

M.Sc. ZOOLOGY SYLLABUS
Course Structure Under
Choice Based Credit System (CBCS)
(With effective from -2021-2022)

ZOOLOGY
(Semester System)



P.G. DEPARTMENT OF ZOOLOGY
Maharaja Sriram Chandra Bhanja Deo University
Sriram Chandra Vihar, Takatpur, Baripada-757003

M.Sc. (ZOOLOGY) EXAMINATION
SEMESTER SYSTEM
(Choice Based Credit System)

1. The course is of two years duration comprising of four semesters of theory and laboratory works.
2. There will one open elective paper in semester-II. This paper is offered for other departments of our university and is of four units and five credits.
3. Each student has to carry out project work from Semester-III and submit a dissertation before the commencement of Semester-IV theory examination.
4. The student can opt one elective course comprising of two papers in the 2nd year of PG programme.
5. The theory examination shall be held for 80 marks (3 hours) and one Internal Assessment Examinations (IAE) of 20 marks (1 hour). The questions shall be of unit pattern, having equal marks, with two alternatives from each unit.
6. For IAE, question shall be asked at least from any two units of a paper covered and will be of one hour duration. The durations of the practical examination shall be 6 hours.
7. For passing semester examinations a candidate must secure a minimum of 40% marks in practical and 30% marks in theory papers.
8. A student securing cumulative Grade Point Average (CGPA) 5.5 shall be declared as pass the Post-Graduation Examination.
9. Calculation of percentage of mark from CGPA
 $(\text{CGPA} - 0.75) \times 10 = \text{Percentage of mark}$
Example: $\{7.85 (\text{CGPA}) - 0.75\} \times 10 = 7.10 \times 10 = 71.0 \%$
10. A candidate securing at least 6.75 CGPA (minimum 60% marks in aggregate) shall be declared as First Class. The First Class First student shall receive the University Gold Medal in the concerned regular P.G. Course provided that he/she has cleared all the papers of the semester examinations in one chance.
11. If candidate passes all the four semester examinations, he/she will be declared to have passed the M.Sc. (Semester) examinations in Zoology, provided further that in no case a candidate shall be allowed to appear any Semester Examination after twice the duration of course period.
12. In order to be eligible to appear at the University examination, a student has to secure at least 75% of attendance.

M.Sc. Zoology –Course Structure under CBCS
(From the session: 2021-22)

The entire P.G. Syllabus of Zoology is spread over four semesters consisting of 100 Credits of which 95 Credits are assigned to the **Core Courses** and the remaining 5 Credits are assigned to **Open** to be offered in Semester-II.

Sem	Course code	Course title	Contact hrs/week	Credit	Exam hrs	Marks		Total
						Int	Ext.	
I	ZO-401	Biosystematics and Biodiversity	5	5	3	20	80	100
	ZO-403	Structure and function in Nonchordates	5	5	3	20	80	100
	ZO-405	Physiology and endocrinology	5	5	3	20	80	100
	ZO-407	Cell Biology & Genetics	5	5	3	20	80	100
	ZO-409	Practical pertaining to above papers	6	5	6	-	-	100
	TOTAL			25		80	320	500
II	**ZO-402	Applied Zoology	5	5	3	20	80	100
	ZO-404	Developmental Biology	5	5	3	20	80	100
	ZO-406	Biostatistics, Techniques and Tools in Biology	5	5	3	20	80	100
	ZO-408	Environmental Biology and Toxicology	5	5	3	20	80	100
	ZO-410	Practical pertaining to above papers	6	5	6	-	-	100
	*ZO-OE412	Fundamentals of Cell Biology	5	5	3	20	80	100
	TOTAL			30		80	320	600
III	ZO-501	Natural Resource Management and their Conservation	5	5	3	20	80	100
	ZO-503	Biosystematics and Taxonomy Elective I (A) Cell and Molecular Biology Elective I (B)	5	5	3	20	80	100
	ZO-505	Biochemistry	5	5	3	20	80	100
	ZO-507	Microbiology and Immunology	5	5	3	20	80	100
	ZO-509	Practical pertaining to above papers	6	5	6	-	-	100
	TOTAL			25		80	320	500
IV	ZO-502	Chordata, Comparative Anatomy, Evolution & Animal Behavior	5	5	3	20	80	100
	ZO-504	Biosystematics and Taxonomy Elective II (A) Cell and Molecular Biology Elective II (B)	5	5	3	20	80	100
	ZO-506	Practical pertaining to above papers	6	5	6	-	-	100
	ZO-508	Project work and Viva	6	5	-	-	-	100
	TOTAL			20				400
	GRAND TOTAL			100				2000

Core Elective: The student can opt for any one out of Biosystematics and Taxonomy (**Group –A**)/ Cell and Molecular Biology **Group –B** groups for Elective-I and Elective-II.

***Open Elective:** Students from other departments can opt for it.

****Skill Based Paper**

Program Specific Outcomes M. Sc. Zoology (onwards)

1. To develop aptitude for learning both classical and applied Zoology.
2. The program covers classical topics such as Faunal diversity, Animal physiology and Evolutionary Biology, and applied topics of Biochemistry, Physiology, Developmental Biology, Enzymology, and Molecular Biology.
3. To focus on various applications-based courses such as Animal Tissue culture, Fishery biology, Entomology, Immunology, Human Genetics and Biochemical tools and techniques.
4. To make the student proficient in research work.

Program Specific Outcomes M. Sc. Zoology (onwards)

1. Understanding the diversity of animals and the importance of classifying animals.
2. Developing a deeper understanding on key concepts of biochemistry, cell biology, developmental biology, molecular biology, immunology, physiology and genetics of animals.
3. Identifying the economic importance of animals in day-to-day life and their use for commercial purposes.
4. Comprehending the importance and the intimate association of environment and natural resources with human beings.
5. Deciphering the diversity of microbial life and the defense mechanisms in human body to deal with microbial infections.
6. Gaining knowledge of various tool and techniques used for performing basic experiments in Zoology.

Semester I

PAPER ZO-401: BIOSYSTEMATICS AND BIODIVERSITY

80 Marks

Course Objective: To get a comprehensive knowledge on Animal Classification and Distribution

UNIT-I Definition and basic concepts of biosystematics and taxonomy; Stages and importance of taxonomy; Newer trends in taxonomy (Morphological, Embryological, Ecological, Behavioural, Cytological Biochemical approaches).

UNIT-II Concept of species (Typological, Nominalistic, Biological, Evolutionary, Recognition species concepts) and its criticism; Species and kinds of species, Subspecies; Nomenclature and types: Basic idea about the international Code of Zoological Nomenclature (ICZN).

UNIT-III Zoological classification: Kinds of classification (Phenetic, Natural, Phylogenetic, Evolutionary, Omnispective). Future of classification, Classification of nonchordates and chordates.

UNIT-IV Concept of biodiversity, Biodiversity hot spots, Biogeography: Concept of biogeography, Zoogeographical Realms of the World (Palaeartic, Nearctic, Neotropical, Ethiopian, Oriental, Australian).

Course Outcomes

1. Understanding the need for classifying animals and approaches followed for classification.
2. Interpretation of the concept of species, biodiversity and biogeography.

Recommended Books

1. The Biology of Biodiversity by Kato M., Springer.
2. Molecular Markers, Natural, History and Evolution by Avise. J.C. Chapman & Hall, New York.
3. Biodiversity, By- Wilson, E.D., Academic Press, Washington.
4. Principle of animal taxonomy by Simpson, G.G., Oxford & IBH Publ.Co.
5. Elements of Taxonomy by E. Mayers.
6. The diversity of life (The college edition), E.O. by W.W. Nor them & Co.
7. Threatened Animals of India by Tikadar B.K., ZSI Publication. Calcutta.
8. Theory and practices of Animal Taxonomy, Kapoor by V.C. Oxford & IBH Publ. Co.
9. Biogeography: An Ecological and Evolutionary Approach by C.B. Cox and P.D. Moore. John Wiley and Sons, 8th Edn.

Course Objective: To get an inclusive idea on the body plan and organization of non-Chordates

UNIT-I

Body organization: Origin of body plan; Body cavity: Acoelom, Pseudocoelom, Coelom (schizo- and enterocoelous); Fate of Blastopore: Protostome, Deuterostome; Classification and general characteristic features of Protozoa, Porifera, Coelenterata, Platyhelminthes, Nematelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Hemichordata

UNIT-II

Organs of respiration in nonchordates: Gill, Book lungs, Trachea and mechanism of respiration; Nephridia, Malpighian tubules as organs of excretion, mechanisms of excretion, osmoregulation.

UNIT-III

Primitive nervous system in Coelenterata and Echinodermata; Advanced nervous system in Annelida, Arthropoda and Mollusca; Trends in neural evolution.

UNIT-IV

Minor phyla and their significance. Organization and general characters of Ctenophora, Sipuncula and Rotifera; Strategies and evolutionary significance of larval forms of crustaceans and helminths.

Course Outcomes

1. Understanding the importance of body forms in classifying non-chordates.
2. Comprehending the diversity of organs of respiration, excretion and nervous systems in non-chordates.
3. Knowing the diversity of major and minor phyla of non-chordates.
4. Deciphering the significance of non-chordate larval forms.

Recommended Books

1. Invertebrates Volume- I to VIII by L.H. Hyman, McGraw Hill Co., New york.
2. Invertebrate Structure and Function by E.J.W. Barrington, Thomas Nelson and Sons Ltd. London.
3. Invertebrates by R.D. Barnes, 3rd Edition, W.B. Saunders Co., Philadelphia.
4. Student Text Book of Zoology, Vol- I and vol- II by A Sedgwick, Central Book Depot, Allahabad.
5. Life of Invertebrates, by S.N. Prasad.

Course Objective: To get a complete idea on animal physiology and endocrine hormones and their regulation

UNIT-I

Physiology of digestion and mechanism of absorption of digested materials; Mechanism of breathing and gaseous exchange, Transport of respiratory gases, Bohr's effect, Chloride shift, Root's effect. Haemopoiesis, Blood clotting, Blood volume, blood volume regulation, Haemodynamics, Cardiac cycle and its regulation; Mechanism of urine formation, counter current multiplier mechanism Stress and adaptation.

UNIT-II

Contractile elements and muscle contraction; Neurophysiology; Action potential, synaptic transmission and maintenance of nerve function, Neuroanatomy of the brain, and spinal cord, central and peripheral nervous system; Electric organ; Bioluminescence.

UNIT-III

Structural organization and functional aspects of endocrine glands (Pituitary, Pancreas, Adrenal, Thyroid); Hormones of Gastro-intestinal tract; Neuroendocrine system and neurosecretion; Hormones and behaviour: Effect of hormones on growth and development; Hormones and reproduction (Hormones of menstrual and estrous cycles, pregnancy, parturition and lactation).

UNIT-IV

Biosynthesis and secretion of hormones: Biosynthesis of steroid, amino acid derived and simple peptide hormones; General characters of hormones; Mechanism of hormone action: Nature of hormone action, hormone receptors; Feedback regulation of hormonal secretion; Hormones and homeostasis; Hormonal regulation of carbohydrate, protein and lipid metabolism.

Course Outcomes

1. Understanding the basic mechanism of digestion, respiration, excretion, muscle contraction and nerve conduction.
2. Comprehend the organization of endocrine glands in the body and neuroendocrine system.
3. Interpret the involvement of hormones in body physiology and mechanism of their action.

Recommended books

1. Animal Physiology: Adaptation and Environment by Nielson Schmiemdt, Cambridge.
2. Comparative Physiology: Life in Water and on Land, Eds. P. Dejours, L. Bolis, C.R. Taylor and E.R. Weibel, Liviana Press Padara, Italy.
3. Text Book of Medical Physiology by A.C. Guyton.
4. Human Body by Best and Taylor.
5. Applied Physiology by Samson and Wright.

Course Objective To get a complete idea on advance cell biology and genetics:

UNIT-I

Structure and functions of Plasma membrane: Chemical composition of membrane, structure and function, functions of membrane proteins and lipids; Membrane fluidity: Dynamic nature of the plasma membrane, movement of substances across the cell membrane. Cytoskeleton and intracellular protein traffic: Microtubules and microfilaments-structure and dynamics, Role of kinesin and dynein in intracellular and axonal transport

UNIT-II

Cell signaling: Signal molecules (hydrophobic and hydrophilic), Receptors (cell surface and intracellular), Cell surface receptors (ion linked receptors, G-protein linked receptors and enzyme linked receptors), Types of intercellular signaling (membrane contact, paracrine, endocrine, synaptic and autocrine), Signaling from plasma membrane to nucleus, Second messenger, Receptor Tyrosine kinases, MAP kinase pathway, Convergence, Divergence and crosstalk among signaling pathways, Cell adhesion molecules (selectin, integrin and cadherin).

UNIT-III

Mendel's Laws of Inheritance, Concept of gene: Allele, multiple alleles, pseudo allele, complementation tests, Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters. Inheritance of Mitochondrial genes, maternal inheritance.

UNIT-IV

Pedigree analysis, lod score for linkage testing, karyotypes, Polygenic inheritance, Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

Course Outcomes

1. Understanding the structure and function of cell membrane and cytoskeleton.
2. Understand the various signaling pathways necessary for gene expression.
3. Concepts of Mendelism, gene and maternal inheritance.
4. Concepts of karyotyping and mutations and their genetic implications.
5. Skill development cytology and genetics techniques and Employability Opportunities in Biomedical and Cytogenetics Research Sector

Recommended Books

1. Molecular Cell Biology, by J. Darnell, H. Lodish and D. Baltimore Scientific American Book, Inc., USA.
2. Molecular Biology of the cell, by B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. Gar Land Publishing Inc., New York.
3. Genes VII, by Lewin, B., Oxford University Press, Oxford.
4. Molecular Biology, by Glick and Pasternak.
5. Cell and Molecular Biology, by P.K. Gupta (Latest Edition), Rastogi Publication.
6. Biotechnology Fundamentals and Applications, by S.S. Purohit (Latest Edition).
7. Introduction to Practical Molecular Biology, by P.D. Dabre, John Wiley and Sons Inc-NY.
8. Molecular Cloning: A Laboratory Manual, by J. Sambrook, E.F. Fritsch and T. Maniatis.
9. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Ed. R.A. Meyers, VCH Publishers, Inc. New York.

10. Principles of Gene Manipulation: An introduction to Genetic Engineering, by R.W. Old and S.B. Primrose

Course Objective: To get hands on training on different animal physiological experiments. To solve the problems related to genetics and to enable the students to classify animals watching their characters.:

Course Content

- 1) Taxonomic study of museum specimens on nonchordates.
- 2) Histological slides on endocrine glands.
- 3) Total count of RBC and WBC in human blood.
- 4) Differential count of WBC in human blood.
- 5) Estimation of haemoglobin in human blood.
- 6) Blood group determination: Demonstration of antigen-antibody interaction by suitable method.
- 7) Localization of mitochondria in animal cell using vital stain.
- 8) Demonstration of Barr bodies in human buccal mucosa cell.
- 9) Temporary aceto-carmin squash preparation of chromosomes.
- 10) Permanent slides on different phases of cell division
- 11) Verification of Mendel's law using suitable models.
- 12) Preparation of Karyotype
- 13) Problems related to genetics

Course Outcomes

1. Gaining practical knowledge of identifying non-chordates.
2. Comprehending the basic structure of endocrine glands through slides.
3. Attaining practical knowledge of blood physiology, karyotyping, Mendelian principles, mitosis and meiosis.

Recommended Books

1. Laboratory manual developed by the department
2. Molecular Cloning: A Laboratory Manual, by J. Sambrook, E.F. Fritsch and T. Maniatis.
3. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Ed. R.A.Meyers, VCH Publishers, Inc. New York.
4. Advance Practical Zoology, J. Sinha, A. K. Chaterjee , P. Chattopadhyay
5. Practical Physiology Geetha N.

Semester II

PAPER ZO-402: APPLIED ZOOLOGY

80 marks

Course Objective: Enable the student to develop ideas on different skills to earn sustainable livelihood and to become entrepreneur

Unit I

Lac Culture: Lac insect and its life history, Host plant management, Strains of lac insects; Propagation of lac insects; Lac crop management; Economic importance of lac. Apiculture: Classification and biology of honeybees; Social organization of bee colony; Artificial bee keeping (Apiary), Methods of extraction of Honey (Indigenous and Modern).

UNIT-II

Sericulture: Types of silk and silk moth: Mulberry silk and non-mulberry silk; Their host plants; Pruning and thinning; Life history of silkworms; Moulting; Voltinism; Rearing of silkworm: Grainage management- Seed (egg) production (Disease Free Egg Laying-DFL), Hatching and rearing of larva, Mounting methods of mulberry silkworm; Harvesting of cocoon; Artificial diet of silkworm; Post-cocoon processing; Pest, predators and diseases of silkworm and diseases of host plant.

UNIT-III

Pisciculture: Site selection and construction of ponds: Pre-stocking and post-stocking management of nursery, rearing and stocking ponds; Breeding of fishes; New generation drugs in induced breeding; Brief study of freshwater aquaculture system: Polyculture, Cage culture, Sewage fed fish culture, Integrated fish farming; Fish products and byproducts; Fish preservation.

UNIT-IV

Prawn, Pearl and Vermiculture: Seed production of commercially important prawns and shrimps; Seed resources: Site selection and techniques of collection; Identification and segregation of seed. Extensive, semi-intensive and intensive shrimp farming practices; important species of pearl oysters and method of artificial pearl production; Earthworm farming (Vermiculture): Extraction (harvest), Vermicomposting harvest and processing.

Course Outcomes

1. Understand the importance of commercially important animals like lac insect, silk moth, honey bees, fishes, prawn, pearl and earthworms in human life.
2. Gain knowledge on various methods to rear animals for commercial purposes like lac, honey, silk production, food and compost preparation
3. Entrepreneurship & employability in Applied Zoology like Apiculture, Aquaculture, Agribusiness (pollination), prawn culture etc.

Recommended Books

1. FAO Manual
2. Economic Zoology by Shukla and Upadhyaya
3. Sericulture by Ganga & Chetty
4. Tasar silkworm of Simlipal. By D.G.Dey, N.Mohanty, B.C.Guru & B.K.Nayak.

Course Objective: To get an inclusive idea on the reproduction biology of animals.

UNIT- I

Developmental Biology: Four principles of Karl Ernst Von Baer; Gametogenesis(Spermatogenesis and Oogenesis); Ultrastructure of sperm and ovum. Cleavage and Blastulation (Chemical changes, Rate, Planes, Patterns, Principles and Products).

UNIT-II

Fertilization (Types, mechanism and significance); Fate map (Amphibia and Chick embryo); Gastrulation (Chick and Amphibia) ; Axes and pattern formation in *Drosophila* and Amphibia.

UNIT- III

Parthenogenesis: Artificial and Natural; Haploid & diploid; Significance; Metamorphosis: Types , Metamorphosis in Chordates, Hormonal control of amphibian metamorphosis; Insect metamorphosis and its hormonal control. Embryonic induction in vertebrate.

UNIT-IV

Extra-embryonic membranes in chick and rabbit; Placenta and Placentation in mammals (Types and physiology);Teratogenesis (Genetic teratogenesis and environmental teratogenesis); Regeneration in Vertebrates and Invertebrates, mechanism of regeneration in coelenterates and amphibia.

Course Outcomes

1. Understanding the key concepts in the development of animals.
2. Comprehending the development of *Drosophila*, Amphibia and parthenogenetic animals.
3. Interpretation of regeneration in vertebrates and invertebrates and teratogenesis in animals.

Recommended Books

1. Reproduction in Animals, by C.R. Auster and A.V. Short.
2. Fertilization, by F.T. Longo, Chapman and Hall.
3. Development Biology, by S.F. Gilbert, Sinauer Associates Inc., Massachussets.
4. Development Biology, by N.J. Berril, Tata McGraw Hill.
5. An Introduction to Embryology, by B. I. Ballinsky.
6. Chordate Embryology, by V. K. Agrawal, S. Chand & Company.

PAPER ZO-406: BIOSTATISTICS, TECHNIQUES AND TOOLS IN BIOLOGY 80 Marks

Course Objective: To get a thorough knowledge on working principles and applications of different tools, techniques and instruments used in biological sciences. The course also focusses to understand biostatistics and tools of RS and GIS in biology.

UNIT-I

Resolution, visibility and principle: Light microscopy, Phase contrast microscopy, fluorescent microscopy, Electron microscopy; Histology and Immunocytochemistry; Detection of molecule in living cells.

UNIT-II

Principle and function: Spectrophotometer; Fluorescent spectroscopy; Chromatography (paper, thin layer, column, gel exclusion, gas, high pressure liquid); Centrifugation; Electrophoresis: Principle and procedure for PAGE and Agarose

UNIT-III

Definition and scope of biostatistics; Concept of population and sample; Census vs Sampling techniques; Frequency distribution; Measures of central tendency (Mean, Median, Mode); Measures of dispersion: Range, Mean Deviation, Standard Deviation, Variance and Coefficient of variation; Skewness and Kurtosis. Correlation (Definition, Types, Methods of studying scatter diagram and Karl Pearson's Coefficient); Regression (Definition, concept of linear and non-linear regression, Derivations of regression lines); Elementary idea about probability;. Theoretical distribution: Binomial, Poisson and Normal; Sampling distribution and Standard error; Test of Hypothesis: Chi-square, t-, F- tests and analysis of variance. Shannon-Weiner Index, Dominance Index, Similarity and dissimilarity indices, Association index

UNIT-IV

RS and GIS: Fundamental principle of remote sensing (RS) and geographical information system (GIS); Stages in RS process; Satellite and Sensors: Platforms, Satellites (LANDSAT, SPOT, IRS, INSAT); Concept of GIS, GPS; Application of RS & GIS.

Course Outcomes

1. Understand the tools and techniques necessary to carry out various biological experiments.
2. Understand and use statistics in biology.

Recommended Books

1. Introduction to Instrumental Analysis by Robert Brown, McGraw Hill International Editions.
2. A Biologists Guide to Principles and Techniques of Practical Biochemistry, Eds. K. Wilson and K.H. Goulding, ELBS.
3. Biochemical Adaptation by P.W. Hochachka, and G.N. Somero, Somero, Princeton, New Jersey.
4. Practical Biochemistry by L. Pummer, Tata McGraw Hill.
5. Practical Biochemistry by K. Wilson and J. Walker.
6. Basic Biostatistics, by Chainy, Mishra and Mohnaty, Kalyani Publishers, Ludhiana.
7. Introduction to Mathematics for Life Scientists by Batschelet, E., Springer- Verlag. Berlin.
8. Statistical Methods, by Snedecor, G.W. and W.G. Cochran. Affiliated East-West Press, New Delhi (Indian edn.).
9. Sampling Design and Statistical Methods for Environmental Biologists by Green, R.H John Wiley & Sons, New York.
10. Mathematical Biology by Murray, J.D. 1, Springer-Verlag, Berlin.

Course Objective: To get a clear idea on ecosystem, environmental biology and toxicological studies related to animals

UNIT-I

Ecosystem: Structural and functional components of ecosystem, Ecological energetics and energy flow models in ecosystem; Biogeochemical cycles (CNP); Productivity of ecosystems: Aquatic and terrestrial (GPP, NPP), Methods of measuring productivity; Biotic and abiotic interactions.

UNIT-II

Population Ecology: Population growth curves, Population regulation, Life history strategies (r-and k-selection), Concept of meta population, Demes and dispersal, Age structure of populations; Concept of habitat and niche: Niche width and overlap, Fundamental and realized niche, Resource partitioning; Character displacement.

UNIT-III

Types of species interactions, Interspecific competition, Herbivory, Carnivory, Pollination, Symbiosis; Nature of communities: Community structure and attributes; Levels of species diversity and its measurement; Edges and ecotones; Types of ecological succession: mechanisms; Changes involved in succession; Concept of climax.

UNIT-IV

Environmental pollution monitoring and management: Biological indicators of pollution, Monitoring of aquatic pollution, Global warming and its impact, Bioremediation. Tolerance limits (LD₅₀, LC₅₀), Dose response, Xenobiotics metabolism and biotransformation of toxicants.

Course Outcomes

1. Deciphering the inter-relation between animals and environment.
2. Understanding the factors affecting the balance between organisms and environment.
3. Skill development in Toxicological Studies and employment generation in Industries, academics and research institutes

Recommended Books

1. Ecology by C.J. Krebs, Harper and Row, New York.
2. Fundamentals of Ecology by Odum, Saunders Publications.
3. Fundamentals of Ecology by M.C. Dash
4. Environmental and Metabolic Animal Physiology by C.L. Prasser, Wiley Liss Inc., New York.
5. Environmental Biology by Torque & Torque
6. The Handbook of Environmental Chemistry Vol-I,II,III, Ed. Hutzinger.
7. Environmental Chemistry by A.K. Dey, Wiley Estorn
8. Pesticides in Indian Environment by Gupta, Interprint

9. Air Pollution by Speding, Clarendon, Oxford
10. Water Pollution by Speding, Clarendon, Oxford
11. Ecology & Pollution of Indian River by Trivedy, Ashish

Course Objective: To impart a minimum required knowledge on the basic unit of life: The Cell to Non-Zoology Students

UNIT-I

Cell organization, structure of organelles, extra cellular matrix, membrane structure and its function, cytoskeleton, cellular motility, cell wall and cell junctions

UNIT-II

Cellular Organelles and membrane trafficking; Mitochondria, Golgi Complex, Endoplasmic Reticulum, Ribosome,

UNIT-III

Chloroplast, flagella, lysosomes, peroxisomes, stem cells

UNIT-IV

Nucleus, Chromatin and Chromosome architecture, Cell cycle, Cell senescence, apoptosis

Course Outcomes

1. To provide knowledge on cell structure and its function.
2. Understanding the structure and function of different organelles and functions.
3. To understand cell dynamics
4. Life skill development

Recommended Books

1. Molecular Cell Biology, by J. Darnell, H. Lodish and D. Baltimore Scientific American Book, Inc., USA.
2. Molecular Biology of the cell, by B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson. Gar Land Publishing Inc., New York.
3. Cell and Molecular Biology, by P.K. Gupta (Latest Edition), Rastogi Publication.

Course Objective: To get a thorough knowledge to solve statistical problems related to animal, toxicological, environmental sciences and to get an idea on the study of different biomolecules with the use of different tools, techniques and instruments.

Experiments

- 1) Calculation of mean, median, mode and variance of given data.
- 2) Test of significance using Student's t-test.
- 3) Study of different larval stages of frog/toad.
- 4) Histological slides related to frog/toad and chick embryology.
- 5) Window preparation of chick embryo at 48/72 hours of incubation.
- 6) Validation of Beer-Lambert's law by UV-visible spectroscopy.
- 7) Absorption maxima of bromophenol blue solution.
- 8) Separation of amino acids by paper chromatography.
- 9) Determination of dissolved oxygen content of water samples.
- 10) Estimation of pH of different water/soil by pH meter.
- 11) Analysis of zooplankton from different water samples.
- 12) Calculation of Biodiversity Indices (Shannon-Weiner, Dominance, Association and Similarity-dissimilarity indices).
- 13) Preparation of bed for vermiculture.
- 14) Study of economically important animals (Silkworm/ Honeybee/ Fish/ Prawn)
- 15) Seminar Presentation.

Course Outcomes

1. Gaining practical knowledge on various commercially useful animals.
2. Understanding frog and chick development through slides.
3. Training to use various instruments used for biological experiments.
4. Performing experiments to evaluate various ecological parameters.

Recommended Books

1. Laboratory manual developed by the department
2. Advance Practical Zoology, J. Sinha, A. K. Chatterjee, P. Chattopadhyay
3. Biostatistics by G.B. N. Cahiney
4. Biostatistics by Mishra and Mishra

Semester III

PAPER ZO-501: NATURAL RESOURCE MANAGEMENT AND THEIR CONSERVATION **80 marks**

Course Objective: To learn the importance of natural resources, their management and conservation

UNIT-I

Conservation, Preservation, Protection, Extinction of species, Extinct threshold, causes of extinction and Depletion, Categories of wild animals (Endangered, vulnerable, rare, threatened, extinct).

UNIT-II

Forest and wildlife management: Importance of forests and wildlife; Deforestation (causes and consequences) and Conservation of Forests; Wildlife management: Wildlife values, Aim, Problems and Basic requirements of wildlife conservation and management.

UNIT-III

Project tiger, Project lion, Project elephant, Crocodile breeding project, CITES, GTF, WWF, IUCN, IBWL, CBSG, SSC.

UNIT-IV

Natural resources and their conservation: Non-renewable and renewable resources; Conservation of minerals: Terrestrial and marine mineral resources, Conservation of terrestrial mineral resources, Ecological aspects of mining; non-conventional renewable source of energy: Solar energy, Wind energy, Ocean (Tidal) energy, Geothermal energy; Water resources and management; Wetland conservation.

Course Outcomes

1. Comprehend the importance of natural resources.
2. Understand the need for conservation and gain knowledge about various organizations involved in conservation.
3. Skill development in Natural resource management studies and employment generation in Industries, academics and research institutes

Recommended Books

1. Forests and Forestry by K. P. Sagreiya, National Book Trust.
2. Textbook of Wildlife Management by S.K.Singh. International Book Depot.
3. Fundamentals of Ecology by Odum, Saunders Publications.
4. Fundamentals of Ecology by M.C. Dash
5. Environmental and Metabolic Animal Physiology by C.L. Prasser, Wiley Liss Inc., New York.
6. The Handbook of Environmental Chemistry, Vol-I,II,III, Ed. Hutzinger.
7. Environmental Chemistry by A.K. Dey, Wiley Estorn.
8. Water Pollution by Speding, Clarendon, Oxford.
9. A Textbook of Microbiology, R.C. Dubey, D.K. Maheswari, S. Chand.
10. Fish and fisheries by Jhingran

Course Objective: To gain knowledge on animal classification and the various ways to classify and offer proper strata to animals

UNIT-I

Taxonomic evidence and evolutionary interpretation: Definition and evidence, Kinds of evidence, Similarity, Homology and Homoplasy.

UNIT-II

Taxonomy to classification: Principles, objectives and arbitrariness, Monophyly and polyphyly, Grades and clades, Vertical and horizontal relationships, Divergence and diversity splitting and lumping, Relative antiquity, Ranks of characters.

UNIT-III

Taxonomic collection: Species registry, Collection methods, Preservation of collected material (curating preparation, relaxing, mounting, storage, cataloguing, maintaining quality of collection).

UNIT-IV

Identification methods: Literature, Keys, Pictures, Direct comparison, Combination of different methods in identification, Taxonomic publication, Preparation of taxonomic papers (description of keys, classification, synonymies, bibliography, nomenclature, illustrations). Reference works in taxonomy: Zoological record, Abstracts (biological, dissertation, entomology, helminthology, protozoology), Taxonomy on web.

Course Outcomes

1. To gain knowledge of Animal Taxonomy
2. To know the art of animal cataloguing.
3. Skill development in Classifying Animals, museum establishment and maintenance and employment opportunities in wild life institutes, research institutes and academics

Recommended Books

1. Biological Systematics- The State of Art by A. Minelli, Chapman and Hall, London.
2. Principles of Animal Taxonomy by G.G. Simpson, Columbia University Press, New York.
3. Principles of Systematic Zoology by E. Mayr and P.D. Ashlock, Mac Graw-Hill, Inc, New Delhi.
4. The Language of Taxonomy- An Application of Symbloic Logic to the Study of Classificatory System by J.R. Gregg, Columbia University Press, New York.
5. Milestones in Systematics by D.M. Willams and P.L. Foley, CRC Press LLC, Boca Raton, Florida, USA.
6. Transformed Cladistics, Taxonomy and Evolution by N.R. Scott-Ram, Cambridge University Press, Cambridge.
7. Foundations of Systematics and Biogeography by D.M. Willams and M.C. Ebach, Springer

Science + Business Media, LLC, New York.

8. Animal Taxonomy by H.E. Goto, HodderAmold H & S.

9. Principles and Practices of Animal Taxonomy by V.C. Kapoor , Science Pyublishers, New Delhi.

10. An Introduction to Taxonomy by T.C. Narendran, Zoological Survey of India, Kolkata.

PAPER ZO-503 (B): CELL AND MOLECULAR BIOLOGY

80 Marks

Course Objective: To get a clear idea on cell and molecular aspects of different biomolecules

UNIT-I

Cell differentiation: Characters, Types, Chemical basis of differentiation, Molecular biology of differentiation, Totipotency of nucleus, Role of egg cytoplasm in differentiation, Levels of differentiation.

UNIT-II

Cell cycle and genomic organization: Cyclins and cyclin dependent kinases, Regulation of CDK-cyclin activity, DNA packaging in Eukaryotes. Programmed cell death, aging and senescence. Oncogenes and tumor suppressor genes: Viral and cellular oncogene from human, Structure, function and mechanism of action of pRB and p53 tumor suppression genes; Cancer and cell cycle; Therapeutic intervention of uncontrolled growth rate.

UNIT-III

DNA recombination: Homologous recombination- Holliday junction, Meselson-Radding model and Double-strand break model; Key enzymes of recombination- RecA and other Rec proteins, Cre-LoxP; Nonhomologous recombination-Site-specific recombination, transposition and gene disruption, Gene targeting.

UNIT-IV

DNA replication, Enzymes and accessory proteins involved in DNA replication; DNA damage and repair; DNA amplification: Polymerase Chain Reaction. Genetic Engineering: Restriction enzymes, Different methods of construction of recombinant DNA, Cell transformation and Cloning, Transgenic animal, Expression of recombination protein using bacterial/animal vectors, Gene Knock out strategies.

Course Outcomes

1. In-depth comprehension of cell cycle and genomic organization.
2. Deeper understanding of concepts in cell and molecular biology like cell differentiation, programmed cell death, cancer, aging, repair, recombination and replication of DNA.
3. Skill development in Biochemical assays Employability in Pharmaceutical, Food, Clinical, biomedical industries, academics and research institutes along with entrepreneurship development

Recommended books

1. Advances in Cell and Molecular Biology by W.J. Dupraw.
2. Molecular Cell Biology, by J. Darnell H. Lodish and D. Baltimore, Scientific American Book Inc. USA.
3. Molecular Biology of the Cell by B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson, Garland Publishing Inc., New York.
4. Molecular Biology of Genes by J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and

A.M. Weiner. The Benjamin/Cummings Publishing Company Inc., Tokyo.

5. Molecular Biology and Biotechnology: A comprehensive Desk Reference by R.A. Meyers

6. Molecular Biotechnology by Glick.

7. Genom by T.S. Brown. 1

8. Biochemistry by Stryer.

9. Principles of Biochemistry by Lehninger.

Course Objective: To learn different metabolic pathways of different biomolecules.

Unit I

Structure and function of biomolecules (proteins, lipids, carbohydrates and nucleic acids); Conformation of proteins: Concept of Ramachandran plot, Domains and motif; Biologically important carbohydrates and their functions; Lipids of biological importance (storage, structural and signal lipids); Conformation of nucleic acids [helix (A, B, Z), t-RNA, micro-RNA], Stability of proteins and nucleic acids.

UNIT-II

Synthesis of purine and pyrimidine nucleotides, Amino acids Synthesis (serine, tryptophan and methionine), Cholesterol biosynthesis, Fatty acid synthesis (saturated) Oxidation of lipid (β -oxidation); Urea cycle; Amino acid catabolism, Nucleic acid catabolism, Metabolism of vitamins.

UNIT-III

Oxidation of carbohydrate: Glycolysis, TCA cycle, Electron transport chain, Oxidative phosphorylation, HMP Pathway, Intermediary metabolism, Glycogenesis, Gluconeogenesis,

UNIT-IV

Classification of enzymes (6 major classes); Prosthetic group (Coenzyme, Cofactor) and Holoenzyme; How enzymes work (active site, ground state, transition state, activation energy, binding energy)? Enzyme kinetics (V_o , V_{max} , K_m and Michaelis-Menten and Lineweaver-Burk equations); Enzyme inhibition: Reversible (competitive, uncompetitive, mixed) and Irreversible; Mechanism of enzyme action; Regulatory enzymes; Isozymes.

Course Outcomes

1. Understanding structure and function of biomolecules.
2. Concepts of nucleotide and fatty acid biosynthesis and oxidation of carbohydrates.
3. Understanding enzymes, their action and kinetics.
4. Skill development in Biochemical assays Employability in Pharmaceutical, Food, Clinical, biomedical industries, academics and research institutes along with entrepreneurship development

Recommended books

1. Biochemistry by Berg, Tymoczko and Stryer, W.H. Freeman, NY.
2. Lehninger Principles of Biochemistry by D. L. Nelson and M. M. Cox, W.H. Freeman, NY.
3. Biochemistry by D. Voet and J.G. Voet, John Wiley and Sons.
4. Physical Biochemistry by D. Freifelder, W.H. Freeman and Company, N

Course Objective: To learn about the culture of different microorganisms and to know the diseases caused by them, our natural response to them and their prevention

Unit I

Concept of microbiology: General characteristics; Ecological groups of microorganisms; Culture media (Natural, Synthetic); Pure culture methods (Pour plate, Streak plate, Spread plate); Microbial fermentation and production of small and macro molecules.

UNIT-II

Infection and diseases: Host-parasite relationship, Types of diseases (Air borne, Food borne, Water borne, Soil borne); Human diseases caused by Viruses (HIV, HPV, Influenza); Control of microorganisms by physical, chemical and chemotherapeutic agents. Microbial genetics: Methods of genetic transfers – Transformation, Conjugation, Transduction.

UNIT-III

Cells and organs of the immune system: Haematopoiesis, Cells of the immune system, Organs of the immune system; Innate immunity: Anatomical barriers, connection between innate and adaptive immunity, Toll like receptors, Inflammation, phagocytosis; Antigen and antibody: Immunogenicity versus antigenicity, Epitope, basic structure of antibody, Antibody binding site, antibody classes and biological activity, antigenic determinant on immunoglobulin (Isotype, Allotype, Idiotype). Complement system (classical, alternative and lectin pathway).

UNIT-IV

Antigen-antibody interaction: Strength of antigen-antibody interactions, Cross reactivity, precipitation reactions, agglutination reactions; ELISA (indirect, sandwich, competitive) and ELISPOT assay, Western blotting); Major Histocompatibility Complex (MHC) and antigen presentation; B-cell and T-cell receptor; B-cell maturation, activation and differentiation, T-cell maturation, activation and differentiation; T-cell maturation, activation and differentiation; Cell mediated cytotoxic responses; Hypersensitivity reactions (Type I,II,III and IV), Cytokines, vaccine

Course Outcomes

1. Deciphering the diversity of micro-organisms and methods of their study.
2. Understanding the causes of microbial infections in humans and their control.
3. Understanding cells and organs of immune system and various immune related responses.
4. Skill development in microbial techniques and Immunological assays. Employability in Pharmaceutical, Clinical, Food, Biomedical industries, academics and research institutes along with entrepreneurship development

Recommended Books

1. Microbiology by Prescott.
2. A text book of Microbiology by Black.
3. Brock Book of Micro organisms by Madigan *et al.*
4. Immunology by Kuby, W.H. Freeman , USA.
5. Fundamentals of Immunology by – W. Paul.
6. Essential Immunology by L.M. Roitt, ELBS Edition.

7. Physical Biochemistry by D. Freifelder, W.H. Freeman and Company.
8. Essentials of Molecular Biology by D. Freifelder

Course Objective: To impart a hand on training on the isolation and quantification of different biomolecules and learn the techniques involved in microbial culture and immunological assays.

Course Content

1. Spectrophotometric estimation protein.
2. Methods of sterilization of glasswares and others (media and buffers) for microbial culture.
3. Isolation and culture of bacteria by plating methods.
4. Effects of temp on enzyme activity (any enzyme).
5. Effects of pH on enzyme activity (any enzyme).
6. Effects of substrate concentration on enzyme activity (any enzyme).
7. Estimation of alkaline phosphatase enzyme activity.
8. Preparation of salivary gland chromosome of Drosophila.
9. Spectrophotometric estimation of DNA and RNA.

Course Outcomes

1. Practical knowledge of performing protein, DNA and RNA estimation in a given sample spectrophotometrically.
2. Performing enzyme assays and its optimization.
3. Basic idea of sterilization process and culture methods.

Recommended Books

1. Laboratory manual developed by the department
2. Molecular Cloning: A Laboratory Manual, by J. Sambrook, E.F. Fritsch and T. Maniatis.
3. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Ed. R.A.Meyers, VCH Publishers, Inc. New York.
4. Advance Practical Zoology, J. Sinha, A. K. Chaterjee , P. Chattopadhyay
5. Practical Physiology Geetha N.
6. Bergey's manual

Semester IV

PAPER ZO-502: CHORDATA, COMPARATIVE ANATOMY, EVOLUTION AND ANIMAL BEHAVIOR

80 marks

Course Objective: To get a complete idea on animal diversity, their evolution and behaviour

UNIT-I

General characters and classification of Chordata upto orders; *Herdmania*- a case study; Structural features and affinities of cyclostomes; Structure, distribution and affinities of Dipnoi and Latimeria; Classification of reptiles based on skull pattern; Flight adaptation in birds; General characters of Prototheria and Metatheria, Comparative account of urinogenital and respiratory system and heart in vertebrates.

UNIT-II

Speciation; Variation; Isolation; Allopatricity and Sympatricity; Phylogenetic tree and tree building methods (distance based, parsimony, Maximum Likelihood, Bayesian). Evolutionary time scale, Lamarckism and Darwinism,; The evolutionary synthesis; Origin and evolution of chordate; Origin of Amphibia and reptiles; Adaptive radiation in reptiles and mammals; Stages in primate evolution including *Homo*.

UNIT-III

Population genetics: Hardy-Weinberg Law, Convergent evolution; Sexual selection; Co-evolution. Concepts of variation, Adaptation, Struggle, Fitness and Natural selection; Spontaneity of mutations

UNIT-IV

Concept of learning: Definition, Types- Flexible (habituation, classical conditioning, trial and error, latent learning, discrimination) and Restricted (imprinting, reasoning and insight).

Course Outcomes

1. Understanding diversity of chordates and their structure.
2. Comprehend the mechanisms of evolution and understand the evolution of amphibia, reptile, mammals and humans.
3. Deciphering learning behaviour.

Recommended books

1. Genetics and Origin of species, by T. H. Dobzhansky, Columbia University Press.
2. Evolutionary biology by D. J. Futuyama, Sinauer Associates Inc., Publishers, Dunderland.
3. Evolutionary Genetics by J. M Smith, Oxford University Press, New York.
4. An introduction to genetic analysis, by A. J. F. Griffith, J. H. Miller, D.T. Suzuki, R.C. Lewontin and M. M. Gilbert, W. H. Freeman Company, USA.
5. Principles of genetics , by D. P. Snustad and M. J. Simmons, John Willey and Sons Inc., NY.
6. Molecular Systematics Edited by David M. Hillis and Craig Mortitz, Sinauer Associates, Inc. Publishers, Sunderland, USA.

7. Evolutionary Biology by Strickberger.

PAPER ZO-504 (A): BIOSYSTEMATICS AND TAXONOMY

80 Marks

Course Objective: To give an idea on taxonomical studies using molecular tools and techniques

UNIT-I

Molecular taxonomy: Population structure, Identification of species boundaries, Estimation of phylogenies. Collection and storage of tissues: Regulations, Removing and preserving tissues in the field (packing, documentation, preservation), Procedures (anesthesia, blood and haemolymph collection, venom collection), Transportation and storage of tissues.

UNIT-II

Barcoding: An initiative to inventorize species; Human Resources; Institutions-National and International organizations associated with taxonomic studies; Rules of Zoological Nomenclature.

UNIT-III

Species concept and lower categories: The genetic species, Evolutionary species, Other kinds of species (taxonomic species, morphospecies, palaeospecies, biospecies, agamospecies), Subspecies, Other intraspecific groups, Superspecies.

UNIT- IV

Higher categories: Base for recognition of higher taxa, Definition and characteristics of higher categories, Analysis of phylogenetic pattern, Examples of mammalian phylogeny, Evolutionary basis of taxa.

Course Outcomes

1. To gain knowledge on molecular taxonomy and methods of species identification and their grouping
2. To know the application of barcoding
3. Skill development in Classifying Animals and employment opportunities in wild life institutes, research institutes, NGOs and academics

Recommended Books

1. Biological Systematics. The State of Art by A. Minelli, Chapman and Hall, London
2. Principles of Animal Taxonomy by G.G. Simpson, Columbia University Press, New York.
3. Principles of Systematic Zoology by E. Mayr and P.D. Ashlock, Mac graw-hill, Inc, New Delhi. System by J.R. Gregg, Columbia university Press, New York.
4. Milestones in Systematics by D.M. Willams and P.L. Foley, CRC Press LLC, Boca Ration, Florida, USA.
5. Transformed Cladistics, Taxonomy and Evolution by N.R. Scott-Ram, Cambridge University Press, Cambridge.
6. Foundations of Systematics and Biogeography by D.M. Willams and M.C. Ebach, Springer Science + Business Media, LLC. New York.
7. Animal Taxonomy by H.E. Goto, hodderAmold H & S.

8. Principles and Practices of Animal Taxonomy, by V.C. Kapoor, Science Publishers, New Delhi.
9. Molecular Systematics Eds. David M. Hillis and Craig Mortitz, Sinauer Associates, Inc. Publishers, Sunderland, USA.

Course Objective: To get an insight into the molecular mechanism involved in the catabolism and anabolism of different biomolecules along with their utilization in the study of modern biology.

UNIT-I

RNA synthesis and processing: Transcription factors and machinery, Formation of initiation complex, RNA polymerases, Capping, Elongation and Termination, RNA processing, RNA editing, Splicing, Polyadenylation. Isolation and purification of RNA; Antisense and ribozymes: Application of antisense and ribozyme technology in biotechnology; Heat shock proteins and their biological significance.

UNIT-II

Protein synthesis and processing: Ribosome, Formation of initiation complex, Elongation, Termination; Genetic code; Aminoacylation of tRNA; Post-translational modification of proteins.

UNIT III

Isolation and purification of proteins; Intracellular trafficking mechanism, Protein synthesis on free and bound polysomes, Uptake into endoplasmic reticulum, Protein sorting and Post translational modification;. Protein targeting and localization in the nucleus, mitochondria, chloroplast and peroxisomes; Protein degrading machinery in the cell; The proteasome: structure and proteasomal degradation of protein.

UNIT-IV

Molecular Mapping: Genetic and physical mapping, Physical mapping and map based cloning, Molecular marker in genome analysis: RFLP, RAPD and AFLP and their application; DNA and protein sequencing.

Course Outcomes

1. Understanding isolation and synthesis of RNA and proteins.
2. Deciphering protein sorting in cells.
3. Understanding molecular markers for genome analysis.
4. Interpretation of the methods of DNA and protein sequencing.
5. Skill development in Molecular Biology and Genetic engineering assays. Employability in Pharmaceutical, Food, Biotech labs Clinical, biomedical industries, academics and research institutes along with entrepreneurship development

Recommended Books

1. Advances in Cell and Molecular Biology by W.J. Dupraw.
2. Molecular Cell Biology by J. Darnell H. Lodish and D. Baltimore, Scientific American Book Inc. USA.
3. Molecular Biology of the Cell by B. Alberts, D. Bray, J. Lewis, M. Raff, K. Roberts and J.D. Watson, Garland Publishing Inc., New York.
4. Molecular Biology of Genes by J.D. Watson, N.H. Hopkins, J.W. Roberts, J.A. Steitz and A.M. Weiner, The Benjamin/ Cummings Publishing Company Inc. Tokyo.
5. Molecular Cloning: A Laboratory Manual by J. Sambrook, E.F. Fritsch and T. Maniatis Cold Spring Harbor Laboratory Press, New York.
6. Molecular Biotechnology by Glick and Pasternak.
7. Genome by T.S. Brown.

8. Biochemistry by Berg, Tymoczko and Stryer, W.H. Freeman, NY.
9. Lehninger Principles of Biochemistry by Nelson and Cox, W. H. Freeman, NY.
10. Biochemistry by D. Voet and J.G. Voet, John Wiley and Sons.

Course Objective: To get a practical knowledge on the collection, preservation and establishment of relationship between different species of animals and to use the bioinformatic tools in Zoology

Course Content

1. Procedure of collection of different biological materials.
2. Preservation and curation of specimens.
3. Morphological identification of specimens.
4. Morphometry of collected specimens.
5. Data mining from different data bases (NCBI and EMBL).
6. Alignment and editing of DNA sequences.
7. Making of input files for different phylogenetic software's (PAUP, Phylip, Mega, Mr. Bayes).
8. Phylogenetic tree building using the above input files.
9. Tree editing using different software's (Tree view, Dendroscope, Tree annotator, Fig tree, Mac Clade).
10. Estimation of divergence time using different software's (DIVA, Mega, PAUP).
11. Seminar topic and Field tour report.

Course Outcomes

1. To understand the methods of collection, identification and preservation of biological specimen.
2. To know the basics of bioinformatics for data mining and making of phylogenetic trees
3. To learn the method of preparing a seminar report and a report of field tour.

Recommended books

1. Principles of Animal Taxonomy by G.G. Simpson, Columbia University Press, New York.
2. Principles of Systematic Zoology by E. Mayr and P.D. Ashlock, Mac graw-hill, Inc, New Delhi. System by J.R. Gregg, Columbia university Press, New York.
3. Milestones in Systematics by D.M. Willams and P.L. Foley, CRC Press LLC, Boca Ration, Florida, USA.
4. Transformed Cladistics, Taxonomy and Evolution by N.R. Scott-Ram, Cambridge University Press, Cambridge.
5. Foundations of Systematics and Biogeography by D.M. Willams and M.C. Ebach, Springer Science + Business Media, LLC. New York.
6. Animal Taxonomy by H.E. Goto, hodderArnold H & S.

Course Objective: To get an idea to use molecular biology and bioinformatics tools and software in the study of animal science.

Course Contents

1. Study on the life history of *Drosophila*.
2. Preparation of permanent histological slides.
3. Isolation of plasmid.
4. Separation of DNA through agarose gel electrophoresis.
5. Extraction and purification of protein by column chromatography.
6. Separation of protein on SDS-PAGE and determination of molecular weight.
7. Restriction Mapping
8. Comparative osteological studies of vertebrates (Amphibia, Reptilia, Aves and Mammalia).
9. Study of histological slides of chordates.
10. Museum specimen of chordates

Course Outcomes

1. Understanding classification and evolution of chordates through specimen study.
2. Practical knowledge of performing molecular techniques to study DNA and protein like gel electrophoresis, chromatography, plasmid isolation and histology.

Recommended Books

1. Laboratory manual developed by the department
2. Molecular Cloning: A Laboratory Manual, by J. Sambrook, E.F. Fritsch and T. Maniatis.
3. Molecular Biology and Biotechnology: A Comprehensive Desk Reference, Ed. R.A.Meyers, VCH Publishers, Inc. New York.
4. Advance Practical Zoology, J. Sinha, A. K. Chatterjee , P. Chattopadhyay
5. Practical Physiology Geetha N.

Course Objective:

Skill development with long term hands - on -training on various biotechniques, microbial, plant and animal tissue techniques along with data analysis software training for application of the research theme chosen for the Dissertation and further research and development in Industries, Institutes and Academics

Course Outcomes

1. To enable students to identify a problem and put relevant questions.
2. To enable students to survey relevant literature for a given problem.
3. To prepare students to design an experiment and execute it.
4. Skill development with long term hands - on -training on various biotechniques, microbial, plant and animal tissue techniques along with data analysis software training for application of the research theme chosen for the Dissertation and further research and development in Industries, Institutes and Academics
