

ST JOSEPH'S UNIVERSITY
BENGALURU-27



SCHOOL OF LIFE SCIENCES
DEPARTMENT OF ZOOLOGY
SYLLABUS FOR POST GRADUATE PROGRAMME
FOR THE BATCH OF 2024-2026

SI No	Paper Titles	Paper codes
FIRST SEMESTER		
HC 1	Systematics, Phylogeny and Biology of Non Chordates	ZO 7124
HC 2	Advanced cell biology and genetics	ZO 7224
HC 3	Developmental and Evolutionary biology	ZO 7324
HC 4	Histology, Histochemistry and Histopathology	ZO 7424
SC 1	Animal Behaviour	ZO 7524
SECOND SEMESTER		
HC 5	Systematics, Phylogeny and Biology of Chordates	ZO 8124
HC 6	Physiology and Biochemistry	ZO 8224
HC 7	Molecular biology and Immunology	ZO 8324
HC 8	Aquatic biology and Fisheries	ZO 8424
SC 2	Entomology	ZO 8524

HC- Hard core, SC- Soft core

FIRST SEMESTER

ZO 7124: SYSTEMATICS, PHYLOGENY AND BIOLOGY OF NON-CHORDATES

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	<p><u>Origin and organization of Invertebrate animals</u></p> <ul style="list-style-type: none"> • Origin: Different hypothesis of metazoan origin – Gastraea hypothesis, Planula hypothesis. • Levels of organization – <u>Germ layers (diploblastic and triploblastic condition) (Self-study)</u>- Development of coelom-Radial and bilateral symmetry - Segmentation and cephalization. Evolutionary advantages of Symmetry, Metamerism and Coelom. 	7
II	<p><u>Introduction to Systematics</u></p> <ul style="list-style-type: none"> • Biological Classification: Principle of taxonomy, Taxonomic hierarchy, <u>Nomenclature – Binomial, Trinomial nomenclature (Self-study)</u>, Zoological collections, identification and description, Concepts of Taxon, holotype, paratype, topotype etc. International code of Zoological Nomenclature. • Taxonomic Keys: dichotomous and polytomous keys. Taxonomic keys presentation, Merits and demerits of keys. AI in taxonomic studies. 	8

III	<p><u>Invertebrate Phylogeny</u></p> <ul style="list-style-type: none"> • 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 – <u>Rotifera, Entoprocta (Self-study)</u>, Phoronida and Ectoprocta. 	10
IV	<p><u>Invertebrate - Comparative functional biology - I</u></p> <ul style="list-style-type: none"> • 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. <u>Respiratory pigments (Self-study)</u>, Mechanism of respiration. <p><u>Invertebrate - Comparative functional biology - II</u></p> <ul style="list-style-type: none"> • 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. <u>Hormones and pheromones (Self-study)</u>. 	15
V	<p><u>Invertebrate development and Life Histories</u></p> <ul style="list-style-type: none"> • <u>Polymorphism in Cnidarians (Self-study)</u>, Coral ecosystems • Patterns of reproduction in invertebrates: Asexual, sexual and parthenogenesis. • Invertebrate larval forms : Trematoda, Cestoda, Crustacea, Mollusca and <u>Echinodermata (Self-study)</u>, and their evolutionary significance 	10

BLUE PRINT FOR PREPARATION OF QUESTION PAPER

Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	7	9
2	8	9
3	10	12
4	25	32
5	10	12
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

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	1
2	Animal-like protists: <i>Balantidium</i> , <i>Noctiluca</i> , <i>Amoeba</i> , <i>Vorticella</i> , <i>Volvox</i> , <i>Euglena</i> , <i>Paramecium</i> w/m and Conjugation, Foraminifera and Radiolaria, <i>Nyctotherus</i> . Pathogenic protist: <i>Trypanosoma</i> , <i>Plasmodium</i> , Monocystis, <i>Entamoeba histolytica</i> . Experiment: Observation of fresh water protozoans	1
3	Porifera: <i>Leucosolenia</i> , <i>Euplectella</i> , <i>Hyalonema</i> , <i>Sycon</i> w/m and L.S, sponge gemmules and spicules. Experiment: Taxonomy of museum sponges (morphological observation, and classification of museum specimens)	1
4	Cnidaria: <i>Hydra</i> , Coral types (<i>Tubipora</i> , <i>Alcyonium</i> , <i>Fungia</i> , <i>Astrea</i> , <i>Meandrina</i>), <i>Physalia</i> , <i>Pennatula</i> , <i>Veleva</i> , <i>Porpita</i> , <i>Aurelia</i> , <i>Obelia</i> , 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 <i>Scolex</i> , Liver fluke, T.S of liver fluke, <i>Ascaris</i> male and female, T.S of <i>Ascaris</i> . Experiment: Taxonomy of parasitic worms (morphological observation, and classification of museum specimens)	1
6	Annelida: <i>Nereis</i> , <i>Aphrodite</i> , <i>Hirudinaria</i> , <i>Arenicola</i> , <i>Sabella</i> , Earthworm, <i>Chaetopterus</i> . Trochophore larva, Parapodium of <i>Neries</i> Experiment: On campus vermiculture practice (RBPT)	1
7	Arthropoda: <i>Peripatus</i> , <i>Lepas</i> , <i>Balanus</i> (Acorn barnacle), Lucifer, Centipede, Millipede, <i>Limulus</i> , tick. Crustacean larval forms: <i>Nauplius</i> , <i>Mysis</i> , <i>Zoea</i> , <i>Metazoea</i> , Lucifer. Mouth parts of Insects - Honey bee, Housefly, Mosquito, Butterfly. Book lung of scorpion. Experiment: Arthropods – Collection and identification of <i>Drosophila</i> / <i>Bactrocera</i> / Mosquito) from different localities.	1

8	Mollusca: <i>Sepia, Patella, Chiton, Loligo, Dentalium, Murex xanchus</i> . Larval forms (<i>Glochidium</i> larva, <i>Velliger</i> larva). Conchology (<i>Unio</i> and <i>Achatinafulica</i>) Experiment: Mating behaviour, mode of reproduction, Fecundity, clutch size studies on edible/ornamental snails.	1
9	Echinodermata: <i>Ophiothrix, Sea urchin, Heart urchin, Starfish, Sea cucumber, Sea lily, Pedicellaria, Sea urchin</i> . Larval forms (<i>Gluteus</i> larva, <i>Echinopluteus</i> larva, <i>Ophiopluteus</i> larva, <i>Bipinnaria</i> larva). Experiment: To make a working model of water vascular system (RBPT)	1
10	Experiment: Phylogeny tree construction using PHYLIP online tool	1

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1. Barnes, R.D. Invertebrates Zoology, III edition. W.B. Saunders Co. Philadelphia.
2. Barrington, E.J.W. Invertebrate structure and function. Thomas Nelson & Sons Ltd., London.
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11. Barrington, E. J. W. 2012. *Invertebrate Structure and Functions*. Affiliated east-west press Pvt. Ltd. New Delhi, 2nd edition.
12. David, M. H, Craig Moritz and K.M. Barbara.1996. *Molecular Systematics*. Sinauer Associates, Inc.
13. Mayer, E.2014. *Principles of Systematic Zoology*. 2nd edition, McGraw Hill Book Company, Inc., NY.
14. Strickberger, M.W. 2013. *Evolution*. Jones and Bartett Publishers, London.
15. Simson G. G. 2012. Principles of animal taxonomy. Scientific publishers, India.
16. Winston, J.E.2000. *Describing species: Practical Taxonomic Procedures for Biologists*. Columbia University Press, Columbia, USA.

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	<p><u>Cell Membranes - Structure and Function</u></p> <ul style="list-style-type: none"> • 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

	<p>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.</p> <ul style="list-style-type: none"> • Structural organization of Cytoskeleton: Actin filaments, Micro tubulins and Intermediate filaments. 	
II	<p><u>Cell cycle, its regulation and Apoptosis</u></p> <ul style="list-style-type: none"> • 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, <u>Extrinsic</u> and <u>Intrinsic</u> pathways of Apoptosis, Role of Bcl2 and Bax gene in apoptosis, inhibition of apoptosis by extracellular factors; <u>Necrosis(Self-study)</u>. 	8
	<p><u>Cell – Cell Interaction and Cell Signaling</u></p> <ul style="list-style-type: none"> • Cell-Cell Interaction: Cell adhesion molecules - Integrins, Selectins, <u>Cadherins</u> (Self-study). Cell communication through Cellular Junctions - Tight junctions, Desmosomes, <u>Hemidesmosomes (Self-study)</u> 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	<p><u>Mendelian and Non Mendelian Genetics</u></p> <ul style="list-style-type: none"> • 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 <i>Lymnaea peregra</i>, b) Organelle heredity – Mutations in <i>Chlamydomonas</i>, Mitochondria-Petite in <i>Saccharomyces</i>, c) Infectious heredity–Kappa in <i>Paramecium</i>, d) <u>Mitochondrial diseases in Man (Self study)</u>. 	4 4

V	<p><u>Human Genetics and Sex determination in animals</u></p> <ul style="list-style-type: none"> • 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 – <u>positive and negative eugenics (Self-study)</u>. • Dosage Compensation, Hyperactivation and inactivation of X-linked genes, Genes involved in sex determination and the hormonal control of Sex determination in mammals, <i>Drosophila</i> and <i>C. elegans</i>. • The Chromosome theory of heredity, Concept of linkage, <u>Experiments of Bateson and Punnet (Self-study)</u>, Construction of linkage maps in <i>Drosophila</i>. • 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 coefficient of coincidence. • Chromosomal aberrations: mutations and their types, rearrangements – Duplications, Deletions, Inversions and translocations. 	<p>3</p> <p>2</p> <p>2</p> <p>6</p>
VI	<p><u>Quantitative Genetics</u></p> <p>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.</p>	4
VII	<p><u>Molecular Genetics</u></p> <p>Fundamentals of Viral and Bacterial Genetics: Genetic Transduction, Transformation and Conjugation (Bacteriophage and <i>Escherichia coli</i>) <u>Genetics and Society (Self-study)</u>.</p>	5

BLUE PRINT FOR PREPARATION OF QUESTION PAPER

Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	12	14
2	8	10
3	10	12
4	8	10
5	13	16
6	4	6
7	5	6
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

Semester	I
Paper code	ZO 7P2
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- <i>Poeciloceris pictus</i> .	1
3	<i>Drosophila</i> 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 <i>Drosophila melanogaster</i> mutants.	1
6	Preparation of polytene chromosome from salivary gland of <i>Drosophila melanogaster</i> .	1
7	Study of tonicity in RBC's.	1
8	Mounting of sex comb and genital plate of <i>Drosophila melanogaster</i> .	1
9	Genetic problems in Recombination and linkage.	1
10	Genetic problems related to Quantitative genetics.	1

REFERENCES

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3. Snustad D P, Simmons M J (2000). Principles of Genetics (III Edn). John Wiley and Sons.
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6. Robert J Brooker (2009). Genetics: Analysis and principles (III Edn). McGraw Hill.
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**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	<p><u>Developmental Biology</u></p> <ul style="list-style-type: none"> • 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	<p><u>Pattern formation</u></p> <ul style="list-style-type: none"> • Axes formation: anterior – gene expression and development, <i>Drosophila</i> posterior polarity, dorso-ventral polarity. (<i>research article discussion, virtual videos</i>). • Introduction to homeotic genes, organization and arrangement, expression and segmentation. Segmentation in <i>Drosophila</i> (Self-study). • Comparative development – comparative analyses of homeobox gene organization, arrangement, and segment formation in <i>Drosophila</i>, <i>Xenopus</i>, and Mouse. (<i>link to evolution mutation and selection</i>). Vertebrate hox code hypotheses. 	8
III	<p><u>Morphogenesis</u></p> <ul style="list-style-type: none"> • 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. (<i>link to evolution, morphological adaptations</i>). • 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. (<i>link with evolution loss and gain of traits</i>). 	10
IV	<p><u>Human Embryonic Development</u></p> <p>Development of Foetal membranes. Foetal development from conception to Parturition (Three trimesters). Human embryo- Prenatal diagnosis-Medical implication of developmental biology (Self-study).</p>	4

V	<p><u>EVOLUTIONARY BIOLOGY</u></p> <ul style="list-style-type: none"> • History of life on earth. History of evolutionary thought. • Darwin and Wallace’s discovery of evolution by natural selection. • Micro and Macroevolution 	4
VI	<p><u>Processes of evolution and tracking evolutionary change</u></p> <ul style="list-style-type: none"> • 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 (<i>summary/discussion of research articles, analyses of data</i>). • 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. • 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 (F_{ST}, G_{ST}) and Nei’s Genetic Distance (D) to estimate population divergence. Random Genetic Drift and applications in conservation biology. • 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. 	8
VII	<p><u>Fundamentals of Molecular evolution</u></p> <ul style="list-style-type: none"> • Fundamentals of molecular evolution. Substitutions and substitution models. Redundancy in genetic code and resulting variation of synonymous and nonsynonymous substitutions and codon bias in genes. The Molecular clock. Neutral and nearly neutral theory of molecular evolution. 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. 	6
VIII	<p><u>Speciation</u></p> <ul style="list-style-type: none"> • Speciation concepts and models – biological, ecological, phylogenetic, species recognition, alternative theories. Occurrence of hybrids and critical analyses of speciation theories. Current status of 	6

	<p>taxonomy – morphological vs. molecular classification of species (Self-study), interactive debate, <i>link to chordates and non-chordates</i>).</p> <ul style="list-style-type: none"> • 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 (<i>research paper reviews drosophila, cichlids, Ragoletis flies, etc</i>). Human evolution. Domestication and artificial selection. • Critical analyses of the speed of speciation – gradual vs. punctuated equilibrium models, current status and evidence. 	
IX	<p>Applications of Evolutionary Biology:</p> <ul style="list-style-type: none"> • Evolutionary medicine, Evolutionary psychology. Evolution of antibiotic resistance, Host-parasite/pathogen arms race, etc. (case studies) 	6

BLUE PRINT FOR PREPARATION OF QUESTION PAPER

Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	8	10
2	8	10
3	10	12
4	4	6
5	4	6
6	8	10
7	6	7
8	6	7
8	6	6
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

Semester	I
Paper code	ZO 7P3
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 <i>Drosophila</i> .	1
3	Observation of segment formation in <i>Drosophila</i> larvae.	1
4	Study of imaginal discs in <i>Drosophila</i> larvae and pre-pupa (brain, leg/wing).	1
5	Identification of first, second, and third instar larvae of <i>D. melanogaster</i> using morphological traits.	1
6	Analyses of sex comb/bristle number variation in cultured and wild <i>Drosophila</i> populations.	1
7	Identification of <i>Drosophila</i> species (<i>melanogaster</i> subgroup).	1
8	Investigation of courtship behavior and female choice in guppies/mollies/ <i>Drosophila</i> .	1
9	Phylogenetic analyses: tree construction, inference.	1
10	Analyses of neutrality and selection in genes.	1

REFERENCES:

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2. Gilbert, S. F and Baressi, M. J. 2016. Developmental Biology. Sinauer Associates Inc. Massachusetts, MA. 11thEdn.
3. Carl Zimmer and Douglass Emlen. 2015. Evolution: making sense of life. 2ndEdn. Roberts Publications.
4. Stearns, S. C. and R. F. Hoekstra 2000. Evolution: An Introduction. Oxford University Press, Oxford.
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6. Freeman, S and J. C. Herron 1998. *Evolutionary Analysis*. Prentice Hall, New Jersey.
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**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	<p><u>Tissue fixation and staining</u></p> <ul style="list-style-type: none"> ● Introduction: Histology – Historical account, Histochemistry and Histopathology. Objectives of histology and its applications. ● Tissue fixation: Objectives and types of tissue fixation: <ul style="list-style-type: none"> ➤ Chemical fixatives: features and groups of chemical fixative ➤ Utility and chemistry of fixation of aldehyde, glutaraldehyde, alcohol, <u>acetic acid (Self-study)</u>, mercury, picric acid and potassium dichromate. ➤ Physical method of fixation - freezing and microwave fixation. ➤ Factors affecting fixation and fixation artefacts. ● Dyes: <ul style="list-style-type: none"> ➤ Differences between stain and dye, chemical properties of dyes. ➤ <u>Acidic dyes and basic dyes (Self-study)</u>. ➤ Natural dyes: Source, chemical properties and utility of colchicine, carmine and haematoxylin. ➤ Synthetic dyes: Chemical properties and utility of eosin, Giemsa, Mallory's trichrome stain. ➤ Dyes used in medical procedure (fluorescein, gadolinium contrast and methylene blue). 	15
II	<p><u>Histology</u></p> <ul style="list-style-type: none"> ● Epithelium: Types and modifications (<u>cilia, stereocilia, (Self-study)</u>, microvilli, flagella, junctional complexes). Cell adhesion molecules ● Functional histo-morphology (human tissue): lung, kidney, spleen, thymus, brain, <u>adipose tissue (Self-study)</u>, testis and ovary. 	15
III	<p><u>Histochemistry</u></p> <ul style="list-style-type: none"> ● Classical histochemistry: Principle, method and application of classical histochemical techniques: <ul style="list-style-type: none"> ➤ Localization of glycoproteins (PAS) ➤ <u>Nucleic acids (Feulgen)(Self-study)</u> ➤ Steroid dehydrogenase activity ● Enzyme histochemistry: Principle and methods ● Immunohistochemistry: Principles, methods (direct, indirect, PAP and ABC) and application of immunohistochemistry. <ul style="list-style-type: none"> ➤ <u>Immunofluorescence technique(Self-study)</u>. ➤ Localization of proteins in endocrine cells in pituitary cell types and islet of Langerhans ➤ Biomarkers for malnutrition and mechanism of autophagy ➤ <i>In situ</i> hybridization of nucleic acids (principle, method and applications) 	15

IV	<p><u>Histopathology</u></p> <ul style="list-style-type: none"> • 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. <u>Types of carcinoma (Self-study).</u> • Histopathology of breast and prostate tumors. • Histopathology of testicular and ovarian cancer. 	15
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BLUE PRINT FOR PREPARATION OF QUESTION PAPER

Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	15	18
2	15	19
3	15	18
4	15	19
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

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

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1. Gretchen, L.H. (1962), Animal tissue techniques. W H Freeman and Company, United states of America.
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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	<p><u>Introduction</u></p> <ul style="list-style-type: none"> • 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 <ul style="list-style-type: none"> ➤ 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	<p><u>Interactions between gene, neuron, hormone and environment</u></p> <ul style="list-style-type: none"> • Phylogeny of behaviour, Evolution of behaviour – cells to society, <u>Individual vs. group selection</u> (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	<p><u>Chronobiology</u></p> <ul style="list-style-type: none"> • <u>Historical account, Chronobiology in India, (Self-study)</u> 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: Chronopharmacology, actigraphy devices and actogram. 	5
IV	<p><u>Foraging</u></p> <ul style="list-style-type: none"> • 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	<p><u>Migration</u></p> <ul style="list-style-type: none"> • Migration (<u>fishes</u>, birds, mammals) (Self-study) • Orientation and navigation. Movement and ranging 	3
VI	<p><u>Animal Communication</u></p> <ul style="list-style-type: none"> • Meaning and components of communication. • Types of signals: Chemical, auditory, visual, tactile. Multimodal communication (Features with examples). 	4
VII	<p><u>Sexual behaviour and parental care</u></p> <ul style="list-style-type: none"> • 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 <i>Drosophila</i>). • Parental care in animals with suitable examples (Self-study) 	7
VIII	<p><u>Socio-biology and Social behaviour</u></p> <ul style="list-style-type: none"> • 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	<p><u>Human behaviour</u></p> <ul style="list-style-type: none"> • 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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BLUE PRINT FOR PREPARATION OF QUESTION PAPER

Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	6	9
2	5	8
3	5	8
4	6	9
5	3	6
6	4	7
7	7	12
8	6	9
8	3	6
Total	45	74
Maximum marks for the paper (excluding bonus questions) = 50		

THEORY EXAMINATION PATTERN

PARTS	NUMBER OF QUESTIONS	TOTAL MARKS
Part A	5 x 1	5
Part B	5 x 2	10
Part C	3 x 5 (4 questions)	15
Part D	2 x 10 (3 questions)	20
Total		50

PRACTICAL EXAMINATION PATTERN – ZO 7P2, ZO 7P3, ZO 7P4

PARTS	COMPONENT	TOTAL MARKS
Part A	Major experiment	10
Part B	Minor experiment	5
Part C	Spotters	5
Part D	<i>Viva-voce</i>	5
Total		25

PRACTICAL EXAMINATION PATTERN - ZO 7P1

PARTS	COMPONENT	TOTAL MARKS
Part A	Minor experiment	5
Part B	Spotters	15
Part C	<i>Viva-voce</i>	5
Total		25

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	<p><u>Origin of Chordates and Protochordates</u></p> <ul style="list-style-type: none"> • Introduction to Chordates: Salient features of Urochordata and Cephalochordata. • <u>Study of larval forms in Protochordates</u>, retrogressive metamorphosis in Urochordata.(Self-study) • Origin of Chordates: Theories on the origin of chordates 	7

II	<p><u>Agnatha and Pisces</u></p> <ul style="list-style-type: none"> • 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: <u>Electric organs, sound producing organs, light producing organs, Poison glands</u>(Self-study) 	10
III	<p><u>Herpatofauna</u></p> <ul style="list-style-type: none"> • Amphibia: General characteristics, classification and phylogeny. Origin of Tetrapoda (Evolution of terrestrial ectotherms); Adaptive radiation Specialized organs: Poison glandseg: 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. <u>Venom types and Venom banks</u> (Self-study) 	10
IV	<p><u>Aves</u></p> <ul style="list-style-type: none"> • Fossil history of birds, General characters, classification and Phylogeny. Palate in birds. • <u>Adaptive radiation in birds</u> (Self-study) • Anatomical and physiological adaptations for flight in birds. 	5
V	<p><u>Mammals</u></p> <ul style="list-style-type: none"> • Evolution of Mammals, Diversity and Phylogeny. • Interesting features of Prototherians, Metatherians and Eutherians • <u>Dentition in Mammals</u> (Self-study) • Gut microbiota as an adaptation in mammals. • Adaptive radiation in mammals. 	6
VI	<p><u>Comparative anatomy</u></p> <ul style="list-style-type: none"> • 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 • <u>Integumentary system in the vertebrates</u> (Self-study) 	12
VII	<p><u>Descriptive anatomy</u></p> <ul style="list-style-type: none"> • 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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Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	7	9
2	10	12
3	10	12
4	5	7
5	6	8
6	12	14
7	10	12
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

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: <i>Balanoglossus</i> , T.S of proboscis, <i>Ascidia</i> , Tadpole larva, Amphioxus w/m, T.S of pharynx, Ammocoetus larva Experiment: Protochordates and vertebrate phylogeny - (Phylogenetic tree construction)	1
2	Pisces: Shark, <i>Trygon</i> , <i>Clarias</i> , <i>Arius</i> , <i>Ostracion</i> , <i>Oreochromis</i> , Channa, <i>Hippocampus</i> , <i>Tetradon</i> , <i>Echeneis</i> . Experiment: Observation of Weberian ossicles, swim bladder and Gill apparatus of commercially available fish.	1
3	Amphibia: <i>Triton</i> , <i>Gegenophis</i> , <i>Amblystoma</i> , <i>Siren</i> , <i>Hyla</i> , <i>Ichthyophis</i> , <i>Dattaphrynus melanostictus</i> Experiment: Morphometrics as a tool for classification (studies on preserved specimen of toad, frog and tadpole)	1
4	Reptilia: <i>Chamaeleon</i> , <i>Phrynosoma</i> , <i>Varanus</i> , King cobra, Krait, Turtle, Crocodile. Extinct reptiles (Dinosaurs) models: <i>Ichthyosaurs</i> , <i>Brontosaurus</i> , <i>Stegosaurus</i> , <i>T. rex</i> , <i>Pteranodon</i> . Key for Identification of venomous and non-venomous snakes. Experiment: Study 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).	1

	Experiment: Online Tools and its application: (OsteoID, Idaho Virtual Museum, BoneID, Avian Osteology, Russell Bone Atlas) (RBPT)	
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) (RBPT)	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
	RBPT: Field exposure visit/ Visit to aquarium / Zoo / Research Institute / to understand Biodiversity	

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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	<u>Cellular Physiology</u> <ul style="list-style-type: none">• Homeostasis: Positive and negative feedback, General patterns of acclimation and <u>acclimatization(Self-study)</u>.• 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	<p><u>Environmental and integrative physiology</u></p> <ul style="list-style-type: none"> • 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, <u>Role of brown fat in temperature regulation (Self-study)</u> • Exercise Physiology: Acute adaptations of exercise - Metabolic, respiratory, musculoskeletal and cardiovascular adaptations and effects of exercise. Resistance exercise and endurance training. 	8
III	<p><u>Integrative Neurophysiology</u></p> <ul style="list-style-type: none"> • Neuronal Physiology: CNS synapses -special characteristics of synaptic transmission, Axonal transmission of nerve impulses, Synaptic integrity, synaptic plasticity, electrochemical gradients – Nernst 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	<p><u>Gastrointestinal physiology</u></p> <ul style="list-style-type: none"> • 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, <u>Secretion of bile by liver (Self-study)</u>, Secretions of small and large intestine. • Digestion and absorption in gastrointestinal tract: Digestion of various foods, Absorption in small intestine. 	8
V	<p><u>Chemical and Physical Foundations of Biochemistry</u></p> <ul style="list-style-type: none"> • 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 	8

	double bonds (hydrogenation reaction); Isomerization reaction; Ligation reaction; Hydrolysis reaction; oxidation-reduction reaction and Phosphorylation .	
VI	<p><u>Metabolism and Bioenergetics</u></p> <ul style="list-style-type: none"> • <i>Carbohydrate metabolism:</i> 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. • <i>Protein Metabolism:</i> biosynthesis of amino acids – transamination, deamination, catabolisms of aromatic and sulphur containing amino acids and urea cycle (Self-study). Diseases associated with amino acid metabolism: Phenylketonuria, Maple-Syrup Urine Disease (MSUD). • <i>Lipid Metabolism:</i> 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. • <i>Nucleotide Metabolism:</i> Biosynthesis and metabolism of purine, and pyrimidines. ▪ <i>Diseases associated with nucleotide metabolism:</i> Von-Gierke’s disease and Gout. 	15
VII	<p><u>Enzymes and Vitamins</u></p> <ul style="list-style-type: none"> • General characteristics of enzymes, definition of coenzyme, holoenzyme, prosthetic groups and classification. • Enzyme Kinetics: Substrate, active site, transition state, activation energy, equilibrium constant K_m, V_{max}, 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 K_m and V_{max}, • Effect of pH, <u>heat</u>, (Self-study) serine 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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Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	6	7
2	8	9
3	8	9
4	8	10
5	8	10
6	15	21
7	7	8
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

Semester	II
Paper code	ZO 8P2
Paper Title	PHYSIOLOGY AND BIOCHEMISTRY
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).	

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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	<p>MOLECULAR BIOLOGY <u>Molecular basis of life</u></p> <ul style="list-style-type: none"> • Introduction to Nucleic acids, experimental proof of DNA as genetic material. <u>Structure, forms (A, B and Z) and characteristics of DNA (Self-study)</u> • RNA structure, characteristics and their functions in different types of RNA (coding, housekeeping and non-coding regulatory RNAs) in prokaryotes and eukaryotes. 	4
II	<p><u>DNA Replication, Damage and Repair</u></p> <ul style="list-style-type: none"> • 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 <u>SOS repair (Self - study)</u> 	8
III	<p><u>Gene transcription and control</u></p> <ul style="list-style-type: none"> • Mechanism of transcription in Prokaryotes and Eukaryotes- <u>Types of RNA polymerases (Self-study)</u>, 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	<p><u>Protein synthesis and ubiquitination</u></p> <ul style="list-style-type: none"> • 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 <u>the role of proteosomes in protein degradation (Self-study)</u>. 	8

V	<p><u>IMMUNOLOGY</u></p> <ul style="list-style-type: none"> • 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, <u>Antigenic determinants (Self-study)</u> 	4
	<p><u>Immunity</u></p> <ul style="list-style-type: none"> • 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	<p><u>Antibodies</u></p> <ul style="list-style-type: none"> • 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
	<p><u>Recognition and response actions</u></p> <ul style="list-style-type: none"> • Cytokines and its types; Cytokine storms and interferons. • lymphokines and <u>chemokines and its responses (Self-study)</u> 	2
	<p><u>Hypersensitivity</u></p> <ul style="list-style-type: none"> • Type I: Allergies and anaphylaxis – IgE, Mast cell degranulation, biologically active agents released in reactions, Clinical manifestations. • Type II: Antibody mediated HS reactions; Mechanism, pathogenicity and cases of type II reactions; Hemolytic-disease of new born (HDN). • Type III: Immune complex mediated HS reactions: Mechanism & pathogenicity 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 pathogenicity, Tuberculin reaction. • Type V: Stimulatory HS reactions. Mechanism and pathogenicity, Grave's disease. Blood groups: AB, Rh system, Lewis-Luthern systems, significance, practical application of immuno methodology in blood transfusions, Erythroblastosis faetalis. 	5

VII	<p><u>Auto immunity, Infectious diseases and human health</u></p> <ul style="list-style-type: none"> • Introduction, Auto recognition, classes of auto immuno diseases. Transplantation: Terminology, Auto graft, Isograft, Allograft, Xenograft. • Immunological basis of transplantation reactions, <u>Immune suppression (Self - study)</u> • 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, <u>Evasion strategies of microbes and parasites (Self-study)</u> 	2 2 3
VIII	<p><u>Immuno engineering</u></p> <ul style="list-style-type: none"> • 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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Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	4	6
2	8	10
3	10	12
4	8	10
5	7	8
6	12	14
7	7	8
8	4	6
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

Semester	II
Paper code	ZO 8P3
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	<i>In vitro</i> 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

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3. Genes and Genomes – By Maxine Singer and Paul Berg
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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	<p><u>The freshwater aquatic environment</u></p> <ul style="list-style-type: none"> • 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	<p><u>Lentic and lotic ecology, management and conservation</u></p> <ul style="list-style-type: none"> • 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
	<p><u>Wetlands and Estuaries.</u></p> <ul style="list-style-type: none"> • 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	<p><u>Marine biology and Oceanography</u></p> <ul style="list-style-type: none"> • 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. (<i>review/summary of research paper, field learning</i>). • Seagrass ecosystems -. Characteristics and global distribution, brief overview of origins and evolution, types of seagrasses, factors influencing seagrass ecosystem dynamics. Overview of seagrass 	16

	<p>community ecology. Ecosystem services. (<i>review/summary of research papers</i>).</p> <ul style="list-style-type: none"> • 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 (<i>review/summary of research papers on reef recruitment, community ecology, threats and management</i>). • Deep sea ecosystem: Characteristics, physico-chemical properties, fauna, special adaptations, recent discoveries (<i>review/summary of research paper</i>). • Mangrove ecosystems: Characteristics and global distribution. Types of mangroves, adaptations, factors influencing ecosystem dynamics, community ecology, ecosystem services. (<i>review/summary of research papers, field learning</i>). • Ocean migrations –factors influencing freshwater/marine animal migration (Self-study). <p>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.</p>	
IV	<p><u>Fisheries: Fish diversity in India</u></p> <ul style="list-style-type: none"> • 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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Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	14	16
2	20	24
3	16	20
4	10	14
Total	60	74
Maximum marks for the paper (excluding bonus questions) = 50		

PRACTICALS

Semester	II
Paper code	ZO 8P4
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, sediment cores, Niskin's water sampler (<i>videos</i>), surface water collection, Secchi's disk for turbidity estimation (<i>demonstration/fieldwork</i>).	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 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 in commercially available fishes	1
	RBPT: Investigation of lake health around Bangalore city. Visit to Govt. Aquarium/fisheries market, field report on aquarium maintenance and local fisheries economics.	

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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 hours + 6 hours Self-study)
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	<p>Introduction and Basic Biology</p> <ul style="list-style-type: none"> • 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. <ul style="list-style-type: none"> ○ Major internal systems: the digestive and excretory system, the circulatory system, reproductive and the gas exchange system. ○ <u>Life cycle- Complete and incomplete metamorphosis (Self-study).</u> ○ Hormonal control of Moulting and development. ○ 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, <u>importance of citizen science (Self-study).</u> 	15

<p style="text-align: center;">II</p>	<p>Insects and Agriculture</p> <ul style="list-style-type: none"> • 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: <u>Mutualism, competition, predation (Self-study)</u>, 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, organophosphates, 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) 	<p style="text-align: center;">10</p>
<p style="text-align: center;">III</p>	<p>Pest management and Biocontrol.</p> <ul style="list-style-type: none"> • <u>Common insects in daily life- (Self-study)</u> 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. 	<p style="text-align: center;">12</p>
<p style="text-align: center;">IV</p>	<p>Medical entomology and parasitic diseases-</p> <ul style="list-style-type: none"> • 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 <u>management of common diseases in livestock (Self-study)</u>. • Emerging infectious diseases. • Forensic entomology. • <u>Impact of insect-borne human diseases on public health (Self-study)</u>. 	<p style="text-align: center;">8</p>

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Unit	Number of hours	Total Marks for which the questions are to be asked (including bonus questions)
1	15	25
2	10	15
3	12	20
4	8	14
Total	45	74
Maximum marks for the paper (excluding bonus questions) = 50		

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THEORY EXAMINATION PATTERN

PARTS	NUMBER OF QUESTIONS	TOTAL MARKS
Part A	5 x 1	5
Part B	5 x 2	10
Part C	3 x 5 (4 questions)	15
Part D	2 x 10 (3 questions)	20
Total		50

PRACTICAL EXAMINATION PATTERN - ZO 8P2, ZO 8P3, ZO 8P4

PARTS	COMPONENT	TOTAL MARKS
Part A	Major experiment	10
Part B	Minor experiment	5
Part C	Spotters	5
Part D	<i>Viva-voce</i>	5
Total		25

PRACTICAL EXAMINATION PATTERN - ZO 8P1

PARTS	COMPONENT	TOTAL MARKS
Part A	Minor experiment	5
Part B	Spotters	15
Part C	<i>Viva-voce</i>	5
Total		25