects and examine their diversity. Importance of insect collections in museums. Initiation of personal insect collection. ● Insect biology- external structures, functions and modifications-mouthparts, legs and antennae. o Major internal systems: the digestive and excretory system, the circulatory system, reproductive and the gas exchange system. o Life cycle- Complete and incomplete metamorphosis (**Self study).** o Hormonal control of Moulting and development. o Diapause, Dispersal, courtship and mating. ● Insect Conservation- primary drivers of the declines, ALAN, common challenges, aspects of insect conservation approaches, Develop approaches to insect conservation, importance of citizen science (**Self study).**	**15**

II	**Insects and Agriculture** ● Principles: Pests, definition, categories, causes for outbreak, general equilibrium position, Effects of Climate change on diversity. Economic damage, economic injury level, economic threshold level, losses caused by pests. ● Insect-plant interactions: Plant nutrition and secondary metabolites, host plant resistance mechanisms- ecological and genetic resistance, sequestration and detoxification in insects. ● Insect-Insect interactions: Mutualism, competition, predation **(Self study)**, multi-trophic interactions. Specialised adaptations and the associated plant damage. ● Chemical interactions: Allelochemicals, Pheromone and its types, olfaction mechanisms, pheromone application in pest management, pheromone traps and lures. ● Toxicity: Insecticides, types (systemic insecticides, organochlorines, organophoshates, carbamates, pyrethroids, inorganics, botanicals, synergists, fumigants, insect growth regulators). Mode of action, formulations, dose, safety measures, advantages and disadvantages of pesticides. Insect resistance to insecticides (types, resistance development mechanisms and management). ● BT (genes, mode of action and resistance)	**10**
III	**Pest management and Biocontrol.** ● Common insects in daily life**- (self study)** preview ● Pests of structured wood- Powder post beetles and Termites, damage and management ● Pests of floriculture- sap suckers and defoliators. ● Integrated Pest Management (IPM) – biological control and mediated chemical control, components, goals and strategies, development and models. Cultural control- purposeful manipulation of an environment to reduce pest abundance and damage. Classical, augmentative, conservation biological control. ● Exotic biocontrol agents- Applications and challenges, Quarantine norms.	**12**
IV	**Medical entomology and parasitic diseases-** ● Contrast modes of disease causation and transmission by insects Historical importance of insect-borne diseases: Malaria, Filariasis, Yellow fever, dengue, and Japanese encephalitis and Leishmaniasis-distribution, biology of vectors and epidemiology. ● Veterinary entomology- Epidemiology, vector biology and management of common diseases in livestock **(Self study)**. ● Emerging infectious diseases. ● Forensic entomology. ● Impact of insect-borne human diseases on public health **(Self study)**.	**8**

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BLUEPRINT:

Course Code: ZO8524
Course Title: ENTOMOLOGY

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	15	23
Unit II	10	16
Unit III	12	19
Unit IV	8	12
Total	**45**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Identify distinguishing morphological features and classify major insect orders and families.	*	*	*								Remember
2. CO 2: Explain the role of insects in agriculture, horticulture, and ecosystem functioning			*	*	*						Understand
3. CO 3: Apply pest identification and management strategies including IPM and biocontrol principles.					*	*	*				Apply
4. CO 4: Analyze insect–plant, insect–insect, and chemical interaction networks and their ecological significance.							*	*	*		Analyze
5. CO 5: Evaluate the role of insects in human welfare and conservation, proposing sustainable management practices.								*	*	*	Evaluate/Create

THIRD SEMESTER

ZO 9123 GENERAL AND MOLECULAR ENDOCRINOLOGY

Semester	**III**
Paper Code	**ZO9125**
Paper Title	**GENERAL AND MOLECULAR ENDOCRINOLOGY**
Number of teaching hours per week	**4**
Total number of teaching hours per semester	**60 (52 hours + 8 hours self-study)**
Number of credits	**4**

Learning Outcome:

Learner should be able to

- Understand the basic operating principles of an endocrine system.
- Gain a thorough knowledge on the endocrine glands and molecular basis for the synthesis and delivery of their hormones and physiological significance.
- Be able to critically think and reason on the concept of endocrine homeostasis and mechanism of hormone action.
- Have a realistic view on endocrine disorders.

Units	Description	Hrs
I	**The Vertebrate Endocrine system** ● Historical perspective (The Science of endocrinology and key discoveries) ● An overview of Mammalian endocrine glands (origin and structure) and their secretions. Attributes of endocrine system. **(Self study)** ● Hormones as general classes of chemical messengers -Peptide, Amino acid derivatives and Steroid hormones. ● Growth stimulating factors, Chalones, Eicosanoids and Pheromones ● Style of hormone delivery - Local hormones, Paracrine and autocrine secretions, Neuroendocrine secretions, Neurocrine-Neurotransmitters and Neuropeptides. ● Regulation of Hormone secretion – regulated and constitutive process, Ionic and metabolic factors.	7
II	**Genetic control of hormone synthesis** ● Structure, expression and regulation of protein hormone encoding gene	8

	• Molecular aspects of peptide hormone secretion and delivery • Transport and peripheral activation of hormones **Receptors and Mechanism of hormone action** • Membrane bound, cytoplasmic and nuclear hormone receptors and Regulation of receptor numbers. • Hormone signal transduction: secondary messengers - cyclic nucleotides (cAMP, cGMP), Phospholipid derivatives (DAG, IP3), prostaglandins and calmodulin. • Non-genomic and Genomic mechanism of hormone action- (Steroid and thyroid hormones) • Termination of hormone action and metabolism of hormones.**(Self study)**	
III	**Hypothalamo-Hypophyseal system** • The Endocrine Hypothalamus: Origin and Structure • Secretion and control of hypothalamic hormones- (TRH,GHRH, GnRH, CRH, Somatostatin and dopamine) and their physiological actions on target glands / tissues. **The Hypophysis** • Development of pituitary, structure and functional cell types • Hypothalomo-hypophysial portal system • Pituitary hormones (GH, Prolactin, FSH, LH) and their physiological actions • Pro-opiomelanocortins (MSH and Endorphins) • Neurohypophysial Hormones and their physiological roles. • Mechanism of secretion, Control and Feed-back regulation of Hypophysial Hormones (any one example). **Pineal gland** • Pineal development and Morphology • Melatonin- secretion, circulation and site of action • Pineal Rhythms and Biological clock. **(Self study)**	**10**
IV	**Homeostasis and Integrative endocrinology** • Hormonal and Molecular basis of Glucose, Calcium and Sodium Homeostasis. • Neuro-endocrine integration: Milk ejection reflex and water balance **(Self study)**	**5**

V	**Endocrine Pancreas** ● Structure and cell types of Islets of Langerhans **(Self study)** ● Insulin: Synthesis and structure. Role of insulin in carbohydrate, fat and protein metabolism. ● Glucagon: Synthesis and its role in glycogenolysis and lipolysis **Pancreatic Islet Pathophysiology** ● Insulin Dependent Diabetes Mellitus (IDDM) and Non-Insulin Dependent Diabetes Mellitus (NIDDM)	**7**
VI	**Thyroid and Parathyroid Glands** ● Thyroid and parathyroid - Origin and structure ● Thyroid hormone (T3 and T4) synthesis, secretion and control. ● Mechanism of action of thyroid hormone and Parathormone. ● Major physiological manifestations of hyperthyroidism and hypothyroidism. **(Self study)**	**7**
VII	**Adrenal Gland** ● Embryological origins of Adrenomedullary and Adrenocortical tissues and histological architecture. ● Chemistry, synthesis, and physiological roles of cortical hormones ● Sympathoadrenal system: Adrenal chromaffin tissue, Synthesis, and physiological actions of catecholamines. **(Self study)** ● Adrenal Pathophysiology: Adrenal chromaffin tumours and Adrenoceptor hypothesis of asthma.	**8**
VIII	**Gastrointestinal Hormones** ● Over view of structure and function of Gastro-Intestinal tract ● Physiological roles of gastrointestinal hormones – Gastrin, Secretin, CCK, Gastric inhibitory peptide (GIP), Vasoactive intestinal peptide (VIP), Ghrelin and Substance-P (SP). ● ANS in control of GI function. **(Self study)** ● Gastrointestinal disorders: Colitis, Constipation, Irritable bowel syndrome (IBS) and Hemorrhoids.	**8**

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BLUEPRINT:

Course Code: ZO9125

Course Title: General and Molecular Endocrinology

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	7	7
Unit II	8	11
Unit III	10	10
Unit IV	5	7
Unit V	7	9
Unit VI	7	7
Unit VII	8	10
Unit VIII	8	9
Total	60	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN GENERAL AND MOLECULAR ENDOCRINOLOGY

Semester	**III**
Paper code	**ZO 9P125**
Paper Title	**GENERAL AND MOLECULAR ENDOCRINOLOGY**
Number of teaching hours per semester	**44**

Lab contents

Sl. No	Description	Units
1	Study of comparative histology of Hypophysis	1
2	Observations on the histologic and histometric changes in diabetic	2

	pancreas and hypertrophy in thyroid follicles	
3	Estimation of Testosterone/Estrogen in the clinical sample by ELISA kit method	1
4	Estimation of the activity of 3β-HSDH in the given sample	1
5	Study on the effect of chemical endocrine disruptor on metamorphosis of insect	1
6	Detection of HCG in the given biological sample	1
7	Estimation of glucose in the given biological sample by Folin Wu tube method.	1
8	Demonstration of compensatory hypertrophy	1
9	Brain mapping – serotonin, dopamine pathway	1

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Explain hormonal regulation and mechanisms of endocrine function.	*	*	*								(Understand)
2. CO 2: Apply principles of endocrinology to assess hormonal imbalances.			*	*	*						(Apply)
3. CO 3: Analyze interactions between endocrine and reproductive systems.					*	*	*				(Analyze)
4. CO 4: Evaluate the effects of environmental and physiological factors on reproduction.							*	*	*		(Evaluate)
5. CO 5: Design experimental studies to assess reproductive endocrinology in animals.								*	*	*	(Create)

ZO 9225: REPRODUCTIVE BIOLOGY

Semester	**III**
Paper code	**ZO 9225**
Paper Title	**REPRODUCTIVE BIOLOGY**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours+8 hours of self-study)**
Number of credits	**4**

Learning Outcomes:

Leaners should be able to

- Describe the anatomy and physiology of male and female reproductive systems.
- Describe the menstrual and estrous cycles, including hormonal changes, ovulation, and uterine cycle regulation.
- Explain fertilization, early embryonic development, and implantation, including key molecular and cellular processes.
- Describe the process of fertilization, embryonic development, and implantation.
- Understand the physiological changes during pregnancy, parturition (childbirth), and lactation.
- Identify the causes, diagnosis, and treatments of common reproductive disorders (e.g., PCOS, endometriosis, erectile dysfunction, infertility).
- Describe methods of contraception, their mechanisms, and their effectiveness.
- Discuss the role of reproductive technologies, such as IVF and assisted reproductive techniques.
- Understand the impact of environmental, genetic, and lifestyle factors on reproductive health.

Unit	Description	Hrs
I	**<u>ORIGIN AND DEVELOPMENT OF GENITAL SYSTEM</u>** ● Development of gonads – role of SRY gene, stages of development – Indifferent stage, urogenital ridge, Somatic mesenchymal tissue formation. ● Origin and migration of primordial germ cells; Origin of bipotential gonad, genetic and hormonal control of differentiation of gonads and gonadal ducts in mammals.	**6**

II	**<u>DEVELOPMENT OF FEMALE REPRODUCTIVE SYSTEM</u>** ● <u>Female Reproductive System- development of external genitalia</u> **<u>(Self-study)</u>** ● Functional morphology of mammalian ovary, Fallopian tube and uterus. ● Hormonal control of follicular development and Ovarian Kinetics - Recruitment and selection of follicles, Follicular dominance, Oocyte maturation, Ovulation, Atresia, and Regulation of corpus luteum.	**6**

III	**FEMALE REPRODUCTIVE PHYSIOLOGY** ● Puberty in humans: factors affecting the onset of puberty. ● Reproductive Cycles: Definition, Components of cycling system, types and duration. Phases and hormonal regulation of Estrous and Menstrual cycle. ● Ovulation and Fertilization – Process of ovulation, types – Spontaneous and reflex/ induced, hormonal control. Molecular Events of fertilization, pre-fertilization changes in ova, cortical and zona reactions during fertilization ● Implantation– pre-implantation processes – blastocyst formation. ● Molecular Process, Types and hormonal control of Implantation. ● Pregnancy –hormonal control of pregnancy - role of hCG, progesterone, estrogen, hCS and Feto-placental unit. ● Parturition – onset of parturition, stages of labor, Ferguson's reflex and hormonal influence. ● Development of mammary gland and Lactation – Origin and development and histology of mammary gland, lactogenesis and Hormonal control of lactation **(Self-study)**	**18**
III	**MALE REPRODUCTIVE PHYSIOLOGY** ● **Structural and functional morphology of mammalian testis** Position of testis in different mammals, mechanism of testicular descent, Tunica albuginea, Interstitial tissue, seminiferous tubules, rete testis, excurrent system. ● **Testicular steroidogenesis**	**24**

	Synthesis of androgen and oestradiol in testis, Role of aromatase in steroidogenesis and its pathological significance. ● **Hormonal control on the male accessory reproductive organs** Action of testosterone and Dihydrotestosterone (DHT) on male accessory organs viz., epididymis, vas deferens, seminal vesicles, ventral prostate, bulbourethral gland, and preputial gland. ● **Dynamics of sperm maturation** Mechanism of maturation- structural, functional, and physiological maturation of spermatozoa. Microenvironment of epididymis responsible for maturation. Mechanism of capacitation. Functional changes associated with capacitation. ● **Biochemistry of semen** Components and contributions of epididymis, seminal vesicle, ampullary gland, prostate gland, cowper's gland and urethral gland. Physiological significance of sialic acid, fructose, citric acid, ascorbic acid, glycerophosphorylcholine and ergothioneine. ● **Kinetics of spermatogenesis** Wave and cycle of spermatogenesis, Stem cell renewal. ● **Hormonal control of spermatogenesis** Role of androgens, androgen binding protein (ABP) in spermatogenesis, FSH regulation, thyroid hormone regulation. ● **Ultrastructure and abnormalities of spermatozoa** Primary, secondary abnormalities and causes.	
IV	**FERTILITY CONTROL AND ASSISTED REPRODUCTION (ART)** ● **Fertility control** Need, principles, practice and efficacy of different male and female temporary and permanent contraceptive methods- hormonal and barrier methods; intrauterine devices and sterilization. ● **Assisted Reproduction** Ovulation induction, Sperm bank, Artificial insemination, different methods of assisted reproduction – In vitro fertilization (IVF), gamete intrafallopian transfer (GIFT), Zygote intrafallopian transfer (ZIFT), intracytoplasmic sperm injection (ICSI), pre-implantation genetic diagnosis (PGD), Surrogacy. Ethical and legal considerations of ART and PGD	**6**

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BLUEPRINT:

Course Code: ZO9225

Course Title: Reproductive Biology

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	6	8
Unit II	6	9
Unit III	18	20
Unit IV	24	24
Unit V	6	9
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN REPRODUCTIVE BIOLOGY

Semester	**III**
Paper code	**ZO 9P225**
Paper Title	**REPRODUCTIVE BIOLOGY**
Number of teaching hours per semester	**44**

Sl. no	Description	Units
1	Observation of permanent slides Comparative histology of ovary and testis in fish and mammal	1
2	Estimation of sperm count in semen samples collected from veterinary / clinical samples	1
3	Analysis of sperm abnormalities in semen samples collected from volunteers / clinical samples	1
4	Study of histology of male accessory reproductive organs (mammalian tissue): epididymis, vas deferens, seminal vesicle and prostate gland	1
5	Study of the oestrous cycle –in rat using vaginal smears	1
6	Staining of vaginal smear by haematoxylin, orange-G and EA-50 stain method	1
7	Estimation of fructose and ascorbic acid/ citric acid in semen samples collected from volunteers / clinical samples	1
8	Observation and count of germ cells (round and elongated spermatids) in stage VII of seminiferous epithelium cycle.	1

9	Study of lipid peroxidation (malonaldehyde concentration); An oxidative stress marker in spermatozoa (semen sample collected from volunteers / clinical samples).	1
10	Study of different contraceptive devices	1

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	**POs**										**BTL**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
1. CO 1: Recall the anatomy and physiology of male and female reproductive systems.	*	*	*								Remember
2. CO 2: Explain hormonal regulation of reproductive cycles, fertilization, pregnancy, and parturition.			*	*	*						Understand
3. CO 3: Apply laboratory techniques to analyze reproductive tissues, hormones, and gamete physiology.					*	*	*				Apply
4. CO 4: Analyze causes and mechanisms of reproductive disorders and infertility.							*	*	*		Analyze
5. CO 5: Evaluate and design reproductive health strategies using assisted reproductive technologies and ethical frameworks								*	*	*	Evaluate/Create

ZO 9325: ECOLOGY, WILDLIFE AND CONSERVATION BIOLOGY

Semester	**III**
Paper code	**ZO 9325**
Paper Title	**ECOLOGY, WILDLIFE AND CONSERVATION BIOLOGY**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**60 (52 hours+8 hours of self-study)**
Number of credits	**4**

Learning Outcomes:

The learner should be able to

- To understand the organisation and function of the ecosystem and animal societies.
- To create awareness about current trends in conservation biology and climate change.
- To appreciate the ecological significance of biodiversity in India.

Unit	Description	Hrs
I	**FUNDAMENTALS OF ECOLOGY** ● **Basic elements of ecosystems**: Biomes and ecosystem diversity. Ecological biogeography: Island Biogeography. Habitat diversity: edge, ecotones, interspersion, and juxtaposition. ● **Ecological energetics:** Energy flow at the population level (case studies) **(Self-study).** Production ecology and ecological efficiency. Concept of Ecosystem Physiology. ● **Population ecology**: Characteristics Population abundance, density, & distribution, r & K selection, Carrying capacity, phenotypic plasticity. Sex ratios & age structure of populations. Demography and life-history parameters: Birth rate, mortality, survival, life-tables, and survivorship curve. Fecundity and population growth rate. Population regulation: density-dependent & density-independent factors. Fundamental and realized niche. Concept of Metapopulation. ● **Community Dynamics**: Types of species interaction- interference, exploitation and invasion, Plant-animal interactions, Global change and plant-animal interactions. Ecological Maturity: Meaning, causes, mechanism, concept of climax, Types with case studies. ● **Nutritional Ecology**: Feeding ecology of herbivores, carnivores, insectivores, detrivores, and omnivores – food selection, quantity, quality (nutritional value), seasonal variations, and relations to food to animal	**14**

	condition. Importance of minerals to animal health, growth, and reproduction **(Self-study).**	
II	**APPLIED ECOLOGY** ● **Biodiversity**: Inventorying, monitoring, and documenting biodiversity-Sources of information, community biodiversity registers. Levels of species diversity and its measurement: Alpha, Beta, and Gamma diversity **(Self-study).** Measurement of biodiversity: Species richness & abundances, Species area relationship. Biodiversity and ecosystem services. ● **Emerging technologies in biodiversity conservation**: Bioclimatic models, GIS, and Remote sensing applications in ecology. Overview of ecological models; basic tools in model building (analyses of case studies). Climate change and biodiversity loss in India (Case studies).	**08**
III	**GLOBAL ISSUES** ● **Environmental Impact Assessment and Energy resources**: Scope and purpose of EIA and other emerging decision support tools. Renewable and non-renewable energy sources; Growing energy needs; Use of alternate energy sources; Energy contents of coal, petroleum, natural gas and biogas; Agro-residues as a biomass energy source. Case studies: Contemporary Indian issues related to mining, dams, forests, energy. ● **Pollution Ecology:** Concept of Global warming, greenhouse effects, ozone layer depletion, acid rain, impact and control measures. Nuclear hazards and human health risks. Bioremediation: Concept, types, advantages and disadvantages. ● **Environmental monitoring**: concept of sustainable development, control and prevention of air, water and noise pollution **(Self-study).** An overview of NEP, IPCC. International agreements and programmes: Earth Summit, UNFCCC, Montreal and Kyoto protocols. Basics of Eco-toxicology.	**10**
IV	**WILDLIFE AND CONSERVATION BIOLOGY** ● **Importance and Protection of Wildlife of India:** Wildlife-scope and importance, India as a mega-biodiversity nation; Biogeographic zones of India **(Self-study).** Biodiversity hotspots; Analysis of threats to wildlife, Endemic and endangered species of India. Protected Areas, Eco-sensitive Zones. IUCN Red list categories. Conservation approaches (in-situ, ex-situ). ● **Human dimensions and Wildlife management**: Wildlife-based Tourism. Impact of livestock grazing and wildlife disease, hunting, MFP, fuelwood extraction and logging on wildlife. Contextual knowledge on HWC and adaptive management; case studies on Tigers, Lions, Leopards and Elephants.	12

	● **Conservation breeding**: Role of scientific institutions and NGOs in Conservation Breeding Programmes. Case studies in India. ● **Wildlife Management & Policy:** Wildlife legislation Wildlife (Protection) Act; Environment (Protection) Act; National Conservation Authorities (National Biodiversity Authority and National Tiger Conservation Authority) **(Self-study).** National and International conventions (RAMSAR, CBD, CITES). Indian case studies on conservation strategy-Project Tiger, Project Elephant, Crocodile breeding project. ● **Conservation Genetics**: Application of genetics for wildlife conservation, cyber forensics, Loss of genetic diversity, resolving taxonomic uncertainties	
V	**CONSERVATION SCIENCE AND SOCIETY** ● **Environmental philosophy and movements in India**: Religions and cultural practices in environmental conservation, An overview of Human ecology, Deep and Shallow Ecology, Ecofeminism. Biodiversity prospecting and indigenous knowledge systems. Chipko movement, Appiko movement, Silent valley, Bishnois of Rajasthan, Narmada Bachao Andolan **(Self-study).** ● **Conservation as a socio-political process:** Carbon foot-print, Resettlement and rehabilitation of developmental projects affected persons and communities with case studies. Environmental justice: National Green Tribunal. Environmental communication and public awareness case studies e.g. CNG vehicles in Delhi, Swachh Bharat Abhiyan, NEAC, National NGC), Eco-clubs, Citizen Science.	10
VI	**WILDLIFE HEALTH, WILDLIFE FORENSICS & ZOO SCIENCE** ● **Zoonotics**: Introduction to disease and epizootiology, Importance of wildlife health studies in population management, Quarantine and Quarantine Act. Zoonotic disease with case studies. ● **Wildlife Forensic**: Overview, Wildlife forensics based on DNA analysis and morphometry. Wildlife crime case studies. Key agencies contributing to wildlife crime enforcement. ● **Zoo Science**: Central Zoo Authority & recognition of Zoos **(Self-study).**	06

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- https://eatrightindia.gov.in/dart/

BLUEPRINT:

Course Code:
Course Title:

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	**14**	**16**
Unit II	**8**	**7**
Unit III	**10**	**11**
Unit IV	**12**	**16**
Unit V	**10**	**11**
Unit VI	**6**	**7**
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

PRACTICALS IN ECOLOGY, WILDLIFE AND CONSERVATION BIOLOGY

Semester	**III**
Paper code	**ZO 9P325**
Paper Title	**ECOLOGY, WILDLIFE AND CONSERVATION BIOLOGY**
Number of teaching hours per semester	**44**

Sl. no	Description	Units
1	Estimation of free carbon dioxide in water samples	1
2	Soil ecology: Estimation of moisture content, alkalinity of soil, and determination of the water-holding capacity of soils	1
3	Community ecology: Assessing pollination of figs by fig wasps Activity: Interspecific competition in Paramecia species affect population growth? (Virtual lab)	1
4	Common quick tests for detection of food adulterants (According to **FSSAI**)	1
5	Applied ecology: ● Analyses of GIS data and images ● Population estimation exercises in the lab using programs like DISTANCE/MARK/PRESENCE.	1
6	Determination of Organic Matter in soil (Walkley - Black method)	1
7	Field ecology: Documenting bird diversity using different sampling methods.	1
8	Analysis of the structure of Community in grassland ecosystem	1
9	Identifying animals based on indirect signs: Pugmark identification & characterization (common large mammals). Scat identification (suitable examples of carnivores and herbivores).	1
10	Campus biodiversity studies: Biodiversity assessments using Shannon index, Simpson index, evenness, Sorensen's Coefficient of Community Similarity worked examples Activity: Exploring the plant-aphid-ant interaction in Campus	1

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Explain ecological principles governing ecosystem dynamics.	*	*	*								(Understand)
2. CO 2: Apply field and laboratory techniques for environmental assessment.			*	*	*						(Apply)
3. CO 3: Analyze ecological data to interpret species interactions and population trends.					*	*	*				(Analyze)
4. CO 4: Evaluate the impact of anthropogenic activities on biodiversity and environment.							*	*	*		(Evaluate)
5. CO 5: Formulate conservation strategies and ecosystem management plans.								*	*	*	(Create)

ZO 9425: RESEARCH DESIGN AND METHODOLOGY

Semester	**III**
Course Code	**ZO 9425**
Course Title	**RESEARCH DESIGN AND METHODOLOGY**
Number of teaching hours per week	**4 Hours**
Number of teaching hours per semester	**60 (52 + 8 hrs self study)**
Number of credits	**4**

Learning Outcomes:

Learners should be able to

- Demonstrate scientific temper and critical thinking regarding the process of scientific inquiry.
- Conduct comprehensive literature searches, critically analyze information, find lacunae in research to date.
- Generate valid research questions and testable hypotheses.
- Design and defend research project proposals.
- Demonstrate project management skills.
- Use commercial statistical software to analyze datasets from multiple sources.

Unit	Description	Hours
I	**Fundamentals of scientific enquiry** ● Scientific thinking: convergent and divergent thinking/inquiry and its importance in research. Theory and empiricism, deductive and inductive theory. ● Importance of literature review, processes involved in systematic literature review. Approaches to identifying and defining problems, generating quality research questions. Difference between questions and formulation of hypotheses.	**8**
II	**Fundamentals of Research Design** ● Types of research: fundamental, applied, exploratory, discovery, descriptive, analytical, etc. Importance of research design. ● Conceptualizing and constructing projects. Qualitative and Quantitative research. Need or potential for merging qualitative and quantitative approaches. Making generalizations, assumptions in research design. Importance of replicates and reproducibility. Troubleshooting problems in research. ● Project management: Examining feasibility, legal matters. Organizing processes, timelines, milestones. Implementation and completion of projects. Overview of funding agencies, grant	**10**

	searches and proposal writing.	

III	**Collection and Analyses of Data** ● Overview of data sources – primary, secondary data sources. Concept of statistical population and characteristics of a good sample: sampling, sample size, sampling error. Practical considerations in sampling and sample size. ● Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages). Bivariate analysis – Cross tabulations and including testing hypothesis of association. ● Biostatistics –testing for Normality of data. ● Parametric vs. non-parametric statistics - Parametric statistics: Types of posthoc parametric tests, analyses of variance types, overview of multivariate statistical tests, overview of regression models. ● Non-parametric statistics: Normalization of non-normally distributed data, non-parametric tests.	**22**
IV	**Computational Approaches** ● Retrieving data from databases – nucleotide and protein databases. ● Computational data analyses pipeline – BLAST, multiple sequence alignment, editing alignments. Estimating intra- and inter-specific parameters in fundamental and applied research. Constructing phylogenetic trees. ● Software for ecology, physiology, clinical analysis, etc. ● Statistical analyses software, types and scope, e.g., SPSS, etc. Protein analyses using RasMol, PyMol, etc.	**8**
V	**Data interpretation, scientific writing, and publication** ● Approaches in avoiding biases in interpreting data and results-qualitative vs. quantitative. Correlation vs. cause-and-effect misinterpretations. ● Objective and scope of research publications. 'Several small' or 'single large' debate, avoiding redundancy and increasing productivity, conflicts of interest. ● Thesis and manuscript preparation – content, layout, formatting. When and where to publish? Weighing manuscript quality and finding appropriate journals. Overview of Journals in Biological Sciences. SCI and Scopus Indexed journals, predatory journals. ● Reference managers: Overview of reference managers, Zotero, Mendeley, Reference Manager, EndNote, etc. Perils of Plagiarism.	**6**

VI	**Ethics and Good Practices in Research** ● Animal ethics and protocols. Use of approved model organisms. Ethics and protocols in human research. Ethical boards – CPCSEA, IAEC, etc. ● Professional and academic ethics, protocols, and standard practices. ● Biases from hypotheses to research results, malpractice in project design, redundancy in research. ● Manipulating data/results/images.	**6**

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BLUEPRINT:

Course Code: ZO 9425

Course Title: RESEARCH DESIGN AND METHODOLOGY

Unit Number	**Number of Hours**	**Total marks for which the questions are to be asked (including bonus questions)**
Unit I	8	9
Unit II	10	12
Unit III	22	25
Unit IV	8	10
Unit V	6	7
Unit VI	6	7
Total	**60**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

ZO 9425: RESEARCH DESIGN AND METHODOLOGY PRACTICALS

Semester	**III**
Course Code	**ZO 9P425**
Course Title	**RESEARCH DESIGN AND METHODOLOGY**
Number of teaching hours per week	**4**
Number of teaching hours per semester	**44**

Sl. No.	Description	Units
1	Project Design	**1**
2	Bioinformatics 1: Nucleotide databases, BLAST	**1**
3	Bioinformatics 2: Protein databases, Primer design by Pick Primers	**1**
4	Literature review and generating research questions 1: Presentation of literature review and tentative project question.	**1**
5	Literature review and generating research questions 2: Presentation of literature review and tentative project question.	**1**
6	Journal Finder, identifying predatory journals and Plagiarism check.	**1**
7	Statistical analyses 1: Parametric tests.	**1**
8	Statistical analyses 1: Non-Parametric tests.	**1**
9	Presentation and critical analyses of projects.	**1**
10	Presentation and critical analyses of projects.	**1**

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Recall principles of scientific enquiry and types of research designs	*	*	*								Remember
2. CO 2: Explain the processes of literature review, hypothesis formulation, and data collection methods.			*	*	*						Understand
3. CO 3: Apply statistical tools and computational methods to analyze biological data.					*	*	*				Apply
4. CO 4: Analyze and interpret research results to identify biases, patterns, and validity issues.							*	*	*		Analyze
5. CO 5: Design and defend a research proposal integrating ethical principles and best research practices.								*	*	*	Evaluate/Create

ZO 9525: ECONOMIC ZOOLOGY

Semester	**III**
Paper code	**ZO 9525**
Paper Title	**ECONOMIC ZOOLOGY**
Number of teaching hours per week	**3**
Number of teaching hours per semester	**45 (39 hours + 6 hours of self- study)**
Number of credits	**3**

Learning outcome:

Learner should be able to

- Gain knowledge about silkworms, honey bees and their products.
- Gain knowledge in Bee keeping equipment and apiary management.
- Acquire knowledge on dairy breeds, diseases and their management.
- Acquire knowledge on the culture techniques of fish and poultry rearing.
- Acquire creative thinking on the use of animal waste/by-products into useful commodity
- Acquire knowledge on the basic procedure and methodology of Vermiculture.
- Get acquainted with entrepreneurial skills and applied sectors.

Unit	Description	Hrs
I	**Introduction:** Components, economic importance of each phyla, recent advancements in the economic enterprises. Sericulture: ● Mulberry and non-mulberry species of silkworm in India ● Mulberry propagation methods, fertilizer schedule and crop protection ● *Bombyx mori* Life cycle, rearing protocol and silk extraction **(self study)** ● Pests and diseases of Silkworm and its management ● Non-conventional use of silk fibre Apiculture: ● Honey bee diversity in India ● Bee keeping – Methods, bee box, equipment for maintenance and honey extraction ● Bee pasturage, bee hotels and off-season management practices **(Self study)** ● Pests and diseases of *Apis cerana* and its management ● Honey quality control, common adulterants and analytical tests Dipteran pollinators and beneficial insects: ● Diversity and host range	**15**

	• Efficiency of dipteran pollinators under protected cultivation • Rearing protocol for syrphid and artificial diet • Insect Predators: Host range and rearing protocol for ladybird beetle • Insect Parasitoids: Host range and rearing protocol for Trichogramma	

II	**Dairy and poultry Management:** Dairy • Introduction to native and exotic dairy animals • Housing system - conventional and advanced systems; advantages and limitations of dairy farming • Fodder crop, commercial cattle feed, oil cake and silage • Milk and milk products, value addition, preservatives and export potential • Cattle diseases and vaccination Poultry • Breeds and rearing methods • Feed formulations • Nutritive value of egg and meat; value-added products **(Self study)** • Disease of poultry, control measures, vaccination and antibiotics	**10**
III	**Aquaculture and vermicomposting**: Aquaculture • Pond culture: Construction, maintenance and management. Composite fish culture and pearl culture. • Ornamental fish culture: Fresh water ornamental fishes- biology, diseases, breeding techniques and feeds. • Aquarium construction: Materials used, aquarium plants, ornamental objects, devices and filters **(self study).** • Maintenance of aquarium: Water quality parameters, control of snail and algal growth. • Seed production: Modern techniques and limitations. Prawn culture • Rearing protocol for commercial prawn culture. • Preparation of farm. Diseases and its management. • Processing, preservation methods and export potential. Vermiculture • Epigeic, endogeic and anecic worms; indigenous and exotic species. • Vermicomposting: Types, raw materials, preparation of bed, feeding, harvesting and storage of vermicompost. **(self study).**	**15**

	• Advantages and limitations of vermicomposting.	
IV	**Entrepreneur skill development (Waste to product)** • Fish amino acid production methods and its applications. • Fish scales as source of bio plastics - patents and protocol. • Paper manufacturing from dung of cow and elephant. • Bio fertiliser manufacturing from bone, feather and blood . • Waste Composting with insect larva and its methods **(self study)** • Edible protein and biodiesel production from insect larva.	**5**

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BLUEPRINT:

Course Code: ZO 9525

Course Title: ECONOMIC ZOOLOGY

Unit Number	Number of Hours	Total marks for which the questions are to be asked (including bonus questions)
Unit I	15	23
Unit II	10	15
Unit III	15	23
Unit IV	5	7
Total	**45**	**70**
Maximum marks for the course (Excluding bonus questions) = 50		

COURSE ARTICULATION MATRIX

Mapping of Course Outcomes (COs) to Programme Outcomes (POs 1 to 10)

[According to Revised Bloom's Taxonomy Level (BTL)]

COs: At the end of the Course, the student will be able to	POs										BTL
	1	2	3	4	5	6	7	8	9	10	
1. CO 1: Describe economically important animal groups and their significance.	*	*	*								(Understand)
2. CO 2: Apply management techniques in sericulture, apiculture, and aquaculture.			*	*	*						(Apply)
3. CO 3: Analyze productivity factors influencing animal-based industries.					*	*	*				(Analyze)
4. CO 4: Evaluate economic and ecological implications of animal resource exploitation.							*	*	*		(Evaluate)
5. CO 5: Design sustainable models for animal-based entrepreneurship.								*	*	*	(Create)