

Semester Courses of M.Sc. Zoology Based on CBCS

The course of M.Sc. Zoology will be spread in two years previous and final. Each of which will have two semester examinations and therefore will be four semester examinations.

Programme Specific Outcomes of Zoology

1. Developing deeper understanding of key concepts of biology at biochemical, molecular and cellular level, physiology and reproduction at organismal level, and ecological impact on animal behaviour.
2. Developing the concept of animal adaptation by exploring the diversity of functional characteristics of various kinds of organisms which is closely related to evolutionary processes and environmental changes.
3. Understanding of Mendel's principle, its extension and chromosomal basis; chromosomal anomalies and associated diseases; developing concepts of regulation of gene activity in prokaryotes and eukaryotes of transcriptional and post transcriptional level.
4. Development of an understanding of animal science for its application in entomology, apiculture, aquaculture, agriculture and modern medicine.
5. Develop an information about and basic concept of developmental biology elucidation of early embryonic development and organogenesis of invertebrates and vertebrates, explanation of embryonic stem cells and their application.
6. To understand the basic components of computers, software (operating system) and application of software used in biological and statistical studies.
7. Development of theoretical and practical knowledge in handling the animals and using them as model organism.
8. By the theoretical project work is aimed to in calculate ability to develop a research question, organize relevant available literature and development of technical writing skill.
9. To understand the impact of chemicals on biodiversity of microbes, animals and plants; Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals; competition and existence; intraspecific and interspecific interactions.

M.Sc. Previous (Zoology)

(Effective from session 2022-23)

The M.Sc. Previous (Zoology) examination will consist of two semesters, called as first and second semesters. Their examinations will be held in the months of December and May respectively. In each of these semester examinations there will be three compulsory theory papers and two elective papers (out of which first elective will be of theory and second elective will be a practical paper) to be selected from each group of optional papers. So, in total there will be four theory papers and one practical paper. Each paper will be of three hours duration and 5 credit (maximum marks 75), except where stated otherwise. There will be 25% internal evaluation in each paper based on:

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|--------------------------|----------|
| 1. Attendance | 05 Marks |
| 2. Class Test/Assignment | 10 Marks |
| 3. Seminar | 10 Marks |

Format of the Question Paper:

There will be one compulsory question consisting of 4 parts of short answer type question based on the whole course, out of which all parts will have to be answered. Besides this, there will be 8 questions from four units (two from each unit), out of which 4 questions will have to be answered (one from each unit). Thus, in all 5 questions will have to be attempted

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Part-I Semester-1		
1.	Core	Non-Chordates: General account
2.	Core	Biological Tool and Techniques
3.	Core	Comparative Animal Physiology
4.	First Elective (Select any one)	1-Toxicology and Animal Behaviour 2-Biostatistics, Computational Biology and Bioinformatics
5.	Second Elective (Select any one)	1-Practical/Field Visit/ Project Presentation 2-Practical/Field Visit/ Project Presentation
Part-I Semester-2		
1.	Core	Chordates-General account
2.	Core	Systematics and Evolution
3.	Core	Cell Biology
4.	Third Elective (Select any one)	1-Immunology 2-Histology and Histochemistry
5.	Fourth Elective (Select any one)	1-Practical/Industrial Training/Project Presentation 2-Practical/Industrial Training/Project Presentation

PAPER-I NON- CHORDATA:

THEORY

Unit-1: Nutrition and reproduction in protozoa: origin of Metazoans; Structural organization, Canal system and affinities of Porifera; Polymorphism and Colony formation in Cnidaria; Coral reefs.

Unit-2: Parasitic adaptations, General organization of Trematoda and Cestoda, Larva stages of Trematoda and Cestoda and Life cycle patterns in Platyhelminthic parasites; outlines of ecology of soil nematodes; segmental organs in Annelida; Adaptive radiations in Annelida.

Unit-3: Organization and affinities of Onychophora; Larval forms in Crustacea; Parasitism in Crustacea; Torsion in gastropods, its effect and significance.

Unit-4: Larval forms in Echinodermata; Water vascular system in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla with special reference to ctenophore, Rotifera, and Phoronida .

Suggested Literature:

1. A life of invertebrates by W.D. Russel-Hunter, MacMillan Publishing Co. inc., New York.
2. Advances in invertebrates' reproduction by K.G. Adiyodi and R.G. Adiyodi, Peralam-Kenoth Kerivellur, Kerala.

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3. Biology of the invertebrates by Jan Pechenik, William C. Brown Publishers, Dubuque, Iowa.
4. Invertebrates zoology by A. Kaestner, Interscience Publishers.
5. Invertebrates zoology by Alfred Kaestner, H.W. Levi & L.R. Levi, John Wiley & Sons Inc.
6. Invertebrates (Protozoa to Echinodermata) by Ashok verma, Narosa Publishing house, New Delhi.
7. Invertebrates Learning by W.C. Corning and J.A. Dayal.
8. Invertebrates Structure and Function by E.J.W. Barrington, The Camolet Press, Great Britain.
9. Invertebrates Zoology by P.A. Meglitsch & F.R. Schram; Oxford University Press.
10. Invertebrates Zoology by R.D. Barnes, V Edition. Holt Saunders International edition.
11. Principles of Comparative Anatomy of Invertebrates by W.N. Bekiemishev, University of Chicago Press.
12. Principles of Comparative Anatomy of Invertebrates by Dr J.M. Mac Lennon; Z. Kabata, Oliver and Boyd Edinburgh.
13. Textbook of Invertebrate Zoology by G.S. Sandher; H. Bhaskar, Campus book International.
14. The Invertebrates by L.H. Hymen, McGraw-Hill Book Company.
15. The Invertebrates: A New Synthesis by R.S.K Barnes, P. Calow, P.J.W. Olive, D.W. Golding, and Spicer, J.I, III Edition, Blackwell Science.

Course Outcomes-After the course the students will be able to understand the basics of this course. Larval forms in Echinodermata; Affinities of Echinodermata and Hemichordata; Brief outlines of the structure and affinities of minor phyla. Get benefit of this course in various competitive examinations.

Paper-II BIOLOGICAL TOOLS AND TECHNIQUES THEORY

Unit-1: Centrifugation; Principle, types and Applications; Principle and Uses of analytical instruments; Flame photometry and Spectrophotometry.

Unit-2: Separation and identification of biomolecules by Chromatography: Paper and thin layer Chromatography, Gel exclusion Chromatography, High performance Liquid Chromatography (HPLC), Affinity Chromatography.

Unit-3: Electrophoresis techniques: General principles, Support media; Electrophoresis of proteins and nucleic acid; capillary Electrophoresis, Principles of differential and density centrifugation.

Unit-4: Recombinant DNA techniques; Restriction Enzymes, Cloning Vectors, Preparation and Screening of cDNA and Genomic DNA libraries, Southern and Northern Hybridization, PCR; Principles and Applications. Detection of Proteins, DNA-Protein and Protein-Protein interaction; Western Blotting, DNA Foot Printing, EMSA.

Suggested Literature:

1. Essential Laboratory Techniques by S.R. Gallagher, E.A. Wiley.
2. An introduction to Practical Biochemistry by D.T. Plummer.
3. Techniques in Live Sciences by D.B. Tembhare.

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4. Principles and Techniques of Biochemistry and Molecular Biology, 6th Edition by Keith Wilson and John Walker, Cambridge University Press.

5. Light Microscopy in Biology: A practical Approach, 2nd Edition by Alan J. Lacey, Oxford University Press.

6. Electron Microscopy: Principles and Techniques of Biologist by John J. Bozzola, Lonnie D. Russell, Jones & Bartlett Publ.

7. Tools and Techniques of Biotechnology by Mousumi Debnath, Pointer Publishers.

Course outcomes- To get the ideas of the media preparations and sterilization, Inoculation and growth monitoring, use of fermentation, microbial Assays and separation and identification of biomolecules by Chromatography: Paper and thin layer Chromatography, Gel exclusion Chromatography. This course is useful in various competitive exams like CSIR-NET etc.

PAPER III COMPARATIVE ANIMAL PHYSIOLOGY:

THEORY

Unit-1: Physiology of Digestion and Absorption of Proteins, Carbohydrates, Lipids and Nucleic Acids; Secretion and regulation of various digestive fluids. Physiology of Respiration; External and Internal respiration, mechanism and regulation of breathing, gaseous exchange in terrestrial and aquatic animals, Oxygen and Carbon dioxide transport, factors affecting oxygen dissociation and respiratory pigments.

Unit-2: Excretion; Urine formation (Glomerular filtration, Tubular reabsorption and Secretion, Counter current mechanism and Hormonal regulation), acid-base balance and Homeostasis, Circulation; Blood- Composition, Blood Group and Coagulation; Heart- Structure, Origin and Conduction of heart beat and its regulation, cardiac cycle.

Unit-3: Muscles; Types, ultrastructure, chemistry and molecular mechanism of striated muscle contraction and its regulation. Nervous System- Structure of Neuron and Neuroglial cells, mechanism of conduction and transmission of nerve impulse, Synapse and synaptic transmission.

Unit-4: Thermoregulation; Thermoregulation based animal categories, mechanism of thermoregulation and thermal acclimatisation, Physiology of sense organs; Eyes and Ears.

Suggested Literature:

1. Animal Physiology by M.Brown, Apple Academic Press.
2. Animal Physiology by R.C. Sobte, Narosa Publishing House.
3. Animal Physiology by F.R. Haninworth
4. Comparative Animal Physiology by C.L. Prosser, W.B. Saunders Company.
5. Comparative Physiology of Animal by R.W.Hill; P.D. Sturke.
6. Environmental Physiology of Animals by P. Willmer; G. Stone, Blackwell Science Ltd.
7. General and Comparative Physiology by W.S. Hoar, Prentice Hall of India Pvt. Ltd.
8. Marshall's Physiology of Reproduction by G.E. Lamming, Churchill Livingstone.
9. Neural and Integrative Animal Physiology by C.L. Prosser, Wiley India Pvt. Ltd.
10. Principles of Animal Physiology by J.A. Wilson.

Course outcomes- To study the osmotic conformity and role of membranes in ionic regulation: Stenohaline, Euryhaline animals, Hypo and Hyper environment and terrestrial

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life and pattern of excretion in different animals. After the course the students get able to get benefit of this course in various national and international competitive examinations.

FIRST ELECTIVE (1) - TOXICOLOGY AND ANIMAL BEHAVIOUR

Unit-1: Toxicology; Introduction, Basic concepts, Types of Toxicants (Heavy metals, Pesticides and Radioactive), Exposure of toxicants, Dose-Response relationship, Translocation of Toxicants and mechanism of action of Toxicants.

Unit-2: Selective Toxicity; Biotransformation, Bioaccumulation and Biomagnification of Xenobiotics; Antidotal Therapy; Toxicity Tests; Biomonitoring of Toxic Chemicals, Bioindicators.

Unit-3: Animal Behaviour; Introduction and Significance of Behaviour; Proximate and Ultimate causes of behavioural evolution; Patterns of behaviour; Communications and animal signals.

Unit-4: Reproductive behaviour in animals; Sexual selection, mating patterns and parental care; territorial behaviour, Social behaviour with special reference to insects and Primates; Biological rhythms.

Suggested literature

1. Toxicology, Earnest Hodgson.
2. Toxicology and risk assessment principles. Methods and application by Anna M Fan, Louis W Chang, Marcel Dekker, inc, New York.
3. Concept of Toxicology, Dr. Omkar
4. An Introduction to Animal Behaviour by Manning and MS Dawkins Cambridge University Press, UK.
5. Animal Behaviour by John Alcock, Sinaer Association, INC.
6. Animal Behaviour in the Laboratory by P. Silverman, London. Chapman and Hall.
7. Introduction to Animal Behaviour by Rishikesh and Niraj, Campus Books.
8. Text Book of Animal Behaviour by FB Mannl PH learning Pvt.

Course Outcomes- Study is useful to physiochemical and bacteriological sampling and analysis of water quality. An introduction to behavior and mechanisms of behavior, various types of communications. This course also helpful for the study of learning and instincts, conditioning, habituation, sensitization. This course useful in various competitive exams like, UGC-NET, CSIR-NET, Civil service examinations etc.

FIRST ELECTIVE (2)- BIOSTATISTICS, COMPUTATIONAL BIOLOGY AND BIOINFORMATICS

Unit-1: Basic components of computer- hardware (CPU, input, output, storage devices), software (operating systems). Application software:: introduction to M S EXCEL use of worksheet to enter data, edit data, copy data, move data; use of inbuilt statistical functions for computation of mean, S.D., correlation, regression coefficients, etc, use of bar diagrams, histogram, scatter plots etc. graphical tools in excel for presentation of data; introduction to MSWORD word processor- editing, copying, moving, formatting, table insertion, drawing flowcharts, etc; Introduction to PowerPoint, image and data handling.

Unit-2: Sampling technique; methods of sampling, choices of sampling methods, sampling and non-sampling errors: tabulation and graphic representation of data; frequency

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distribution, tabulation, bar diagram, histogram, pie diagram; and their significance and limitations; Measures of Central tendency; Mean, Median, Mode, measures of dispersion: variance and standard variation, coefficient of variation, measures of skewness, coefficient of skewness, kurtosis; probability : theorems on probability, application of permutation and combination.

Unit-3: Measures of dispersion: variance and standard variation, coefficient of variation, measures of skewness, coefficient of skewness, kurtosis; probability: theorems on probability, application of permutation and combination, Test of significance-t, F, Chi-square test; Correlation and Linear Regression.

Unit-4: Bioinformatics; Introduction and scope of Bioinformatics, Archiving and retrieval of information; Search engines, databases (Nucleic acid sequences, genomes, protein sequence and structure, bibliographic), Access to molecular biology databases {Entrez, Sequence retrieval system (SRS), Protein identification resource (PRI)}, Sequence alignment and Phylogenetic tree.

Suggested literature:

1. Biostatistics by P N Arora and P.K Malhan, Himalaya publishing house
2. Principles of Biostatistics by Pagano M. Gauvreau, K (2000), Duxbury press, USA
3. Fundamental of Biostatistics by I A Khan and A Khanam, Ukaaz publication, Hyderabad
4. Barnes & Grey (ed): Bioinformatics for geneticists, Wiley (2003)
5. Lesk: Bioinformatics, Oxford (2003, Indian ed)
6. Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)

Course Outcomes- Introduction to basic components of computers, Software (operating systems) and application software used in biological and statistical studies. An overview of databank search data mining, data management and interpretation. An introduction and learning of Probit Log Analysis for interpretation of toxicity data.

Semester-I Practical

Distribution of Marks:

	Time: 4 hours
Dissection / <i>Anatomical Model / Minor project</i>	20 Marks
Technique/ Instrumentations	05 Marks
Physiology Exercise	05 Marks
Toxicology and Animal behaviour/ Biostatistics,	10 Marks
Computational Biology and Bioinformatics	
Spotting (10 spots)	20 Marks
Viva voce	7 Marks
Class records	8 Marks

Total Marks: 100 (25- internal evaluation + 75- external examination)

General characters and classification of the non- chordates phyla (Protozoa to Echinodermata) with the help of museum specimens and slides.

Protozoa: Vital staining and staining preparation of Paramecium; Permanent preparation of Ceratium, Noctiluca, Vorticella,

Study of prepared slides: Balantidium, Nyctotherus, Opalina. Paramecium conjugation / binary fission, Entamoeba histolytica, Giardia, Trypanosoma, Leishmania, Trichomona.

Porifera: Permanent preparation of gemmules, sponging fibres and different kinds of spicules, Study of museum specimens/models; Lecuosolania, Sycon, Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Chliona, Chalina, Spongilla, Spongia, Hippospongia.

Cnidaria and Ctenophora: Permanent preparation of Hydra; Obelia and other hydrozoan colonies and Obelia Medusa ; Study of museum specimens/ models : Tubularia , Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Velella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Zoanthus, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Cestum .

Helminths: Study of museum specimens/ whole mounts: Convoluta, Dugesia, Bipalium, Fasciola, Paramphistomum, Schistosoma, Taenia, Moniezia, Echinococcus, Trichuris, Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus, Wuchereria; study of prepared slides :Scolex of tape worm ,mature and gravid proglottid of tape worm; Study of cysticercus larva, hydatid cyst, larval stage of Fasciola .

Annelida: Study of museum specimens/models: Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola, Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Metaphire, Placobdella, pontobdella Branchellion, Polygordius,: Study of prepared slides:T.S. of body of leech passing through various places.

Arthropoda: Study of museum specimen: Limulus, Palamnaeus, Lycosa, Apus, Argulus, Balanus, Sacculina, Mysis, Gammarus, Squilla, Prawn, Lobster, true crab, hermit crab, Julus, Scolopendra, Scutigera, Lepisma, Mantis, stick insect, grass hopper, termites, Forficula, Pediculus, Ranatra, Dysdercus, Musca, Lady bird beetle, butterfly, wasp, Xenopsylla, life history of honey bee, lac insect and silk moth; Study of prepared slides: Mouth parts of mosquitoes, house fly, honey bee, butterfly, Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthirus.

Mollusca: Study of museum specimen/models: Chiton, Dentalium, Pila, Aplysia, Baccinum, Doris, Lymnaea, Mytilus, Patella, Pecten, Limax, pearl oyster, Teredo, Nautilus, Loligo, Sepia, Octopus. Study of prepared slide: Radula, T.S of shell of Unio, T.S of gill lamina of Unio, T.S of body of Unio passing through middle region; Larvae of molluscs.

Echinodermata: Study of museums specimen/ models: Astropecten, Asterias, Ophiothrix, Ophiura, Echinus, Clypeaster, Echinocardium, Thyone, Holothuria, Antedon; Study of prepared slides: Larvae of echinoderms: Aristotle's lantern. Hemichordata : Study of museum specimens: Balanoglossus, Cephalodiscus: Tornaria larva, Minor phyla: Representative specimens of Onychophora (Peripatus), Sipunculida (Sipunculus), Echiurida (Bonellia)

Dissection: Nervous system of Pila, Unio, Aplysia, Loligo, Palaemon, Squilla

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Basic principles and functioning of Microtomy, Spectrophotometry, Paper chromatography, Centrifugation.

To identify different amino acids in a mixture using paper chromatography.

Bleeding and clotting time, Preparation of Haemin crystals, Determination of Haemoglobin percentage, Total count of Leucocytes, Differential Leucocyte Count, Blood group determination.

SECOND ELECTIVE (1)- Practical Lab IA: Effect of ammonia and mercury on rat, Study of geotaxis/phototaxis behavioural responses of the animal provided (*Musca domestica*).

SECOND ELECTIVE (2)- Practical Lab IB: Measure the pre and post clitellar lengths of earthworms and calculate mean, median, mode, standard deviation etc. Measure the height and weight of all students in the class and apply statistical measures. To learn the basics of computer applications. To learn sequence analysis using BLAST. To learn Multiple sequence alignment using CLUSTALW. To learn about Phylogenetic analysis using the programme PHYLIP.

SEMESTER - II

PAPER-I CHORDATES: GENERAL ACCOUNT: THEORY

Unit-I: Protochordates and Pisces: General organization and affinities of Hemichordata, Urochordata and Cephalochordata, Characteristic features and affinities of Cyclostomes, General organization of fishes: General organization and affinities of Ostracoderms, Dipnoi and Coelocanth.

Unit-II: Amphibia: Origin of Tetrapods, General organization of Anura, Neoteny and Parental care. Reptilia: Origin and Evolution, Adaptive radiation, Dinosaurs, Crocodilia, Poisonous snakes and their venom.

Unit-III: Aves: Origin and Evolution, Flightless birds, Adaptations for flight, Migration in Birds.

Unit-IV: Mammalia: Origin of Mammals, Adaptive radiation in Eutheria, Uterus modifications, Aquatic mammals.

Suggested literature:

1. Harvey et al: The Vertebrate Life (2006)
2. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002, Wiley - Liss)
3. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
4. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
5. McFarland et al: Vertebrate Life (1979, Macmillan Publishing)
6. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
7. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
8. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)
9. Neilson (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

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Course outcomes:

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of chordate diversity
- explain structural and functional diversity of chordate
- explain evolutionary relationship amongst chordate

**PAPER-II SYSTEMATICS AND EVOLUTION:
THEORY**

Unit-I: Definition and basics concept of biosystematics & Taxonomy; Historical aspects of systematic and its importance and applications in biology; Trends in biosystematics: concepts of different conventional and newer aspects – chemotaxonomy, cytotoxonomy, ethotaxonomy, molecular taxonomy, numerical taxonomy.

Unit-II: Dimensions of speciation and taxonomic characters: type of lineage changes, production of additional lineage, species concepts – species category, different species concepts, subspecies and infraspecific categories, theories of biological classification, hierarchy of categories, taxonomic and non-taxonomic character.

Unit-III: Procedures in taxonomy: collection, preservation and identification, taxonomic keys- different kinds of taxonomic keys their merits and demerits, systematic publications. Different kinds of publications, type concept – different zoological types, international code of zoological nomenclature (ICZN) –its operative principles, interpretation and application of important rules, zoological nomenclature, formation of scientific names of various taxa.

Unit-IV: Darwinian and pre-Darwinian concepts of evolution : Birth of concept of organic evolution; Lamarckian theories , Darwin's theory of natural selection : merits and demerits, Neodarwinian concepts and sources of variation : post – Darwinian concepts of evolution: Gradualistic vs: Non-gradualistic theories, Mayr's Founder Principle , Gould's punctuated equilibrium theory , Kimura's neutral theory , Endo-symbiotic theory of Margulis, contemporary views ; Neo- Lamarckism, Neo – Darwinism, Modern synthetic theory of evolution. Isolation and speciation; Genes in population; Hardy Weinberg Law and Sewell Wright effect, micro evolution, macro evolution and mega evolution, Evolution in action.

Suggested Literature:

1. Biology Systematics by A. Mielli, Chapman and Hall
2. Evolution by Hall and Hallgrímsson , Johnson and Bartlett publisher
3. Evolution by mark ridley. Blackwell science
4. Evolution by barton N.H. briggs, D.E.G., Eisen J.A., Goldstein, A.E. Ptel, N.H., cold spring Harbor Laboratory press New York, U.S.A.
5. Evolution by futuyma, D.J., sinauer associates inc., sunderland , USA
6. Evolution by Hall, B.K. and Hallgrímsson, B. Jones and Bartlett publisher, Sudbury, USA
7. Evolution analysis by Freeman and Herron, Person /prentice hall
8. Methods and principle of systematic Zoology by E.Mayer , E.G.Linsley , R.L. vsinger, McGraw – Hill Book Company , ICN
9. Numerical Taxonomy by joseph felsentein, springer – verlag Berlin Heidelberg New York
10. Procedure in Taxonomy by E.T.Schenk and J.H.Mc.Masters , Stanford University Press Stanford , California

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11. Taxonomy; A text and reference book by r.e.blackwelder , john wiley and sons , INC
12. What evolution is by mayr E. Basic Books, New York, USA

Course outcomes:

The study of the DNA fingerprinting & Molecular markers for detection evaluation of polymorphism, RFLP, RAPD etc and numerical taxonomy, for useful to student for research methodology and further study of research work in different topics. This course is useful in various competitive exams like CSIR-NET etc.

**PAPER-III CELL BIOLOGY:
THEORY**

Unit-I: Structure and function of Membrane & Cytoskeleton: Biomembranes and architecture: lipid bilayer and protein components • Microfilaments: actin structures, myosin powered cell movements • Intermediate filaments: Organization & function • Microtubules: Organization and dynamics, Kinesin and dynein powered movements.

Unit-II: Endomembrane system and intracellular trafficking; Compartmentalization in eukaryote cells • Gated transport between nucleus & cytosol • Structure of nuclear pore complex • Signal sequences & sorting transporters • Role of monomeric GTPases in protein sorting • Protein sorting to ER and mitochondria. • Vesicular trafficking, secretory pathways, receptor mediated endocytosis.

Unit-III: Cellular communication; General principles of cell communication • Extracellular matrix and Cell adhesion, Cell signalling • Signalling molecules and cell-surface receptors (G-protein coupled receptors, Ion-channel linked receptors, Enzyme linked receptors • Second messengers • Regulation of signalling pathways, JAK-STAT pathway, MAP Kinase pathway.

Unit-IV: Cell cycle and Cell division; Cell cycle overview and control • Checkpoints in cell-cycle regulation • Regulation of Mitosis and Meiosis • Cancer and apoptosis.

Suggested literature:

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
2. Alberts et al: Molecular Biology of the Cell: Garland (2002).
3. Cooper: Cell: A Molecular Approach: ASM Press (2000).
4. Karp: Cell and Molecular Biology: Wiley (2002), Pierce B. Genetics. Freeman (2004).
5. Lewin B. Genes VIII. Pearson (2004).
6. Watson et al. Molecular Biology of the Gene. Pearson (2004).

Course outcomes:

The course will lay down the foundation of biochemistry among students where they will develop a deep understanding of structure of biomolecules like proteins, lipids and carbohydrates and how simple molecules together form complex macromolecules. They will be able to understand the thermodynamics of enzyme catalysed reactions and mechanisms of energy production at cellular and molecular levels.

THIRD ELECTIVE (I)- IMMUNOLOGY:

Unit-I: Types of Immunity (Innate, Adaptive, humoral, cell-mediated), Cells of Immune system (B & T lymphocytes, Phagocytes, Granulocytic cells, Mast cells, NK Cells,

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Dendritic cells), Organs of Immune system- (Primary and secondary lymphoid organs- Thymus, Bone marrow, lymph nodes, spleen, MAST), Generation of B & T cell responses.

Unit-II: Immunoglobulins (structure, Types/Classes & functions) Epitopes, Maturation differentiation and activation of BCR and TCR. Monoclonal and polyclonal antibodies. Antibody diversity Organization & Expression of Immunoglobulin genes.

Unit-III: Antigen antibody interactions (Agglutination Reactions, Precipitation Reactions, cross reactivity, Antibody affinity and avidity, immunofluorescence, flow cytometry, western blotting, immunoelectron microscopy, RIA, ELISA and it's types).

Unit-IV: Antigen: types, processing & presentation, Major Histocompatibility complex: classes, structure, expression, immune responsiveness, and disease susceptibility (HLA) Complement system-classical, alternative, lectin pathways, Vaccine.

Suggested literature:

1. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
2. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
3. Immunology by Ian. R. Tizard Saunders college Publishing Chicago, New York.
4. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.

Course outcomes:

The student at the completion of the course will be able to understand:

- the scientific reasoning exhibited in experimental life science.
- an in depth understanding about Immune System & it's elaborate mechanisms.
- state of art information about recent trends in Immune therapy in case of several diseases like cancer, hepatitis etc

THIRD ELECTIVE (2)- HISTOLOGY AND HISTOCHEMISTRY:

Unit-I: Fixation and Fixatives. Types of fixatives. Chemistry of fixation. Choice of Fixatives. Tissue processing. Dehydration. Clearing and Embedding.

Unit-II: Microtomy. Types of microtomes. Sectioning paraffin blocks. Staining of paraffin sections. Principle and methods of staining. Histological stains. Haematoxylin and Eosin.

Unit-III: Principles and methods of histochemical localization and identification of the following: Carbohydrate moieties Glycogen and glycoproteins with oxidizable vicinal diols by Periodic acid Schiff method Glycoproteins with carboxyl groups and/or O-sulphate esters by Alcian blue methods, Protein end groups General proteins by Bromophenol blue method-NH₂ groups by Nihydrin-Schiff method - SS groups by Performic acid -Schiff and performic acid- alcian blue methods

Unit-IV: Principles and methods of histochemical localization and identification of the following: Lipid moieties General lipids by Sudan black B method Neutral lipids by total Sudan III and Sudan IV methods Nucleic acids Methyl green pyronin for DNA and RNA Feulgen reaction for DNA Enzymes: Acid and alkaline phosphatases by Metal precipitation

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and Azo dye methods. Immunocytochemistry: Basic principles. Fluorescence histochemistry: Basic principles.

Suggested literature:

1. Bancroft, J.D. & Stevens, A. Theory and Practice of Histological techniques, ChurchillLivingstone, 2002
2. Casselman, W.G.B. : Histochemical techniques, John Wiley, 1959
3. Pearse, A.G.E.: Histochemistry; Theoretical and Applied (Vol. I, II & III), (4th ed.), ChurchillLivingstones, 1980-1993

Course outcomes:

The student at the completion of the course will be able to understand:

- the basic histological tools and techniques.
- use of various histo-chemicals to perform a variety of experiments.
- the methods to design and perform experiments on their own.

Semester-II Practical

Distribution of Marks:

Time: 4 hours

Dissection <i>Anatomical Model/Minor Project</i>	20 marks
Systematics and Evolution	05 marks
Cell Biology Exercise	05 marks
Immunology/ Histology and Histochemistry	10 marks
Spotting (10 spots)	20 marks
Viva voce	7 marks
Class records	8 Marks

Total Marks: 100 (25- internal evaluation + 75- external examination)

General character and classification of chordate phyla. Urochordata: study of museum specimens/ whole mount: oikopleura, Herdmania, Ascidia, pyrosoma, doliolum, salpa. Cephalochordate: study of museum specimen: Branchiostoma, Cyclostomata; study of museum specimens /models: peltomyzon, Myxine; Ammocoete larva. Pisces: study of museum specimens/ models: sphyra (hammer-headed shark), Trygon, (string-rays), pristis, Raja (skate), Torpedo (electric-rays), chimaera, polypterus, Acipenser, polydon, Amia, Lepidosteus, hilsa, harppodon, notopercus, labeo, catla, cyprinus, cirrhina, ariys, heteropneustes, clarias, wallago, mystus, Anguilla, exocoetis, hippocampus, channa, amphiprion, anabas, synaptura, echeneis, neoceratodus, protopterus, lepidosiren; study of disarticulated bone of carp. Amphibia: Study of museum specimen /models: Ichthyophis, uracotyphlus, cryptobranchius, ambystoma, axolotl, larva, salamandra, amphiuma, triturus, proteus, Necturus, siren, alytes, bufo, hyla, rhacophorus, study of disarticulated bone to frog. Reptilia: Study of museum specimen/models: chelone, kachuga, sphenodon, hemidactylus, calotes, draco, phrynosoma, iguana, heloderma, varanus, ophisaurus, typhlops, python, natrix, ptyas, dendrophis, bungarus, naja, russle's viper, pit viper, hydrophis, cerotalus, crocodilus, alligator, gavialis, ichthyosaurus, dimention, brontosaurus, tyrannosaurus, stegosaurus, study of disarticulated bones of varanus. Aves: Study of museum specimens /

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models :Archaeopterys,Milvus(kite), gyps(vulture). Pavo(peacock), Columba (pigeon), eudynamys (koel), psittacula (parrot), bubo (owl), coracias (nilkanth), dinopium (woodpecker), house sparrow , corvus (crow) ; study of disarticulated bones of fowl .
Mammalians: study of museum specimens / models: echidna, ornithorhynchus , macropus , erinaceus , shrew, pteropus , bat , loris , manis , hystrix, funambulus, rattus, oryctologus or lepus, herpestes, lutra, (otter), civet cat , macacar ,study of disarticulated bones of rabbit , skull of dog .

To study different cell types such as buccal epithelial cells, neurons, striated muscle cells using Methylene blue. To study the different stages of Mitosis in root tip of onion. To study the different stages of Meiosis in grasshopper testis.

FOURTH ELECTIVE (1)- Practical Lab IIA: Immunology lab: Examination of Peripheral blood smears for blood cells, demonstration of Western Blot Analysis and ELISA, Immunofluorescence staining of B and T Cells.

FOURTH ELECTIVE (2)- Practical Lab IIB: Histology and Histochemistry lab: Microtomy and staining: Hematoxylin-eosin – Demonstration, Histopathology: Study of histopathological changes (permanent slides) – gastric ulcers, cirrhosis of liver, breast tumors, cystic follicles of ovary, pancreas in diabetics, cryptorchid testis and leukemia. Histochemistry: Histochemical localization of glycogen in rat/mouse liver by Bauer Feulgen technique.

Part-II Semester-3		
1.	Core	Principles of Endocrinology
2.	Core	Developmental Biology
3.	Core	Principles of Ecology and Wildlife
4.	Fifth Elective (Select any one)	1-Morphology, Physiology and Development of Fishes 2-Insect Taxonomy, Morphology and Physiology
5.	Sixth Elective (Select any one)	1-Practical Lab-IIIA/Field Visit/ Project Presentation 2-Practical Lab-IIIB/Field Visit/ Project Presentation
Part-II Semester-4		
1.	Core	Genetics and Molecular Biology
2.	Core	Biochemistry
3.	Seventh Elective (Select any one)	1-Applied Ichthyology 2-Applied Entomology and Pest management
4.	Research Project/ Dissertation	Major Research Project/ Dissertation

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SEMESTER - III

PAPER-I PRINCIPLES OF ENDOCRINOLOGY:

THEORY

Unit-I: Fundamentals of Endocrinology; Introduction and evolutionary perspective, hypothalamus, structure and function, SON, PVN, POA, Arcuate nucleus. Hypophysiotropic hormones, Pituitary gland, structure and function (adenohypophysis, Neurohypophysis, pars intermedia), Thyroid gland, Biosynthesis and chemistry of thyroid hormones, Mechanism of action, biological actions of thyroid hormones, Pancreas, Insulin, glucagon and other secretions.

Unit-II: Chemical regulation of feeding and digestion, Endocrine regulatory molecules, Chemical classification of hormones, Hormone receptors, Mechanism of hormone action, Neurotransmitters and neuropeptides, Regulatory pathways.

Unit-III: Neuroendocrine integration; Hypothalamo-hypophyseal axis, Feedback mechanisms, Adrenal gland-cellular organization, Catecholamines and General Adaptation Syndrome.

Unit-IV: Endocrine regulation of homeostasis; Hormones and Homeostasis, Electrolytes and water balance (Renin-Angiotensin system), Energy homeostasis, Parathyroid gland, Calcium homeostasis, Endocrine regulation of bone morphogenesis.

Suggested literature:

1. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press
2. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier
3. Comparative Vertebrate Endocrinology: P. J. Bentley, 3rd Edition, Cambridge University Press
4. Neuroendocrinology: Charles B. Nemeroff, CRC, US
5. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press
6. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education
7. Molecular Endocrinology: F. F. Bolander, 3rd Edition, 2004, Elsevier Academic Press
8. Essential Endocrinology: Darville Brook, C.G. & Marshall, Wiley Blackwell
9. Endocrinology at a Glance: Greenstein B, Wiley Blackwell
10. Evidence-Based Endocrinology: V. M. Montori (ed.), Humana Press
11. General and Comparative Endocrinology: John B. Allard, Cumming Duan, Intelliz Press LLC (2016)

Course outcomes:

The course will enable the students: • To develop an understanding of the basic endocrinology • To study the endocrine regulatory molecules mediating physiology and behaviour • To study the neural and endocrine components of physiological function and neuroendocrine regulation • To understand the role of hormones in metabolic regulation and maintaining homeostasis • To understand the integrative working of signalling system

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PAPER-II DEVELOPMENTAL BIOLOGY: THEORY

Unit-I: Basic concepts of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development.

Unit-II: Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals.

Unit-III: Morphogenesis and organogenesis in animals: Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Unit-IV: Programmed cell death, aging and senescence

Suggested literature:

1. Developmental Biology: T. Subramaniam, (Reprint) 2013, Narosa Publishing House Pvt. Ltd., New Delhi
2. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.) 2012, Wiley-Blackwell.
3. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook: Russ Hodge, 2009, Infobase Publishing.
4. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, 1998 Elsevier.
5. Developmental biology: Werner A. Müller, 2012, Springer Science & Business Media.
6. Human Embryology and Developmental Biology E-Book: Bruce M. Carlson, 2018, Elsevier Health Sciences.
7. Developmental Biology: Michael J. F. Barresi, Scott F. Gilbert, 2019, Oxford University Press.

Course outcomes:

The student at the completion of the course will be able to understand: • a variety of interacting processes, which generate an organism's heterogeneous shapes, size, and structural features, • how a cell behaves in response to an autonomous determinant or an external signal, and • the scientific reasoning exhibited in experimental life science.

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PAPER-III PRINCIPLES OF ECOLOGY AND WILDLIFE: THEORY

Unit-I: The Environment: Physical environment; biotic environment; biotic and abiotic interactions. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

Unit-II: Species Interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. Community Ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones. Ecological Succession: Types; mechanisms; changes involved in succession; concept of climax.

Unit-III: Ecosystem Ecology: Ecosystem structure; ecosystem function; energy flow and mineral cycling (C, N, P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, estuarine). Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.

Unit-IV: Applied Ecology: Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; major drivers of biodiversity change; biodiversity management approaches. Conservation Biology: Principles of conservation, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).

Suggested literature:

1. What is biodiversity by James MacLaurin and Kim Sterelny, U. Chicago.Edu.
2. Schuh, R.T., and A.V.Z. Brower. 2009. Biological Systematics: Principles and Applications, 2nd Ed. Cornell University Press. 311+xi pp.
3. Wiley, E. O. and B. S. Lieberman. 2011. Phylogenetics: Theory and Practice of Phylogenetic Systematics, 2nd Ed. Wiley-Blackwell. 406+xvi pp.
4. Williams, D. M. and M. C. Ebach. 2010. Foundations of Systematics and Biodiversity. Springer. 309+xvii pp.
5. Biodiversity and Ecosystem Functioning by E.D. Shulze and H. A. Mooney, Springer Publication.
6. Methods and Practice in biodiversity Conservation by David Hawksworth, Springer publication
7. A Text Book of Biodiversity by K.V. Krishnamurthy, CBS Publication

Course outcomes:

The student at the completion of the course will be able to understand: • basic concepts of biosystematics, evolutionary biology and biodiversity which will enable the students not only to understand the subjects but also to solve the biological problems related to the environment, and • principles of taxonomy for identification, classification and naming the organisms scientifically. • origin and modification of various life forms during various time scales.

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Dr. S. S.

FIFTH ELECTIVE (1): MORPHOLOGY, PHYSIOLOGY & DEVELOPMENT OF FISHES:

Unit-I: Outlines of functional morphology (origin of paired fins, air bladder, webberian ossicles, sound and electric organs, lateral line system).

Unit-II: Physiology of digestion, respiration, excretion, osmoregulation and reproduction (gonads, role of hypothalamo-hypophysial hormones in reproduction).

Unit-III: Trends in the classification of Fishes (Evolutionary and Genealogical) Systematics and bionomics of at least one important fish from following fish orders (with particular reference of Uttar Pradesh): Beloniformes, Clupeiformes, Mastacembeliformes, Lugaliformes, Cypriniformes (Cyprini and Siluri), Ophiocephaliformes, Perciformes

Unit- IV: Breeding Techniques: Bundh breeding: Types of bundhs: a) dry bundhs b) Wet bundhs c) Modern bundhs Artificial fertilization by stripping, Induced breeding by hypophysation: Definition, Hormones responsible for induced breeding, Dissection and removal of pituitary gland, Preservation and storage of pituitary gland, Preparation of gland suspension for injection and dosage, Collection, rearing and selection of brooders, Synthetic hormones used in induced breeding.

Suggested literature:

1. Datta-Munshi & Hughes: Air-breathing fishes of India (1992, Oxford and IBH)
2. Evans: The Physiology of Fishes (2006, CRC Press)
3. Hoar & Randall: Fish Physiology, Series Vol. I - XIV (1979-2006, Academic Press)
4. Jhingran: Fish and Fisheries of India (1985, Hindustan Publishing Corporation)
5. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
6. Lagler *et al.*, ichthyology (2003, John Wiley)
7. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan)
8. Pillar Aquaculture: Principles and Practices: Fishing News Books: (2005, First Indian reprint)
9. Gupta and Gupta: General and applied Ichthyology (Fish and Fisheries) (2006, Chand)
10. Bone and Moore: Fish Biology

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FIFTH ELECTIVE (2): INSECT TAXONOMY, MORPHOLOGY AND PHYSIOLOGY:

Unit-I: Study of the morphology, development, metamorphosis and evolution of insects.

Unit-II: Physiology of digestion, excretion; metamorphosis and diapause including endocrine aspects.

Unit-III: An outline classification of insects; characters and identification of the economically important families. Social insects and Insect hormones.

Unit-IV: The distribution and bionomics of the following order: Thysanura, Orthoptera, Diptera, Isoptera, Mallophaga, Hemiptera, Dictyoptera, Thysanoptera, Lepidoptera, Hymenoptera and Coleoptera.

Suggested literature:

1. Chapman: The Insects: structure and function (4th ed, 1998, ELBS)
2. Imms: A general text book of entomology, 2 vols (1997, Asia Publishing House)
3. McGavin: Essential Entomology (2001, Oxford Univ Press)
4. Srivastava: A text book of applied entomology, Vol I & II (1993, Kalyani Publishers)
5. Wigglesworth: Principles of Insect Physiology (1972, ELBS)
6. Gullan and Cranston: The Insects: An outline of entomology (5th ed, 2014, Wiley Blackwell)

Semester-III Practicals

Distribution of Marks:

Time: 4 hours

Dissection <i>Anatomical Model/Minor Project</i>	20 marks
Principles of Endocrinology	05 marks
Developmental Biology	05 marks
Fishery/ Entomology	10 marks
Spotting (10 spots)	20 marks
Viva voce	7 marks
Class records	8 Marks

Total Marks: 100 (25- internal evaluation + 75- external examination)

ENDOCRINOLOGY PRACTICAL

1. Dissect and display of Endocrine glands in laboratory bred rat*
2. Study of the permanent slides of all the endocrine glands
3. Compensatory ovarian/ adrenal hypertrophy *in vivo* bioassay in laboratory bred rat*
4. Demonstration of Castration/ ovariectomy in laboratory bred rat*

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5. Estimation of plasma level of any hormone using ELISA
6. Designing of primers of any hormone

DEVELOPMENTAL BIOLOGY PRACTICALS

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
3. Study of the developmental stages and life cycle of *Drosophila* from stock culture
4. Study of different sections of placenta (photomicrograph/ slides)
5. Project report on *Drosophila* culture/chick embryo development

PRINCIPLES OF ECOLOGY PRACTICALS

1. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided
2. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community
3. Study of an aquatic ecosystem: Phytoplankton and zooplankton, Measurement of area, temperature, turbidity/penetration of light, determination of pH, and Dissolved Oxygen content (Winkler's method), Chemical Oxygen Demand and free CO₂
4. Report on a visit to National Park/Biodiversity Park/Wild life sanctuary

SIXTH ELECTIVE (1)- Practical lab IIA: FISH AND FISHERIES

1. Morphometric and meristic characters of fishes
2. Study of *Petromyzon*, *Myxine*, *Pristis*, *Chimaera*, *Exocoetus*, *Hippocampus*, *Gambusia*, *Labeo*, *Heteropneustes*, *Anabas*
3. Study of different types of scales (through permanent slides/ photographs).
4. Study of crafts and gears used in Fisheries
5. Water quality criteria for Aquaculture: Assessment of pH, conductivity, Total solids, Total dissolved solids
6. Study of air breathing organs in *Channa*, *Heteropneustes*, *Anabas* and *Clarias*
7. Demonstration of induced breeding in Fishes (video)
8. Demonstration of parental care in fishes (video)
9. Project Report on a visit to any fish farm/ pisciculture unit/Zebrafish rearing Lab.

SIXTH ELECTIVE (2)- Practical lab IIIB: ENTOMOLOGY

1. Study of one specimen from each insect order
2. Study of different kinds of antennae, legs and mouth parts of insects
3. Study of head and sclerites of any one insect
4. Study of insect wings and their venation.

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5. Study of insect spiracles
 6. Methodology of collection, preservation and identification of insects.
 7. Morphological studies of various castes of *Apis*, *Camponotus* and *Odontotermes*
 8. Study of any three insect pests and their damages
 9. Study of any three beneficial insects and their products
- Field study of insects and submission of a project report on the insect diversity.**

SEMESTER-IV

PAPER-I: GENETICS AND MOLECULAR BIOLOGY

Unit-I: Mendelian principles: Dominance, segregation, independent assortment. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests Extensions of Mendelian principles: Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters:

Unit-II: Gene mapping methods: Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders. Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping. Mutation: Types, causes and detection, Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy.

Unit-III: DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination). RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

Unit-IV: Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase, and translational proof-reading, translational inhibitors, Post- translational modification of proteins). D) Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

Suggested literature:

1. Development genetics of higher organisms by George M. Malacinski, Maxmillan
2. Embryology by M.P.Arora , Himalaya publishing house
3. Fundamantal of human genetics by Sanjay Madsal , new central book agency, London
4. Fundaments of genetics by G.S.Migalani , norsa publishing house
5. Genetics by P.K Gupta, Rastogi publication

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6. Genetics by E. Conrad, apple academics press
7. Genetics by Ursula Goodenough, Holt-Saunders international edition
8. Genetics by J. Russell, Benjamin-Cummings publishing company, San Francisco, California.
9. Modern genetics analysis: integrating genes and genome, by Griffiths J.F., Gelbart M., Lewontin, C. and Miller, W.H. Freeman and company, New York, USA
10. Molecular genetics by Guther S. Stent Richard Colendar. CBS publication and distributors
11. Principles of genetics by Snustad and Simmons (4th Ed. 2005), John Wiley & sons, USA
12. Genes by Lewin, (9th Edition 2008), Jones and Bartlett Publishers, Boston, USA
13. Genetics (Analysis of genes and Genomes) by Denial L. Hartl, Jones and Bartlett publishers.
14. Molecular biology of The Cell by Bruce Alberts, Garland Science Taylor and Francis Group
15. Molecular Biology of the Gene by Watson et al. (5th Ed. 2004), Pearson Education, Delhi INDIA

Course outcomes-

By studying, the students get ideas of this course including sex chromosome, sex determination, multiple allelism, Numerical and structure chromosome aberrations and their significance, DNA replication, Transposable elements in prokaryotes and eukaryotes; Role of transposable elements in genetic regulation for help in to the research work. Students get benefit to this course in various competitive examinations. An introduction to structure of nucleic acids, folding motifs, conformational flexibilities, denaturation, renaturation, kinetics of hybridization, super-coiling of DNA, packaging of DNA in the nucleus, structure of chromatin, chromatin territories used for the students for further study. regulation of Pre-mRNA Processing, micro RNA and other non-coding RNAs, degradation of RNA. Description of transport across the nuclear envelope and stability of RNA, processes of nuclear import and export and their regulation, degradation of RNA. This course is useful in various competitive exams like CSIR-NET etc.

PAPER- 2: BIOCHEMISTRY:

Unit-I: Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, nucleic acids and vitamins). Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties).

Unit-II: Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, isozymes

Unit-III: Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds). Conformation of nucleic acids (helix (A, B, Z), t-RNA, micro-RNA).

Unit-IV: Stability of proteins and nucleic acids. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

Suggested Literature:

1. Biochemistry by J.M. Berg J.L. Tymoczko, W.H. Freeman Plagraue Macmillan
2. Biochemistry by Zubey, Styer

Review

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3. Self-physiology and Biochemistry by W.D. McElory, Preptice Hall of INDIA Pvt. LTD
4. Comparative biochemistry by K.A Munday, Pergmon Press Oxford London
5. Essentials of Biochemistry by Srivastva; Lal; N.Singh, Rekha Publications
6. Essentials of Biological chemistry by Fairley Kil gour, Affiliated east -west Press
7. Harper's Biochemistry by R.K. Murray, D.K Granner, A long medical book.
8. Introduction to biochemistry by J. Awapra, Printice Hall of INDIA Pvt. LTD
9. Lehninger Principles of biochemistry D.L. Nelson, M.M.Cox W.H. Freemann Company

Course outcomes-

To study the Kinetics of enzyme of reaction and kinetic of enzyme catalyzed reactions, order of enzyme reaction, rate equations, two substrate reactions; Temperature Coefficient, Activation Energy; Enzyme Inhibition, Competitive and non-competitive inhibitors; Applications of enzyme inhibition techniques in pest control, Allosteric Enzyme. This course is useful in various competitive exams.

SEVENTH ELECTIVE (1): APPLIED ICHTHYOLOGY

Unit-I: Cold water, Estuarine and Marine Fisheries of India, Fish farming in India; Type of fish farming, Fish ponds, Physico-chemical and biological characteristics of Ponds, Manuring and fertilization of fish ponds, Control of weed and Predators.

Unit-II: Fish seed production and management; Induced Breeding; Hatcheries, Spawning, collection, rearing, stocking, and transport of fish.

Unit-III: Methods of Fishing, Fishing Gears & Crafts with particular reference to Uttar Pradesh, Important Exotic fishes; Larvivorous fishes and Public Health; Fish as food and fish by products; Diseases of food fishes.

Unit-IV: Principles and methods of Fish Preservations: Traditional and advanced methods of fish preservation- sun- drying, salt drying, pickling, smoking, chilling, freezing, canning etc, Invasive fish species and their impact on indigenous fishes. Aquarium fishes and their maintenance.

Suggested Literature:

1. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers)
2. Khanna and Singh: Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House)
3. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, John Wiley)
4. Nilsson & Holmgren: Fish Physiology Recent Advances (1986, Croom Helm)
5. Singh: Advances in Fish Research, Vol. I and II (1993 and 1997, Narendra Publishing House)
6. Srivastava: A Textbook of Fishery Science and Indian Fisheries (1985, Kitab Mahal)
7. Pillay: Aquaculture; Principles and Practices: Fishing News Books; (2005, First Indian reprint)

SEVENTH ELECTIVE (2): APPLIED ENTOMOLOGY AND ECOLOGY OF INSECTS

Unit-I: Principles and methods of different types of insect control with special reference to cultural, biological and chemical control. Fundamentals of chemistry, properties, formulation of insecticides; brief description of appliances employed.

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Unit-II: Mode of action of insecticides and physiology of insect resistance to insecticide. Some economically important pests with particular reference to biology and control of the following:

1. Pests of food grain and food products: *Sitophilus oryzae*, *Phizopertha*, *denimida*, *Tragoderma*, *Tribolium castaneum*, *Callosobruchus chinensis*, *Sitotreta cerealella*, *Coreyra cephalonica*.
2. Pests of cotton: *Dysdercus koenigii*, *Pectinophora gossypiella*
3. Pests of sugarcane: *Pyrilla perpusilla*, *Tryphiza nivella*
4. Pests of crops yielding cereal products: *Leptocorisa varicornis*, Locust
5. Pests of oilseed, fruits and vegetables: *Aulacophora forvecollis*, *Bagrada picta*, *Idiocerus atkinsoni*.

Unit-III: Ecological factors governing insect development and metamorphosis. Bee keeping, Lac and Silk industry in India. Plant protection and extension entomology in India.

Unit-IV: Medical Entomology:

1. Pests of Public importance and their control- Mosquito, house fly, bed bug, lice, Fleas
2. Insect borne diseases of man- Typhus, yellow fever, dengue, encephalitis, plague, Leishmaniasis, Sleeping sickness, Malaria, Filaria
3. Insect venom and allergens

Forensic Entomology:

1. Insect succession on corpse
2. Determination of time of Death

Suggested Literature:

1. David and Ramamurthy: Elements of Economic Entomology (6th ed.), Namrutha, 2011
2. Gullan & Cranston: The Insects: An Outline of Entomology (5th ed.) Wiley Blackwell, 2014
3. Imms: A General Text Book of Entomology (2 vols.), Asia Publishing House, 1997
4. Ishaaya and Degheele: Insecticides with novel modes of action: Mechanism and Application Springer-verlag, 1998
5. Ishaaya: Biochemical sites of insecticide action and resistance Springer-Verlag, 2001
6. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002

• **MAJOR RESEARCH PROJECT/ DISSERTATION**

