Campus

OK

माँ शाकुम्भरी विश्वविद्यालय, सहारनपुर
Maa Shakumbhari University, Saharanpur

Syllabus

M.Sc. (Zoology)

(For fourth and fifth years of Higher education)

(As per guidelines of U.P. Government according to National Education Policy-2020 w.e.f. the session 2022-2023)

07-10-24

7th Oct. 24

07-10-2024

Post-Graduation in Zoology
& Pre. Ph.D. Course-WORK PROGRAMME
CURRICULUM & SYLLABUS

For

School of Science-Zoology
Maa Shakumbhari University, Saharanpur

And
Department of Zoology, Affiliated Colleges
Maa Shakumbhari University, Saharanpur

Members, Board of Studies (Zoology)

S. No.	Name	Designation	College/University	Signature
1.	Prof Garima Jain	Dean Science	D.A.V. (P.G). College, Muzaffarnagar	
2.	Prof. Sandhya Jain	Convener	D.A.V. (P.G). College, Muzaffarnagar	07-10-24
3.	Prof. Anju Panwar	Member	D.A.V.(P.G.) College. Muzaffarnagar	7th Oct 24
4.	Dr. Yogendra Singh	Member	Vijay Singh Pathik Govt. P. G. College, Kairana, Shamli	
5.	Dr. Om Dutt	Member	M.S. College, Saharanpur	07.10.2024
6.	Prof. D. S. Malik	External expert	Gurukul Kangri University, Haridwar	
7.	Prof. Dinesh Kumar Sharma	External expert	Km. Mayawati Govt. Girls (PG)College, Badalpur , Goutam Budhnagar	Joined Online
8.	Prof. A. K. Verma	External expert	Govt. College, Saidabad, PRG	

SCHOOL OF SCIENCE (ZOOLOGY)

Post-Graduation in Zoology

School of Science-Zoology
Maa Shakumbhari University, Saharanpur

VISION OF THE SCHOOL

To produce academicians with morality, global competence, vision and skills, as are necessary to meet the challenges of emerging global knowledge, economy by the power of innovation, creativity and efficient learning ability. Besides these to create an innovative atmosphere for teaching and learning to achieve excellence in field of Zoology.

MISSION OF THE SCHOOL

To emerge among the top institutions in India within next ten years through applicability, humanity, implementing and operating dynamic-academic, administrative and functional process, for optimal use of available resources and a step towards consideration of valuable species in different habitats.

ABOUT THE SCHOOL OF SCIENCE - ZOOLOGY

The School of Zoology is to be established with the objective of promoting post-graduate studies and research in various branches of Zoology. Zoology is the base of all sciences, therefore the importance of Zoology in any curriculum is self-evident. This is the single science subject that is being used by all other disciplines, that is why its growth over the years has been phenomenal. In view of this, Zoology at Post-Graduate level, is one of the subjects, which is to be introduced in the University since inception.

VISION

- To provide quality education for higher studies and competitive examinations like ICMR, ICAR, ZSI, DBT, DRDO, BARC, NEERI, IPM, CSIR-UGC JRF/NET, GATE, SLET, Civil Services, Scientist, and research programme.
- School of Zoology will try to make our university students competitive with other national and international universities.

MISSION

- To develop and impart excellence in education, training and research in academic field.
- To impart world-class education in an environment of fundamental and applied research in field of Zoology.
- To emerge as a global centre of digital learning, academic excellence and innovative research.
- To include innovative skills, teamwork, bioethical practices and biosafety rules and regulation among academician so as to meet societal expectations.

M.Sc. Zoology Programme prerequisites

To study this programme a student must have/ had the subject Zoology at UG level.

Programme Outcomes (PO's)

PO1: Apply the knowledge of Zoology, Life Sciences and allied subjects to the understanding of complex life processes and phenomena.

PO2: Innovate, invent and solve complex zoological problems using the knowledge of pure and applied Zoology.

PO3: Provide opportunities in higher education and development on the professional front. It also gives the opportunity for career advancement in teaching, research, and in various industries.

PO4: Integration of Interdisciplinary thinking and practice.

PO5: Design processes/strategies that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO6: To inculcate the scientific temperament in the students and people outside the scientific community through field visits for better understanding of the industrial processing, biodiversity.

PO7: Deploy and use effective skills, tools, and techniques necessary for information systems practice.

PO8: Most importantly, the program inculcates among the students the higher values which enable them to withstand the challenges of life.

PO9: Deploy and use effective skills, tools, and techniques necessary for information systems practice.

PO10: Effectively communicate about their field of expertise on their activities, with their peer and society at large, such as, being able to comprehend and write effective reports and design documentation.

Programme Specific Outcomes (PSO's)

PSO1. After successful completion of this program, the students would be able to apply knowledge of Zoology, in all the fields of learning, including higher research and its extensions.

PSO2. To provide students with knowledge and capability in formulating and analysis of life science models of real-life applications.

PSO3. Understand the testing of hypothesis and different behaviour patterns of animals.

PSO4. Demonstrate competence to use modern Zoological tools, Models, Charts and Equipment.

PSO5. To provide students with knowledge, abilities and insight in Zoology and techniques so that they are able to work as life science professional.

PSO6. They would have plethora of job opportunities in the education, environment, agriculture-based, and health related sectors.

PSO7. Encourage personality development skills like time management, crisis management, stress interviews and working as a team.

PSO8. The bright and ignited mind may enter into research in the contemporary areas of Zoological/Biological Sciences.

PSO9. Understand good laboratory practices and safety.

PSO10. The broad skills and the deeper knowledge in the field would make them highly successful and excellent researcher in advanced areas of research in the biological sciences.

Syllabus M.Sc. (Zoology)
LIST OF PAPERS IN ALL FOUR SEMESTERS

Year	Semester	Course Code	Core/Elective/ Value Added	Paper Title	Theory/ Prac / Project	Credits	CIE	External Marks (Min. Marks)	Total Marks	Minimum Marks (INT+ EXT)	Teaching Hours Theory + Tutorial
I	I		Core Compulsory	Evolutionary Biology	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Diversity of Invertebrates	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Biotechniques and Bioinstrumentation	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Cell and Molecular biology	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Practical	Practical	4		100(40)	100	40	120 hours
	II		Core Compulsory	Genetics	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Biochemistry	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Biostatistics and Bioinformatics	Theory	4	25	75(25)	100	40	60 hours
			Elective	Physiology and Developmental Biology	Theory	4	25	75(25)	100	40	60 hours
			Elective	Endocrinology and Immunology	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Practical	Practical	4		100(40)	100	40	120 hours

Year	Semester	Course Code	Core/Elective/ Value Added	Paper Title	Theory/ Practical/ Project	Credits	CIE	External Marks (Min. Marks)	Total Marks	Minimum Marks (INT+ EXT)	Teaching Hours Theory + Tutorial
II	III		Core Compulsory	Diversity of Chordates	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Ecology and Ethology	Theory	4	25	75(25)	100	40	60 hours
			Elective	Animal Biotechnology	Theory	4	25	75(25)	100	40	60 hours
			Elective	Biology of Parasitism	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Project	Project	4			100		
			Core compulsory	Practical	Practical	4		100(40)	100	40	120 Hours

Biosystematics and Biodiversity

Year	Semester	Course Code	Core/Elective/ Value Added	Paper Title	Theory/ Practical/ Project	Credits	CIE	External Marks (Min. Marks)	Total Marks	Minimum Marks (INT+ EXT)	Teaching Hours Theory + Tutorial
II	IV		Core Compulsory	Classical Taxonomy and systematics	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Molecular Taxonomy and systematics	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Biodiversity Management	Theory	4	25	75(25)	100	40	60 hours
			Core Compulsory	Project	Project	4			100		
			Core Compulsory	Practical	Practical	4		100(40)	100	40	120 Hours

Project evaluated at the end of semester (After Second III /IV semester), Total Marks-100, If student publish research in UGC-CARE listed journal, He/She will get 25 marks directly out of 100. Follow the instruction for research project explained in G.O. No-401/Sattar-3-2022 dated 9-2-2022

Examination Pattern	
Continous Internal Evaluation (CIE): *For CIE purpose follow the G.O. No 2058/Sattar-3-2021-08(33)/2020TC dated 26-8-2021*	
External Examination: Written Exam of 75 marks 3Hrs Duration.	
External Examination Pattern	Section-I: Attempt all five questions. Each question carries 3 marks.
	Section- II: Attempt Any Two out of three. Each Question carries 7.5 marks.
	Section-II: Attempt Any Three out of Five. Each Question carries 15 marks.
Internal Examination Pattern	1. One written Test of 20 Marks (5 Marks Quiz + 15 Marks (Very Short + Short + Long Question))
	2. 5 Marks for Seminar/Assignment/Field study
	Minimum Marks:
	1. In each individual paper 40 Marks i.e. 40% with aggregate of 50% in all courses.
	2. Division: First Division - CGPA 6.5 and less than 10, Second division - CGPA 5.0 and less than 6.5. There is no provision of Third division.
	Equivalent Percentage = CGPA x 9.5
	Note: Percentage and Grading system applicable as per NEP2020 GO 1032/Sattar-2022-08(35)/2020, Higher Education Division -3, Lucknow Dated 20.04.2022
Project-	*Project evaluated at the end of semester (After Third III & IVth semester), Total Marks-100, If student publish research in UGC-CARE listed journal, He/ She will get 25 marks directly out of 100. Follow the instruction for research project explained in G.O. No-401/Sattar-3-2022 dated 9-2-2022*
V lab	25% experiments in each semester done through V-Lab or other govt/university virtual experiments.
MOOCs Equivalence	20% credits allowed through SWAYAM or other recognised MOOCs, Equivalent MOOCS are defined at the end of paper.

Project work shall be assigned individually.

- It must be carried out under the guidance of a faculty from the same college with or without an external guide OR in an external institution under the combined guidance of internal and external guides.
- The project report may be presented in following sub-heads ⌋ Contents ⌋ Acknowledgements ⌋ Introduction ⌋ Review of literature ⌋ Material and methods ⌋ Results and discussion ⌋ References ⌋ Appendices
- The student has to submit the dissertation before the external examiner appointed by the University for Evaluation/General Viva voce examination.

External Examination: Written Exam of 75 marks 3Hrs Duration.

External Exam Pattern:

Section-I: Attempt all five questions. Each question carries 3 marks.

Section- II: Attempt Any Two out of three. Each Question carries 7.5 marks.

Section-III: Attempt Any Three out of Five. Each Question carries 15 marks.

Minimum Marks:

1. In each individual paper 40 Marks i.e. 40% with aggregate of 50% in all courses.
2. Division: First Division - CGPA 6.5 and less than 10, Second division - CGPA 5.0 and less than 6.5. There is no provision of Third division.

Equivalent Percentage = CGPA x 9.5

Note: Percentage and Grading system applicable as per NEP2020 GO 1032/Sattar-2022-08(35)/2020, Higher Education Division -3, Lucknow Dated 20.04.2022

Detailed Syllabus M. Sc. (ZOOLOGY)

Programme/Class:	Year: First	Semester: First
Subject: Zoology		
Course code:0727801	Course Title: Evolutionary Biology	
Course outcome: Evolution or evolutionary biology aims to impart the concept of evolutionary thoughts that lead to the evolution of the life on earth from most simple to complex forms along with the mechanism and function of various evolutionary factors and forces.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Concepts of variation, adaptation, struggle, fitness and natural selection-spontaneity of mutation and the evolutionary synthesis. Endosymbiotic theory, Punctuated equilibrium. Origin and Evolution of Life, The RNA world, The First Cell.	Total No. of Lectures (60)
II	Evolutionary theories and evidences: Contributions of Lamarckism, Darwin-Wallace postulates, Overview of evidences- - Paleontological, Embryological, - Comparative morphological, Anatomical, Genetics and Cytological, Molecular Biological evidences, limitations of Darwinism, Neo Darwinism	
III	The Origin of Species, categories of species (Demes, Metapopulation, Geographical Races, Ecological Races, Climes), Types of Species Speciation: Phyletic Speciation, Quantum Speciation, Gradual Speciation (Allopatric, Peripatric, Sympatric, Parapatric)	
IV	Neutral theory of molecular evolution; molecular divergence; molecular drive. Molecular clocks- genetic equidistance. Phylogenetic relationships- Homology; Homologous sequences of proteins and DNA.	
V	Palaeontology and evolutionary history: The evolutionary time scale - Eras, periods and epoch - Major events in the evolutionary time scale - Origins of unicellular and multi cellular organisms - Stages in human evolution.	

Recommended Books:

1. Barton, N.H., Briggs, D.E.G., Eisen, J.A. Goldstein, D.B. and Patel, N.H. (2007. Evolution. Cold-Spring, Harbour Laboratory Press
2. Dobzhansky Th. et al. (1976): Evolution. Surjeet Publ.
3. Futuyma D. J. (1998): Evolutionary Biology. Sinauer
4. Hall, B.K. and Hallgrimsson, B. (2008) Evolution, IV Edition. Jones and Barlett Publishers
5. Kimura M. (1984): The Neutral Theory of Molecular Evolution. Cambridge.
6. Li Wen-Hsiung and Dan Graur (1991): Fundamentals of Molecular Evolution. Sinauer
7. Ridley, M (2004). Evolution. III Edition. Blackwell publishing
8. Strickberger M. W. (2000): Evolution. Jones and Bartlett
9. White M. J. D. (1978): Modes of Speciation. Freeman

Programme/Class:	Year: First	Semester: First
Subject: Zoology		
Course code:0727802	Course Title: Diversity of Invertebrates	

Course outcome: Invertebrates are the numerous and widely diverse group of animals from protozoa to Echinodermata. The course will explain the diversity of invertebrates and comparison of various morphological, physiological phenomenon and adaptations in various phyla. This will help and enable the students to take up the research in life sciences.

Credits: 4		
Max. Marks: (25+75)	Core Compulsory	
Unit	Min. Passing Marks: 40	
	Topics:	
I	Origin of Protists, Prokaryotes and Eukaryotes, Levels of organization in animal kingdom, Multi-cellularity, Ediacaran and Burgess Shale fauna, Cambrian explosion- causes and consequences, Red Queen principle, Possible theories of metazoan origin. Symmetry, Coelom and Metamerism- evolutionary advantages.	Total No. of Lectures (60)
II	Lower Metazoans- Porifera, Cnidaria- Polymorphism, Ctenophora, Placozoa, Mesozoa, Acoelomata and Pseudocoelomata evolutionary relationships and adaptive modifications.	
III	Protostomes and Deuterostomes, Phylogenetic position of Molluscs, Phylogeny of Arthropoda. Larval forms of Annelids, Molluscs and Arthropods. Monophyly and Polyphyly, Reasons for the success of Arthropods. Major classes under Arthropoda. Adaptive Radiation in Molluscs and Annelids and Arthropods.	
IV	Lesser Protostomes- Sipuncula, Echiura, Phoronida, Brachiopoda, Onychophora and Chaetognatha- Phylogeny only. Echinoderms – Classification, Adaptive radiation and Larval forms.	
V	Hemichordates -Position in the animal kingdom, phylogeny and evolutionary significance. Impact of sedentary life on the organization of invertebrates.	

Recommended Books-

1. Barnes. Invertebrate Zoology (Holt-Saunders International, 4th edition, 1980)
2. Barnes et al (2009). The Invertebrates – A synthesis. Wiley Blackwell 17
3. Brusca and Brusca (2016) Invertebrates. Sinauer
4. Hunter. Life of Invertebrates, Collier Macmillan Pub. 1979
5. Jan Pechenik (2014) Biology of the Invertebrates. McGraw Hill
6. R.L. Kotpal Invertebrate series; Textbook of Invertebrates
7. Marshall. Parker & Haswell Text Book of Zoology, Vol. I, 7th edition, Macmillan, 1972
8. Moore: An Introduction to the Invertebrates, Cambridge University Press, 2001.

Programme/Class:	Year: First	Semester: First
Subject: Zoology		
Course:0727803	Course Title: Biotechniques and Bioinstrumentation	

Course outcome: The students at the end of course will have a deep insight into various biotechniques and enable them to apply these in their future researches. The course is expected to provide sufficient information to enable the students to select a technique that would be appropriate for a particular analysis and would help them to develop a valid and reliable analytical method. They will also able to start their own biotechniques research labs, a further step towards self-employment.

Credits: 4	Core Compulsory
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	
I	Introduction to Microscopy, Resolving Power, Limit of Resolution and Magnification, Types of microscopes, Basic principles of Light, Electron, Fluorescence and Confocal Microscopy	Total No. of Lectures (60)
II	Buffers, pH meter, Colorimetry, Spectrophotometry, UV/IR spectroscopy, mass spectroscopy, X-ray crystallography, N.M.R, Chromatography and Centrifugation types.	
III	Electrophoretic techniques: Agarose Gel Electrophoresis, Polyacrylami Electrophoresis (PAGE), Southern, Northern and Western blotting, Autoradiography	
IV	Raising Polyclonal and Monoclonal Antibodies, Antigen-Antibody Interactions Immunodiffusion, ELISA, Radioimmunoassay	
V	Cell culture and its basic requirements. Culture media-Nutrient and Non-nutrient, commonly used media for human cell lines. Sterilization of culture wares and media, Cell harvesting and Storage Methods, Autoclave and Laminar Air Flow, Safe laboratory practices.	

Books Recommended

1. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd Ed.), Benjamin/Cumin, 1993
2. Clark and Switzer. Experimental Biochemistry. Freeman (2000)
3. Freifelder: Physical Biochemistry (2nd Ed.), Freeman, 1982
4. Holme and Peck: Analytical Biochemistry (3rd Ed.), Tata McGraw Hill, 1998
5. Plumer: An Introduction to Practical Biochemistry (3rd Ed.), Tata-McGraw Hill, 1990
6. S.V.S. Rana: Biotechniques Theory and Practice
7. Sambrook et. al. Molecular cloning Vols I, II, III. CSHL (2001)
8. Wilson and Walker: Practical Biochemistry (3rd Ed.), Cambridge Univ. Press, 2000.

Programme/Class:	Year: First	Semester: First
Subject: Zoology		
Course code: 0727804	Course Title: Cell and Molecular Biology	
Course outcome: The course will attract the students to do their best in further advancement in the field of cytology and molecular biology. Advance topics related to molecular biology will enable the students to have a deep insight in the subject and prepare them for research.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Cell membrane-Structural organisation of bio-membranes. Functions of plasma membrane (transport. diffusion, active transport, pumps, uniports, symports and anti-ports). Cell organelles-origin. structure and function of nucleus, mitochondria. Endoplasmic reticulum and ribosomes, Golgi complex, endosome, lysosomes, peroxysomes, Centrosome.	Total No. of Lectures (60)
II	Cytoskeleton, Organisation and dynamics of microtubules. actin filaments (micro-filaments), intermediate filaments, cilia & flagella. Cell communication - cell signalling, cell surface receptors, second messenger system, kinase pathways, signalling from plasma membrane to nucleus (signal trans-duction).	
III	Cell adhesion & cell junctions, Cellular affinity, cell adhesion molecules (CAMS), Ca++ dependent cell-cell adhesion, Ca++ independent cell-cell adhesion, cadherins, selectins, integrins, cell junctions. Cancer. Oncogenes, tumour suppressor genes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis, therapeutic interventions of uncontrolled cell growth.	
IV	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. Transcription in prokaryotes and eukaryotes, RNA processing, RNA editing, splicing, structure and function of different types of RNA, RNA transport	
V	Translation in prokaryotes and eukaryotes, Genetic code, Post-translation modification of proteins, protein targeting. Gene regulation, Lac operon, trp operon, Arabinose operon. Gene regulation in eukaryotes.	

Book recommended

1. Alberts et al: Molecular Biology of the Cell (4th Ed.), Garland,2002
2. Lodish et al: Molecular Cell Biology (5th Ed.), Freeman, 2004
3. DeRobertis & DeRobertis: Cell & Molecular Biology, Lea & Febriger, 1987
4. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
5. Michael Jr.: Microbiology, Tata McGraw Hill, 1990s
6. P.K. Gupta: Cell and molecular biology
7. Karp: Cell and molecular biology: Wiley (2002).
8. Cooper: Cell. A Molecular approach: ASM Press (2000)

Practical Course Syllabus **Semester I** **Credit -4** **Time -4 Hrs**

- Virtual Dissection
- Major Dissection- Nervous system of Prawn, Pila, Unio, Sepia, Octopus
- Minor Dissection- Setae, nephridia, appendages of Prawn, statocyst, hastate plate, radula, Anatomy of Holothuria
- Mounting- Gemmules, spicules, Obelia colony, medusa of obelia, Pennatula, Crustacean larva
- Microtomy- Source tissue, fixing, dehydration, block making, section cutting and staining
- Slides and specimens of various invertebrate phyla
- Evolution- Preparation of coacervates, adaptive radiation in Darwin Finches through chart and models, Weber's line, Wallace line through chart or model.
- Numerical based on gene pool and genetic drift. Demonstration/ photography of mimicry, protective coloration.
- Elementary knowledge about preparation of various reagents used in laboratory
-
- Microscopy- Light microscope, phase contrast, confocal microscope
- Flow cytometry, Centrifugation, Electrophoresis, chromatography
  Ag- Ab in tab str, Immunoprecipitation, ELISA, Demonstration / virtual demonstration of monoclonal antibodies,
  Hybridoma Technology through chart,
  Western blot, DNA isolation and its quantification through stage of mitosis and meiosis, Squash technique
- Field study / visit and project (mandatory)

Distribution of Marks-

• Major Dissection	-	10
• Minor Dissection	-	05
• Mounting	-	05 (2x2.5)
• Microtomy	-	10 (4+3+3) (Section cutting, stretching and staining)
• Spotting	-	10 (1x10)
• Evolution	-	5
• Techniques	-	10
• Cell Biology	-	10
• Mol. Biology	-	5
• Collection field visit	-	10
• Viva	-	10
• Record	-	10

Programme/Class:	Year: First	Semester: Second
Subject: Zoology		
Course code:0827802	Course Title: Genetics	

Course outcome: The course will enable the students to apply the skills of genetic technologies in various fields related to pharmaceuticals, biotechnology and diagnostic clinics. It will bring awareness on various genetic disorders, its inheritance patterns and to develop techniques of fighting against these disorders.

Credits:	Core Compulsory
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	
I	Mendelian principles-Dominance, segregation, independent assortment, deviations from Mendelian inheritance. Methods of genetic transfer-Transformation, conjugation, transduction, bacteriophages-types, structure and morphology of T_4 phage.	Total No. of Lectures (60)
II	Chromosomes-Molecular anatomy of eukaryotic chromosomes, heterochromatin and euchromatin, Organisation of genetic material-packaging of DNA as nucleosomes in eukaryotes, repetitive and unique DNA sequences, split genes, overlapping genes and pseudogenes, transposons, giant chromosomes: polytene and lampbrush chromosomes, sex chromosomes.	
III	Gene mapping-Concept of recombination, linkage map, cytogenetic map, physical map, molecular maps, levels of genome mapping, Genetic code-Properties of genetic code, codon assignments, chain initiation and termination, mutations and the genetic code.	
IV	Genetic techniques-Cloning, PCR, DNA sequencing FISH, GISH, DNA fingerprinting. Chromosome walking and applications of genetic engineering. Somatic cell genetics-cell fusion and hybrid –agents and mechanism of fusion, heterokaryon.	
V	Structural and numerical alteration of chromosomes Genetic disorders-chromosomal disorders, inborn errors of metabolism, Tay-sachs disease, albinism, phenylketonuria, Lesch-Nyhan chromosome. Population genetics-Gene pool and gene frequencies, Hardy- Weinberg law of genetic equilibrium and changes in gene frequencies.	

Books Recommended

1. Brooker: Genetics: Analysis and Principles (Addison-Wesley, 1999)
2. Gardner et al: Principles of Genetics (John Wiley, 1991)
3. Griffith et al: Modern Genetic Analysis (Freeman, 2002)
4. P.K. Gupta: Genetics
5. Lewin, Genes VIII (Wiley, 2004)
6. Russell: Genetics (Benjamin Cummings, 2002)
7. Snustad & Simmons: Principles of Genetics (John Wiley, 2003).
8. Benjamin A. Pierce: Genetics a conceptual approach

Programme/Class:	Year: First	Semester: Second
Subject: Zoology		
Course code: 0827801	Course Title: Biochemistry	
Course outcome: Biochemistry is regarded as the mother of all biological sciences disciplines as it unveils the chemical basis of life an all the living organisms from micro-organisms to plants and animals. Keeping in pace with the developing trends in various areas of biochemistry the subject course contains fundamental as well as latest and upcoming developments in the field of biochemistry.		
Credits:4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Structure of atoms, molecules and chemical bonds Composition, structure and function of biomolecules carbohydrates, lipids, proteins, Conformation of proteins (Ramachandran plot, secondary, tertiary and quaternary structure; domains; motif and folds) nucleic acids and vitamins.	Total No. of Lectures (60)
II	Principles of biophysical chemistry pH, buffer, reaction kinetics, thermodynamics, colligative properties. Enzymes, classification, enzyme kinetics, mechanism of enzyme catalysis, enzyme regulation, isozymes, coenzymes, Abzymes, ribozymes.	
III	Bioenergetics, high energy rich biomolecules, phosphoryl transfer reactions, oxidation reduction reactions Carbohydrate metabolism: glycolysis, gluconeogenesis, glycogenolysis, glycogenesis, pyruvate oxidation, TCA cycle, PPP pathway, oxidative phosphorylation.	
IV	Lipid metabolism beta oxidation of fatty acid, steroid synthesis, cholesterol synthesis, fatty acid synthesis (SFA, UFA). Protein metabolism (catabolism of carbon skeleton, nitrogen skeleton, urea cycle.)	
V	Nucleic acid metabolism (Synthesis of purines and pyrimidines nucleotides and its catabolism) Enzyme technology: immobilization, physical, adsorption, entrapment, covalent modifications.	

Books recommended:

1. Nelson et al: Lehninger Principles of Biochemistry (3rd Ed.), MacMillan Worth, 2000
2. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
3. J.L. Jain: Fundamental of Biochemistry
4. Mathews et al.: Biochemistry (3rd Ed.), Pearson, 2004
5. Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
6. Murray et.al: Harper's Illustrated biochemistry: McGraw Hill (2003) Elliott and Elliott
7. Lubert Stryer: Biochemistry
8. Voet & Voet. Biochemistry Vols I &2: Wiley (2004)

Programme/Class:	Year: First	Semester: Second
Subject: Zoology		
Course code:0827804	Course Title: Biostatistics and Bioinformatics	

Course outcome: The course will lead to comprehensive understanding of the principles and various practices in Biostatistics. Bioinformatics course covers the principles and computational methods used to search and compare the DNA, RNA and proteins cast as biological sequences.

Credits: 4	Core Compulsory
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	Total No. of Lectures (60)
I	Biostatistics – Basic concepts. Fundamentals of measurement. Qualitative & Quantitative Variables, Collection, Classification, Tabulation & Presentation of data Mean, Median, Mode, Dispersion, Standard Deviation, merits & demerits.	
II	Chi-square test & 't' test. Analysis of variance (ANOVA), Probability Distribution and normal distribution (Gaussian Distribution) Correlation Analysis – Importance of Correlation Analysis. Types and measures of Correlation. Regression Analysis. Regression of Y on X and X on Y.	
III	Bioinformatics – Introduction. Components of Computer, Internet – Basics for Biologists (Electronic mail, Electronic Mail, Servers, Downloading files with anonymous File Transfer Protocol, Gopher, WWW, Mosaic.	
IV	Primary & Secondary Databases. Sequence Databases (European Molecular Biology Laboratory, Gene bank). DNA Data Base of Japan (DDBJ), SWISS-PORT, Protein Information Resource, TREMBL, Protein Family/Domain Databases (Prosite. Pfam & Prints).	
V	Submitting sequence to Database and information retrieval through ENTREZ. Collecting & Storing Sequences, Local alignment, Global Alignment, BLAST (BLASTP, BLASTN, BLASTX, TBLASTN, TBLASTX).	

Recommended Books:

1) Bioinformatics for geneticists: Wiley (2003)
2) Lesk: Bioinformatics, Oxford (2003, Indian ed)
3) Westhead et al: Bioinformatics Instant Notes, Viva Books (2003, Indian ed)
4) Jerrold H. Zarr: Biostastistical Analysis (Fourth edition), Pearson Education Inc., Delhi
5) W.W. Daniel and C.L. Cross: Biostatistics (Tenth edition), Wiley
6) John E. Havel, Raymond, E. Hampton and Scott J Meiners: Introductory Biological Statistics (Fourth edition)
7) Satguru Prasad: Elements of Biostatistics
8) Pranab Kumar Banerjee: Introduction to Biostatistics

Programme/Class:	Year: First	Semester: Second
Subject: Zoology		
Course code:0827803	Course Title: Physiology and Developmental Biology	

Course outcome: The course will enable students to understand the functions of important physiological systems including the cardiac, respiratory, renal and reproductive systems. They will understand how these various systems interact to yield integrated physiological changes in the body. Along with this, students will be able to understand the progressive development of various theories of Developmental biology, patterns and process of embryonic development, body plan, fate map, induction, competence for the study of developing embryo.

Credits: 4	Elective
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	
I	Physiology of Digestion and absorption, Gastrointestinal hormones and regulation, BMR. Physiology of respiration Pulmonary ventilation, gaseous exchange through respiratory membranes and tissues. Neural and chemical regulation of respiration. Blood -blood corpuscles, haemopoiesis, formed elements, plasma, blood volume, blood groups, haemoglobin, haemostasis.	**Total No. of Lectures (60)**
II	Structure of heart, myogenic heart and neurogenic heart, cardiac cycle, neural and chemical regulation of heart, blood pressure, ECG- Its principle and significance. Physiology of muscle, Sequence of events in contraction and relaxation of skeletal muscle, energetics of muscle contraction and its neural regulation.	
III	Physiology of Neurons, Axonal and Synaptic transmission central and peripheral nervous system. Sense organs: Vision (Retinal components and photoreceptors), olfactory, hearing and tactile response. Thermoregulation - Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. Stress and adaptation.	
IV	Theories of development, basic concepts of development Production of gametes, Fertilization, Cleavage, Blastula formation, embryonic fields, gastrulation and formation of germ layers in animals.	
V	Axis and pattern formation in Drosophila, amphibia and chick Origin of anterior- posterior axis and dorsal-ventral polarity in Drosophila Metamorphosis in insects and amphibians, Extra embryonic membranes and placentation	

Recommended Books:

1. C.C. Chatterjee: Human physiology vol 1&2. 11th edition. CBS Publishers (2016)
2. Christopher D. Moyes, Patricia M. Schulte: Principles of Animal Physiology. XI edition John Wiley &Sons (2006)
3. Ganong: Review of Medical Physiology (21st Ed.), Lang Medical Publications, 2003
4. Guyton and Hall: Text Book of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd./W.B. Saunders, 2006
5. Hill, Richard W., et al.; Animal physiology Vol. 2. Sunderland, MA: Sinauer Associates, (2004)
6. Keel et al: Samson Wright's Applied Physiology (13th Ed.), Oxford Press, 1989
7. Balinsky: An introduction to Embryology (5th ed 1981, Saunders)
8. Gilbert: Developmental Biology (8th ed 2006, Sinauer)
9. P.S. Verma and V.K. Agarwal: Developmental Biology
10. Philip Grant: Developmental Biology
11. Kalthoff: Analysis of Biological development (1996, McGraw)
12. Wolpert: Principles of Development (3rd ed 2007, Oxford)

Programme/Class:	**Year:** First	**Semester:** Second
Subject: Zoology		
Course code: 0827803	**Course Title: Endocrinology and Immunology**	
Course outcome: Enable students to identify the glands, organs, tissues and cells that synthesize and secrete hormones, hormones precursors and associated compounds along with the regulation of hormones and their biological activities, and allow the students to have a deep insight into various concepts of immune system and its detail mechanism		
Credits: 4		**Elective**
Max. Marks: (25+75)		**Min. Passing Marks: 40**

Unit	Topics:	
I	Scope and Techniques in Endocrinology, Hormones classification. Miscellaneous regulatory substances, Neuroendocrine system. Mechanism of hormone action. Pituitary gland: Morphology, anatomy and hormones of adeno and neurohypophysis,	**Total No of Lectures (60)**
II	Thyroid gland: Morphology, anatomy and hormones, related disorders. Parathyroid gland: Structure and function of parathyroid hormone. Adrenal gland: Anatomy, corticosteroids and catecholamine: structure, nomenclature and function. Renin Angiotensin System. Pineal gland, Ultimobranchial body, Multihormonal regulation of calcium homeostasis.	
III	Pancreas: Anatomy and cytology, Insulin: structure, regulation of insulin secretion and functions, Glucagon: structure, biosynthesis and function, Diabetes. Gonadal hormones: Male and female sex steroids: structure and functions. GI tract hormones– types and functions.	
IV	Lymphoid organs of the body, thymus, bone marrow, lymph nodes spleen, GALT, MALT, Types of immunity, Innate immunity, acquired immunity, Lymphoid cells mononuclear cells, granulocytic cells, mast cells, basophils, dendritic cells, MHC molecules and compliments.	

V	Structure of immunoglobulins-IgG, IgM, IgA, IgE, monoclonal antibodies. Antigen antibody interactions, cross reactivity, precipitation reaction, agglutination reaction. Hypersensitivity, Autoimmunity, Transplantation, Immunodeficiency diseases, Passive and active immunization, Vaccines, whole organism vaccines, recombinant vector vaccines. DNA vaccines, synthetic vaccines.	

Recommended Books:

1. Vertebrate Endocrinology by Norris (Lea and Febigar)
2. Basic & Clinical Endocrinology by Greenspan and Strewler
3. Essentials of Immunology, David, Brostoff and Roitt, Mosby & Elsevier Publishing
4. Kuby Immunology by Glodsy, Kindt and Osborne
5. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Elsevier Publishing
6. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, Garland Science Publishing
7. Hadley: Endocrinology, Prentice hall. International Edition. 2000
8. Brooks and Marshall: Essentials of Endocrinology, Blackwell Science. 1995
9. Turner and Bagnara: General Endocrinology, W. B. Saunders Company Philadelphia. 1984
10. Larson: Williams Text Book of Endocrinology, 10th edition. W. B. Saunders Company, Philadelphia.

Practical Course Syllabus **Semester II** **Credit -4** **Time -4 Hrs**

- Numerical related to deviation of Monohybrid and Dihybrid ratio.
- Numerical related to H & W law.
- Barr's Body, Karyotype, Idiotype
- Chromosome banding Pattern.
- Study of (case) of Genetic disorders- Demonstration.
- Pedigree analysis by chart / demonstration
- **Biostatistics-** Histogram, Bar chart, Pie diagram, Central tendency, standard deviation Chi square test, t-test,
- **Bio informatics-** BLAST, FASTA, Protein Data base, primer designing for gene amplification
    - Genomic annotation, using ORF (open reading Frame), construction of phylogenetic Tree, Software to study Protein structure.
- **Physiology-**
    - Histological slides – Pituitary, Thyroid, Parathyroid, Adrenal glands, Kidney, CNS, arteries, veins, Liver, Pancreas, Testes, Ovary.
    - RBC, WBC Count, Bleeding time, Clotting time,
    - Hb %, Haemin Crystals, ESR, Blood group determining test
    - B.P., Muscle twitch, Knee jerk, Reflex action
- **Biochemistry-**
    - Osmosis. pH, Buffers, Biochemistry test related to carbohydrate Protein lipid, Nucleic acid
    - Project report lab related to Bioinformatics and Biochemistry.

Marks Distribution-

• Genetics	1-Numerical	15
• Biostatistics	Numerical	15
• Bioinformatics	(Exp.)	10

Experiments

• Physiology-2/Endocrinology	10
• Bio chemistry -2	10
• Spotting	10
• Field/ Project report	10
• Viva	10
• Record	10

Programme/Class:	Year: Second	Semester: Third
Subject: Zoology		
Course code:0927801	Course Title: Diversity of chordates	
Course outcome: The course will enable the students to understand the evolutionary history and relationship between the different classes of chordates. It will also help them to understand the significance of the differences in their habits, habitats and distribution.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Origin and evolution of chordates, General Organization & Affinities of Cephalochordates and Urochordates Vertebrate ancestry: Introduction, origin and evolution of vertebrates.	Total No. of Lectures (60)
II	Fish: General Organization, classification and Affinities of Agnatha, and Gnathostomes-Placoderms, Ostracoderms Acanthodians, Chondrichthyes, Osteichthyes, Coelacanthiformes and Dipnoi Parental care and migration. Structural and Functional adaptations of fishes.	
III	Terrestrial Vertebrates, Tetrapod phylogeny. Modern Amphibians-Diversity, Distribution, Status, General organization, Classification, Parental Care, Neoteny and paedogenesis.	
IV	Reptiles: General Organization and classification, Skull of reptiles and its significance in systematics, Adaptive radiation in reptiles, Mesozoic world of reptiles and extinction. Birds: Origin, General organization and classification, Structural and functional modifications for aerial life. Birds are glorified reptiles.	

V	Mammals: General Organization and classification, Organization & Affinities of Prototheria, Metatheria and Eutheria, Organisation and adaptation of aquatic mammals, Adaptive radiation in mammals.	

Recommended Books:

1. Colbert,.E. H., Morales, M. and Minkoff, E. C. Colbert's Evolution of the Vertebrates: A history of the backboned animals through time, 5th edition, John Wiley - Liss, Inc., New York, 2002. (29)
2. H.H. Newman: The Phylum Chordata
3. Harvey et al.: The Vertebrate Life (2006)
4. Kotpal, R. L. The Birds, 4th edition, Rastogi Publications, Shivaji Road, Meerut, 1999.
5. Marshall, A. J., Biology and Comparative Physiology of Birds, Volume I & II, 1960.
6. Parker, T. S. and Haswell, W. A., Text Book of Zoology, Vol. II, ELBS, 1978.
7. Romer, A. S. and Parsons, T. S., The vertebrate body, 6th edition, CBS Publishing Japan Ltd, 1986.
8. Sinha, A. K., Adhikari, S. and Ganguli, B. B.: Biology of Animals, Vol. II, New Central Book Agency, Calcutta, 1988.
9. Young, J. Z. The life of vertebrates, 3rd edition, ELBS with Oxford University Press, 1981.

Programme/Class:	Year: Second	Semester: Third
Subject: Zoology		
Course code: 0927803	Course Title: Ecology and Ethology	
Course outcome: To provide a broad framework for understanding the delicate relationship between the humans and their environment. Behaviour is the link between the organisms and environment, between the nervous system and the ecosystem. Behaviour is that part of an organism by which it interacts with its environment. The students will acquire the knowledge of key concepts and principles and themes in animal behaviour.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	
Unit	Topics:	

I	Concept of Environment and Habitat, Major terrestrial biomes Population ecology, population dynamics, population regulation, life history strategies (r and K selection): concept of metapopulation-demes and dispersal. Species interactions- interspecific competition, herbivory, carnivory, pollination, symbiosis. Community ecology- community structure, diversity, complexity and stability, edges and ecotones.	Total No. of Lectures (60)
II	Ecosystem: Structure and function: energy flow and mineral cycling (CNP), Niche width and overlap: fundamental and realized niche: resource partitioning, character displacement. Ecological succession: Pattern, Types and mechanism of succession.	
III	Environmental pollution; global environmental change. Conservation biology Principles of conservation, Concept of sustainability and sustainable development Remote sensing and prospects of remote sensing in India, Geoinformatics and GPS technology.	
IV	Introduction and History of ethology. patterns, objectives and mechanism of behaviour. Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM	
V	Hormones and pheromones influencing behaviour of animals Eusociality, social organization in Insects and Primates Altruism – reciprocal altruism, group selection, kin selection and inclusive fitness, cooperation, alarm call. Parental care, parental manipulation	

Books Recommended

Odum: Basic Ecology (Saunders, 1985)
Turk and Turk: Environmental Science (4rth ed. Saunders, 1993)
Calabrese: Pollutants and High-Risk Groups (John Wiley,1978)
Raven, Berg, Johnson: Environment (Saunders College Publishing, 1993)
Cunningham and Saigo: Environmental Science (McGraw Hill Boston, 5th ed., 1999)
Kormondy: Concepts of Ecology
Ricklefs and Miller: Ecology (Freeman and Company, New York, 4th ed., 2000)
An Introduction to Animal Behaviour (6th Edition). Aubrey Manning and Marian Stamp Dawkins, Cambridge University Press.
Animal Behaviour (11th Edition). Dustin R. Rubenstein and John Alcock, Sinauer Associate Inc., USA, 2018.
Animal Behaviour: Psychobiology, Ethology and Evolution David McFarland.
Animal Behaviour (Ethology) by Agrawal V.K, S. Chand publication.
Animal Behaviour: Psychobiology, Ethology and Evolution

Programme/Class:	Year: Second	Semester: Third
Subject: Zoology		
Course code: 0827804	Course Title: Animal biotechnology	

Course Outcomes- Enable the students to understand the principles and practices of biotechnology and provide broad training in technical skills of biotechnology. To produce responsible biotechnologists that can work within the interdisciplinary framework of biotechnology and other relates biological fields.

Credits: 4	Elective
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	
I	Introduction and scope of biotechnology, Tools and techniques in biotechnology. Cell culture media (natural and defined), Preparation and sterilization, Primary cell culture, Cell lines, Pluripotent stem cells, Cryopreservation of cultures.	Total No. of Lectures (60)
II	Molecular Techniques in Gene manipulation Introduction to the concept of Recombinant DNA Technology, Cloning vectors, Restriction and modifying enzymes, Transformation techniques (microbial, plants and animals), Construction and screening of DNA libraries, Molecular analysis of DNA, RNA and Proteins. Microarray, chromosome walking, Cre lox system, CRISPR-CAS technology.	
III	Transgenic Animal Technology Production of transgenic animals-nuclear transplantation, Retroviral method, DNA microinjection method, Applications of transgenic mice, sheep, goat, pig, birds and fish, Dolly and Polly, Scientific significance, Therapeutic applications, Human cloning, Ethical issues of transgenic animals.	
IV	Applications of Biotechnology Molecular diagnosis of genetic diseases. RFLP, RAPD and DNA fingerprinting, Vaccines and therapeutic agents, Recombinant DNA in medicines, Gene therapy, Heterologous protein production, Bioremediation.	
V	Industrial Biotechnology: Industrial-Scale Fermentation, bioreactors and its types, Bioreactors for Cell Culture, Enzymes in detergents and leather industries, Intellectual property rights, Biosafety levels and guidelines.	

Recommended Books:

1. Glick, B.R. and Pasternak, J.J. (2009). Molecular biotechnology- Principles and applications of recombinant DNA. IV Edition. ASM press, Washington, USA.
2. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An introduction to genetic analysis. IX Edition. Freeman & Co., N.Y., USA.
3. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007). Recombinant DNA- genes and genomes- A short course. III Edition. Freeman and Co., N.Y., USA.
4. Watson, J.D., Gilman, M., Witkowski, J. and Zoller, M., (1983) Recombinant DNA. II Edition. Freeman and Co., N.Y., USA.
5. Butler, M. (2004). Animal cell culture and technology: The basics. II Edition. Bios scientific publishers.
6. Brown, T.A. (1998). Molecular biology Labfax II: Gene analysis. II Edition. Academic Press, California, USA.
7. Primrose and R.M. Twyman, Principles of gene manipulation and genomics.

Programme/Class:	Year: Second	Semester: Third
Subject: Zoology		
Course code:0927805	Course Title: Biology of Parasitism	

Course outcome: The course will give ample space to understand the various types of interactions of parasites with their hosts and their life cycle especially of protozoan and helminths. : The course material will provide a deep insight into the various physiological and biochemical aspects of parasites and will help students to pursue research in parasitology.

Credits: 4	Elective
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	Total No. of Lectures (60)
I	Introduction to parasitology; animal associations and host – parasite relationship; Parasitic Adaptation: Evolution of Parasitism. Fate of Parasite. Adaptation to Parasitism Host specificity, Ectoparasite, Endoparasite i. Action of Parasite upon their Hosts	
II	Morphology, lifecycle, mode of infection, molecular biology of Plasmodium & Leishmania, – drug targets, mechanism of drug resistance, vaccine strategies Morphology, biology, life-cycle, mode of infection of Trypanosoma, Entamoeba, Giardia	
III	Gastro-intestinal nematodes, morphology, biology, life-cycles, modes of entry of *Schistosoma, Wuchereria, Ancylostoma, Trichinella* and *Dracanculus*; Parasitic adaptions & molecular biology of nematodes, vaccine strategies.	
IV	Immune response and self-defence mechanisms, immune evasion and biochemical adaptations of parasites; Immunobiology of Protozoans, Nematodes, Trematodes and Cestodes, parasites of veterinary importance.	
V	Parasites of insects and their significance; nematode parasites of plants, morphology, biology, lifecycle and infection of crop plants by plant parasitic nematodes.	

Recommended Books:

1.General Parasitology by TC Cheng. Publisher Orlando: Academic Press
2.Foundations of Parasitology, Roberts L.S. and Janovy J., McGraw-Hill Publishers, New York, USA.
3.Modern Parasitology: A Textbook of Parasitology, FEG Cox., Wiley-Blackwell, U. K
4.Immunoparasitology by Phillip Scott. Publisher: Blackwell Munksgaard
5.Immunoparasitology by André R.G. Capron. Publisher: Saunders, Philadelphia
6.Advances in Parasitology by B Dawes. Publisher: Academic Press, NY
7.Modern Parasitology: A Textbook of Parasitology by FEG Cox. Publisher: John Wiley & Sons, USA

Practical Course Syllabus **Semester III** **Credit -4** **Time -4 Hrs**

- **Virtual Dissection**
- **Major Dissection-**
  - Cranial Nerves of Scoliodon and Frog, Efferent and afferent Blood vessel of Scoliodon
- **Minor Dissection** – Wheel organ and oral hood of Amphioxus, Afferent blood vessel, ampulla of
  - lorenzini, Internal ear, hyoid apparatus, columella auris (Frog)
  - Museum specimens and slides of various chordate classes
- **Comparative osteology-** Amphibia, reptiles, Aves and mammals (Articulated & Disarticulated
  - bones Skull, vertebrae, limbs and Girdles)
- **Mounting** – amphioxus whole mount, oral hood, vestibule, Ciona, Scales of Fish, feathers of birds, smooth and skeletal muscle.
- **Histological Techniques** –
  - Fixation, Dehydration, clearing, Embedding, microtomy, staining.
  - Embryology- Preparation of chick embryo- (primitive streak and different embryonic stages slides)
  - Frog- Preparation and slides Blastula, Gastrula,
- **Ecology-** pH, TDS, EC, Hardness, DO, soil Moisture, Detection of soil, Aquatic Fauna, pelagic,
  - Benthic, Population dynamics, community, Ecological energetics
- **Pollution-** AIR pollution, water pollution, Periodic monitoring of surrounding and its data analysis
  - Field visit to Sewage treatment plant, National Parks, Biosphere reserves, Zoo, Botanical gardens and prepare reports.
- Behaviour- Fixed action pattern, Taxes (Chemo-, thigmo-, thermo-, photo)
- Social behaviour- Honey Bee, Ants and Termites
- Territorial Behaviour- Primates
- Demonstration of Photoperiodic clock.
- Recording of body temp. (15/30 days periodic)
- Demonstration of assay on circadian rhythm using animal model system.
- Field visit

Marks Distribution

• Major Dissection	:	10
• Minor Dissection	:	05
• Mounting	:	05
• Microtomy	:	10 (4+3+3) (section cutting, stretching and staining)
• Spotting	:	1x10 (4+4+2) Slides, specimens, Bones
• Embryology	:	5x2=10
• Ecology	:	5x2=10
• Parasitology/Biotechnology	:	5x2=10
• Collection / Field report	:	10
• Viva	:	10
• Record	:	10

Programme/Class:	Year: Second	Semester: FOURTH
Subject: Zoology		
Course code: 1027801	Course Title: Classical Taxonomy and Systematics	

Course Outcome: To understand animal taxonomy and taxonomic characters, acquire knowledge on taxonomic keys and identify species, develop interest in the field taxonomy of animals, acquire in-depth knowledge on fauna and its ancestral relationships.

Credits: 4	Core Compulsory
Max. Marks: (25+75)	Min. Passing Marks: 40

Unit	Topics:	
I	The scope of Taxonomy, History of Indian taxonomic zoology, Taxonomic evidence and evolutionary interpretation: Definition and Kinds of evidence, Similarity, Homology and Homoplasy.	Total No. of Lectures (60)
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.	
III	Concept of characters. Role of morphology, comparative anatomy, embryology, karyology, paleozoology, ecology, physiology and biochemistry in taxonomy, Ranking in taxonomy.	
IV	Taxonomic collection, cataloguing and curation (dry and fluid objects, collection care, pest prevention, environmental factors affecting collections, collection storage). Reference works in taxonomy: Zoological record, Abstracts, Biological dissertation, (entomology, helminthology, protozoology).	
V	Identification methods: Literature, Keys, Pictures, Direct comparison, Combination of different methods in identification, Taxonomic identification, Preparation of taxonomic papers (description of keys, classification, synonymies, bibliography, nomenclature, illustration).	

Recommended Books:

1. An introduction to Taxonomy. Narendran, T.C. 2008. Zoological survey of India.
2. Principles of Systematic Zoology. Mayr, E. McGraw Hill Book Company, Inc., NY.
3. This is Biology: The Science of Living world. Mayr, E. Universities Press Ltd.
4. Theory & Practice of Animal Taxonomy V.C. Kapoor, 5th Edition Oxford & IBH Publishing Co.

Programme/Class:	Year: Second	Semester: Fourth
Subject: Zoology		
Course code: 1027802	Course Title: Molecular Taxonomy and Systematics	
Course outcome: Understand the importance of molecular taxonomy and the importance of molecular tools in taxonomy.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Molecular Systematics: Context and controversies; collection and storage of cells and tissues. Methods of estimating genetic diversity – isozymes, RFLP, RAPD and its modifications. Applications of molecular systematics.	Total No. of Lectures (60)
II	Animal Genomes: Generating molecular data- gene mapping and gene sequencing; Types of molecular data, analysis of molecular data – alignment of sequences, homoplasy, phylogeny reconstruction, gene trees and species trees; molecular characters- mitochondrial DNA and its role in systematics, Role of RNA in Systematics.	
III	Digital Taxonomy – Principles of computer-aided taxonomy – data retrieval systems – Phenetic taxonomy: objectives and hypothesis – selection of operational taxonomic units, character clans and character stage, degree of overall similarity and dissimilarity, cluster analysis. Cladistic taxonomy: Use of morphological, zoochemical and molecular data in cladistics. molecular systematics and phylogeny. Soft-wares and their use in construction of dendrograms and cladistic analysis.	
IV	Taxonomic data bases, need for such databases, Taxonomic Databases working Group, The Tree of life – Tree base – Database on Phylogenetic knowledge – Taxonomic information systems, databases on Biodiversity.	
V	Numerical data analysis with R; data structures, import of data, visualisation, programs in R, multivariate data analysis (clustering, PCA, classification) in R, program package in R, interface with MySQL	

Recommended Books:

1. Bioinformatics-Sequence and Genome Analysis-David W. Mount, CSHL Press
2. Molecular Systematics, 2nd ed. D.M. Hillis, C. Moritz and B.K. Mable, Sinauer Associates, Sunderland. Massachusetts.
3. Fundamental Concepts of Bioinformatics, Krane, D.E. and Raymer M.L. Pearson Education
4. Molecular Systematics. David M. H, Craig Moritz and K.M. Barbara. Sinauer Associates, Inc.
5. Tree thinking: an introduction to phylogenetic biology, Baum, David A.; Smith, Stacey D., Greenwood Village, Colo., Roberts.

Programme/Class:	Year: Second	Semester: Fourth
Subject: Zoology		
Course code:1027804	Course Title: Biodiversity Management	
Course outcome: To understand the importance of biodiversity conservation, biodiversity conservation laws, wildlife management methods, biodiversity hotspot and to gain expertise in different biodiversity quantifying methods. To understand the biodiversity of India with special reference to the Himalayas.		
Credits: 4	Core Compulsory	
Max. Marks: (25+75)	Min. Passing Marks: 40	

Unit	Topics:	
I	Biodiversity- Definition, history, present status and documentation. Relevance of Systematics and molecular taxonomy to biodiversity and conservation. Mega diverse countries, Global hotspots. Quantifying Biodiversity: Assessing, Inventory, Monitoring, Faunal assessment and sampling techniques, species area relation, marine realms and freshwater regions. Latitudinal and Altitudinal gradients of biodiversity, Zonation in seas and mountains. Endemism and Biodiversity. Ecological relations, keystone species, umbrella species, flagship species and endangered animals, Red data list.	Total No. of Lectures (60)
II	Threats to biodiversity: Extinction- past mass extinction, current human caused extinction, extinction rates in islands, local extinctions, vulnerability to extinction, endemic species and extinction, Habitat destruction, Fragmentation, Overexploitation, Invasive species and diseases. Genetic erosion and degradation of aquatic ecosystems and pollution. Species extinction, metapopulation, minimum viable population. Effects of global warming on biodiversity Values of Biodiversity: Natural capital, Direct and indirect values- economic, ecological, evolutionary, aesthetic, emotional and ethical, Economic evaluation of biodiversity, Ecosystem services and its importance. Conservation of Biodiversity: Ex-situ and in-situ methods, Captive breeding and gene banks. Evaluation of priorities for species and habitats: Choosing species to protect. Hotspots for conservation, UNESCO Man and Biosphere Programme, World heritage sites. Genetics in Conservation of biodiversity. (TEK), Biodiversity and sustainable development.	
III	Conservation Organizations and laws: CBD, Ramsar Convention, CITES, UNFCC; IUCN, WWF, Conservation International (CI), TRAFIC, UNEP, WCMC etc. Earth summit, World summit, Biological Diversity Act 2002 and Rules 2004, National Action Plan and Strategy for biodiversity conservation, National Biodiversity Authority, State Biodiversity Boards, State Action Plan, Biodiversity Management Committees (BMCs); People's participation in the conservation of biodiversity, Peoples biodiversity register (PBR).	

IV	Principles and practices of wildlife management. Management of special habitats; riparian zones, grasslands etc. Analysis and need for wildlife management, problems in plantations and exploited forests; Species conservation projects - tiger, lion, rhino, and elephant. Management plan for Protected Areas: Forest working plans and wildlife management plans. Landscape approach and use of modern technology - GIS/GPS/Imagery, camera trapping/Drones etc) in wild life management. Human wildlife conflicts.	
V	Biodiversity of India with special reference to the Himalayas, Eco regions of India, Distribution of biodiversity hotspots, endangered species, National parks, Biosphere reserves, World natural heritage sites and Wild life sanctuaries. Origin of the Himalayas, Geology and geographical Features, Rivers, Environment, biodiversity, Protected Areas of the Himalayas. Threats to Bio Diversity of the Himalayas. The Paradigm Changes -Habitat Fragmentation, Degradation and Loss, Shrinking Genetic Diversity- Declining Natural Resource Base and Overexploitation of Resources, Invasive Alien Species, Climate Change and Desertification, Impact of Development Projects, NMSHE and SECURE Himalaya Project, Biodiversity of Himalayas, protected areas, conservation initiatives and challenges. Local issues and Traditional farming practices. India's Biodiversity Act 2002 and its role in conservation.	

Recommended Books:

1. Biodiversity and Ecosystem functioning. edited by Michel Lorean, Shahid Naureen and Pablo Inchausti (Oxford University Press.)
2. Biodiversity and Conservation in Forests. By Diana. F. Tomback. Publication MDPI
3. Methods and Practice in Biodiversity Conservation by David Hawks-worber. (Springer Publication)
4. Recent Studies in Biodiversity and Traditional Knowledge in India. By Chandra Ghosh and A.P. Das (Publisher: Levant Books)
5. Biodiversity and Protected Areas by Beazley, Karen, Baldwin, Robert. (Publishers: MDPI)
6. An Advanced Text book on Biodiversity (Principle and Practice) by K.V. Krishnamurthy. (Publication-CBS)
7. Biodiversity Hotspots edited by Vittore Rescigrio and Savario Moletta. (Publishers: Nova Science Publishers)
8. Wildlife Management and Conservation. Contemporary Principles and Practices. 2013. Paul R. Krausman and James W. Cain III (ed). John Hopkins University Press.
9. Essential readings in Wildlife Management and Conservation. 2013. Paul R. Krausman and Bruce D. Leopold. John Hopkins University Press.

Practical based on above

Practical class/field visit record file evidences to be maintained by the students and submitted at the time of practical examination for evaluation by the examiners.

Duration: 5 hrs **M.M.: 100 Marks**

- Study of museum specimens - 70 invertebrates and 30 vertebrates (List the studied items with brief descriptions. Diagrams not necessary). Larval forms – any 10 larvae from different taxa
- Preparation of dichotomous key of 4 specimens up to family (insects/spiders/ fishes/ snakes of any three taxa). Preparation of Cladogram based on the specimens provided (at least five museum specimen)
- Collection of planktons from freshwater, brackish/marine water ecosystems & identification of at least 5 planktons from each ecosystem
- Collection and separation of soil organism using Bearman's and Berlese apparatus and Identification
- Study of tools &instruments and standard methods used in collection of different organisms from the field.
- Tools and techniques involved in museum preservation of specimens.
- Demonstration of BLAST for sequence comparison and MEGA for phylogenetic analysis and phylogenetic tree construction.
- Study and calculation of the following biodiversity indices based on field data: (a)Shannon-Wiener Index
- (b)Richness index
- (c)Evenness index
- (d)Simpson's Diversity Index
  Using Excel or other software.
- Composition assessment of the taxonomic diversity/biodiversity in a habitat
- Population studies - Estimation of Abundance, Population Density, Relative density Frequency and Relative frequency
- Prepare field study reports and submit for evaluation
- Visit to museums/repositories and make a report and submit for evaluation.