J .C. Bose University of Science and Technology, YMCA,

Faridabad

(Formerly YMCA University of Science and Technology)

Accredited 'A+' Grade By NAAC

A State Govt. University established wide State Legislative Act. No. 21 of 2009

SECTOR - 6, FARIDABAD, HARYANA-121006

Department of Life Sciences

w.e.f. 2023

SCHEME AND SYLLABI

M.Sc. ZOOLOGY

J C BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA

VISION

J. C. Bose University of Science and Technology, YMCA aspires to be a nationally and internationally acclaimed leader in technical and higher education in all spheres which transforms the life of students through integration of teaching, research and character building.

MISSION

● To contribute to the development of science and technology by synthesizing teaching, research and creative activities.

● To provide an enviable research environment and state-of-the art technological exposure to its scholars.

● To develop human potential to its fullest extent and make them emerge as world class leaders in their professions and enthuse them towards their social responsibilities.

DEPARTMENT OF LIFE SCIENCES

VISION

A department established with a multidisciplinary approach for exploring different dimensions of biology and its applications for imparting conceptual and technical skills to students leading to the fostering of scientific temperament.

MISSION

- To mentor students for developing conceptual understanding of the subject leading to its application in resolving societal and environment concerns.
- To provide holistic training to the student to succeed in the society
- To inculcate the thirst for learning and the zest for research.

PROGRAM OUTCOMES OF PG PROGRAM OF FACULTY OF SCIENCES

PO1	**Knowledge**	Capable of demonstrating comprehensive disciplinary knowledge gained during course ofstudy
PO2	**Research Aptitude**	Capability to ask relevant/appropriate questions for identifying, formulating and analyzing the research problems and to draw conclusion from the analysis
PO3	**Communication**	Ability to communicate effectively on general and scientific topics with the scientific community and with society at large
PO4	**Problem Solving**	Capability of applying knowledge to solve scientific and other problems
PO5	**Individual and Team Work**	Capable to learn and work effectively as an individual, and as a member or leader in diverse teams, in multidisciplinary settings.
PO6	**Investigation of Problems**	Ability of critical thinking, analytical reasoning and research-based knowledge including design of experiments, analysis and interpretation of data to provide conclusions
PO7	**Modern Tool usage**	Ability to use and learn techniques, skills and modern tools for scientific practices
PO8	**Science and Society**	Ability to apply reasoning to assess the different issues related to society and the consequent responsibilities relevant to the professional scientific practices
PO9	**Life-Long Learning**	Aptitude to apply knowledge and skills that are necessary for participating in learning activities throughout life
PO10	**Ethics**	Capability to identify and apply ethical issues related to one‘s work, avoid unethical behaviour such as fabrication of data, committing plagiarism and unbiased truthful actions in all aspects ofwork
PO11	**Project Management**	Ability to demonstrate knowledge and understanding of the scientific principles and apply these to manage projects

PROGRAM SPECIFIC OUTCOMES (PSOs)

The program specific outcomes (PSO‘s) are the statement of competencies/abilities that describes the knowledge and capabilities of the post-graduate will have by the end of program studies.

After successful completion of M.Sc. Zoology, the students will be able to

PSO1	Strengthen their foundation on various zoology concepts and phenomena through theoretical and practical knowledge
PSO2	Upgraded themselves with new discoveries in biological world and inculcate continuous learning and self-improvement and gets motivated for higher studies and research.
PSO3	Tackle detailed problem-solving and analytical tasks associated with pure and applied zoological questions, in areas that include evolution, ecology and conservation
PSO4	Develop independent thinking, good communication and scientific skills and to acquaint them with professional ethics so that they can work well in an industrial or academic environment

J. C. BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA, FARIDABAD

DEPARTMENT OF LIFE SCIENCES
SCHEME M.Sc. ZOOLOGY

SEMESTER-I

Sr.No.	Course Code	Subject	Teaching hours per week			Maximum marks			Credits	Category course
			L	T	P	Int	Ext	Total		
1.	MZO-101	Biochemistry	4	0	0	25	75	100	4	DCC
2.	MZO-102	Biostatistics and Scientific ethics	4	0	0	25	75	100	4	DCC
3.	MZO-103	Cell and Molecular Biology	4	0	0	25	75	100	4	DCC
4.	MZO-104	Genetics	4	0	0	25	75	100	4	DCC
5.	MZO-105	Microbiology	4	0	0	25	75	100	4	DCC
6.	MZO-106	Zoology Lab Course I	0	0	12	30	70	100	6	DCC
7.		MOOC*								
		Total	**20**		**12**			**600**	**26**	

DCC: Discipline Core Course; MOOC: Massive online open course; L: Lecture; T: Tutorials; P: Practicals

*The students must pass at least one mandatory MOOC course with 4−6 credits (12−16 weeks) from the list given on the Swayam portal or the list given by the department/ university from 1st semester to 3rd semester as notified by the university.

Instructions to the students regarding MOOC

1. Two types of courses will be circulated: branch specific and general courses from the website https://swayam.gov.in in the month of June and November every year for the forthcoming semester.
2. The department coordinators will be the course coordinators of their respective departments.
3. Every student must pass a selected MOOC course within the duration as specified below: Programme Duration for M.Sc.: Sem. I to Sem. III

The passing of a MOOC course is mandatory for the fulfilment of the award of the degree of concerned programme.

4. A student must register for the course for which he is interested and eligible which is approved by the department with the help of course coordinator of the concerned department.
5. A student may register in the MOOC course of any programme. However, a UG student will register only in UG MOOC courses and a PG student will register in only PG MOOC courses.
6. The students must read all the instructions for the selected course on the website, get updated with all key dates of the concerned course and must inform his/her progress to their course coordinator.
7. The student must pass the exam (online or pen−paper mode as the case may be) with at least 40% marks.
8. The students should note that there will be a weightage of Assessment/quiz etc. and final examination appropriately as mentioned in the instructions for a particular course.
9. A student must claim the credits earned in the MOOC course in his/her marksheet in the examination branch by forwarding his/her application through course coordinator and chairperson.

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DEPARTMENT OF LIFE SCIENCES
SCHEME M.Sc. ZOOLOGY

SEMESTER-II

Sr.No.	Course Code	Subject	Teaching hours per week			Maximum marks			Credits	Category course
			L	T	P	Int	Ext	Total		
1.	MZO-201	Animal Biotechnology	4	0	0	25	75	100	4	DSC
2.	MZO-202	Biotechniques	4	0	0	25	75	100	4	DCC
3.	MZO-203	Ecology and Environmental ZOOLOGY	3	0	0	25	75	100	3	DSC
4.	MZO-204	Genetic Engineering and Introductory Bioinformatics	4	0	0	25	75	100	4	DCC
5.	MZO-205	Immunology	4	0	0	25	75	100	4	DSC
6.	MZO-206	Zoology Lab-II	0	0	12	30	70	100	6	DSC
7.		AUDIT COURSE	2	0	0	25	75	100	0	
		Total	**21**		**12**			**700**	**25**	

DSC: Discipline Specific Course; AUD: Audit Course

*Audit course will be offered as per courses offered by various departments in the University

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DEPARTMENT OF LIFE SCIENCES
SCHEME M.Sc. ZOOLOGY

SEMESTER-III

Sr.No.	Course Code	Subject	Teaching hours per week			Maximum marks			Credits	Category course
			L	T	P	Int	Ext	Total		
1.	MZO-301	Metabolism	4	0	0	25	75	100	4	DCC
2.	MZO-302	Animal Behaviour	3	0	0	25	75	100	3	DSC
3.	MZO-303	Molecular and Applied Endocrinology	3	0	0	25	75	100	3	DSC
4.	MZO-304	Structure and functions of non-chordates	4	0	0	25	75	100	4	DSC
5.		Discipline Elective I • Chronobiology (MZO-DE002) • Insect vector and diseases (MZO-DE003) • Fisheries and aquaculture (MZO-DE004) • Comparative Physiology (MZO-DE005) • Applied Zoology (MZO-DE001)	3	0	0	25	75	100	3	DSE
6.	MZO-305	Zoology Lab Course-III	0	0	12	30	70	100	6	DSC
7.		Open Elective Course	3	0	0	25	75	100	3	OEC
		Total	**20**		**12**			**700**	**26**	

DSE: Discipline Specific Elective Course

*Open Elective course will be offered as per courses offered by various departments in the University

J. C. BOSE UNIVERSITY OF SCIENCE AND TECHNOLOGY, YMCA, FARIDABAD

DEPARTMENT OF LIFE SCIENCES
SCHEME M.Sc. ZOOLOGY

SEMESTER-IV

Sr.No.	Course Code	Subject	Teaching hours per week			Maximum marks			Credits	Category course
			L	T	P	Int	Ext	Total		
1.	MZO-401	Developmental biology	4	0	0	25	75	100	3	DSC
2.	MZO-402	Evolutionary Biology	3	0	0	25	75	100	4	DSC
3.	MZO-403	Structure and functions of chordates	4	0	0	25	75	100	4	DSC
4.		Discipline Elective II • Virology (MMT-DE002) • Genomics and Proteomics (MMT-DE001) • Environmental Toxicology (MZO-DE006)	3	0	0	25	75	100	3	DSC
5.	MZO-404	Zoology Lab Course-IV	0	0	12	30	70	100	6	DSC
6.	MZO-405	Dissertation	0	0	8			100	4	DSC
		Total	**14**		**20**			**600**	**24**	

DSE: Discipline Specific Elective Course

*Open Elective course will be offered as per courses offered by various departments in the University

M.Sc. ZOOLOGY SEMESTER I
CODE: MZO-101
SUBJECT NAME: BIOCHEMISTRY

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective:
To provide students with a strong foundation in the molecular and chemical processes that govern biological systems, and prepare them for further study or research in related fields such as biotechnology, physiology, pharmacology, and medicine.

Unit I
- Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice
- Carbohydrates: Structure, occurrence and biological importance of monosaccharides, oligosaccharides and polysaccharides; Glycosaminoglycans; Lectins

Unit II
- Common structural features, classification and properties of amino acids
- Classification and structure of proteins (Primary, secondary, tertiary & quaternary); Ramachandran Plot; Protein folding and role of chaperons in protein folding, Determination of amino acid sequence.
- Classification, structures and properties of fatty acids; Acylglycerols; Structure and properties of different types of phospholipids and sphingolipids (sphingomyelins, cerebrosides&gangliosides)

UNIT III
- Nucleotides; Nucleic acid as genetic material-experimental evidences; Chargaff's Rule; Double helical model of DNA structure; Structural polymorphism of DNA (A, B and Z-DNA); RNA; Biological functions of nucleotides
- Vitamins: general characteristics and properties

Unit IV
- General characteristics and nomenclature of enzymes; Mechanism of enzyme catalysis.
- Enzyme kinetics: Michaelis-Menten kinetics, Lineweaver-Burk, Hanes-Woolf, Woolf Augustinsson-Hofstee, Eadie-Scatchard; Direct linear plot
- Types of inhibition, Abzymes, Zymogens, Catalytic antibodies

References
1) Biochemistry by Berg. J. M, Tymoczko. J. L, Stryer, L. 9 ed. W.H. Freeman, 2019.
2) Bioenergetics at a glance by D.A. Harris. John Willey and Sons Ltd, 1995.
3) Lehninger's Principle of Biochemistry by Nelson D.L, Cox. M. M. 8 ed. W. H. Freeman, 2021

4) Principles of Biochemistry by D. Voet, J. Voet and C.W.Pratt. Biochemistry.5th ed., John Wiley, 2018.
5) Harper's Illustrated Biochemistry by P. Kennelly, K. Botham, O.McGuiness, V. Rodwell and P.A.Weil

Course Outcome:

After the successful completion of the course the learner would be able to:
CO.1. Comprehend the importance of chemical foundation in living organisms.
CO.2. Develop an understanding of various biomolecules in the cell and their functions
CO.3. Utilization of the concepts in various biochemical studies, research and analysis.

Y SEMESTER I
CODE: MZO-102
SUBJECT NAME: BIOSTATISTICS AND SCIENTIFIC ETHICS

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course focuses on developing concepts about types of experimental biological data, processing and analysis to further formulate hypothesis in experiments.

Unit I

- Application of statistics in Biology**,** Types of Biological data, Collection, Frequency Distributions, Cumulative Frequency Distributions, Population and Samples, Outliers
- Measures of central tendency: Mean, Median, Mode, Quartile, and Percentile. Measures of Dispersion: Range, Variance, Standard deviation, Coefficient of Variation, Correlation and Regression
- Probability and its applications: Laws of Addition and Multiplication, Compound Probability, Bayes theorem. Probability distributions: Binomial, Poisson and Normal distributions and their applications.

Unit II

- Testing of hypothesis: Parameter and Statistic, Sampling distribution and Standard error, Null and Alternative hypotheses, Simple and composite hypotheses, Two types of errors, Level of significance and Power of the test, One tailed and two tailed tests.
- Tests of significance: t and Z tests for mean and proportion for one and two samples, Chi square test of goodness of fit and independence. F test, Analysis of variance for one way and two way classification.
- Elementary ideas of Designs of Experiments Important statistical softwares and their applications

Unit-III

- Technical writing skills: types of reports, layout of a formal report. Plagiarism, software for plagiarism.
- Scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references. Drafting titles and framing abstracts.
- Publishing scientific papers: peer review process and problems, recent developments such as open access and non-blind review; bibliometric analysis; Scientific misconduct.

References

1. Daniel, Wayne W. (2007) Biostatistics: A Foundation for Analysis in Health Sciences 10th Edition, Wiley Series.
2. Pagano, Marcello and Gauvreau, Kimberlee (2000) Principles of Biostatistics, 2nd Edition, Session: 2020-21 18 CRC Press.
3. Zar, J. H. (1999). Biostatistical analysis. Pearson Education Inc.
4. Sokal, R. R., Rohlf, F. J., &Rohlf, J. F. (1995). Biometry. Macmillan.
5. Valiela, I. (2001). Doing Science: Design, Analysis, and Communication of Scientific Research. Oxford: Oxford University Press.
6. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press.
7. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. AmericanScientist, 78 (Nov-Dec 1990), 550-558.

Course Outcomes:

CO1. Understand the concept and scope of statistics in biological data generation, collection and sampling.

CO2. Develop skills for writing scientific paper and understanding of plagiarism and scientific misconduct.

CO3. Apply the acquired skill in data interpretation, record keeping and scientific document generation.

M.Sc. ZOOLOGY SEMESTER I
CODE: MZO-103
SUBJECT NAME: CELL AND MOLECULAR BIOLOGY

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: To provide students with basics of cellular organization and underlying molecular mechanism.

Unit I

- Bio membranes: Molecular composition and arrangement, functional consequences, different mechanisms of transport across membrane
- Cell-cell interactions: adhesion junctions, tight junctions, gap junctions, plasmodesmata, Calcium dependent and Calcium independent adhesion

- Cytoskeleton and cell movement: Structure and organization of actin filaments, Actin, myosin and cell movements, Structure and dynamic organizations of microtubules, Microtubule motors and movement, Intermediate filaments, Cilia and flagella

Unit II

- Genome organization
- Cell cycle: The eukaryotic cell cycle, Regulators of cell cycle progression, events of M phase, cytokinesis, Meiosis
- Cell signaling: GPCR and role of second messenger (cAMP), Receptor protein tyrosine kinase, regulation of blood glucose level, calcium as an intracellular messenger
- Apoptosis (Programmed Cell Death), brief idea of cancer (p53 and pRb)

Unit III

- DNA Replication: Prokaryotic and eukaryotic DNA replication, Mechanisms of DNA replication, enzymes and accessory proteins involved in DNA replication and DNA repair.
- Transcription: Prokaryotic transcription, Eukaryotic transcription, RNA polymerase, Modifications in RNA: 5'-Capping, 3'-end processing and polyadenylation, Splicing, Editing, Nuclear export of mRNA, mRNA stability

Unit IV

- Translation: Prokaryotic and eukaryotic translation, the translation machinery, Mechanisms of initiation, elongation and termination, Regulation of translation, co- and post translational modifications of proteins
- Protein Localization: Synthesis of secretory and membrane protein, Import into nucleus, mitochondria, chloroplast and peroxisomes.
- Regulation of gene expression in prokaryotes and eukaryotes: lac, trp and ara operons, enhancers and silencers.

References

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. Garland Publishing Inc., New York
3. Cell and Molecular Biology by De Robertis
4. The Cell: A molecular approach by Geoffrey Cooper, 8thed, OUP USA Publishers
5. Cell and molecular biology by Gerald Karp and James G Patton, 7thed, John Wiley & Sons

Course Outcome:

CO1. Develop conceptual understanding of cell cycle and various cellular interactions.
CO2. Generate concepts of genome replication and regulation.
CO3. Apply the knowledge to analyze cellular behaviour.

M.Sc. ZOOLOGY SEMESTER I
CODE: MZO-104
SUBJECT NAME: GENETICS

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: To develop an understanding of the concepts of inheritance and various principles and mechanisms involved in heredity at cellular level.

Unit I

- Mendelian vs. Non-Mendelian inheritance, monohybrid and dihybrid crosses, Mendelian Principles- Dominance, Segregation and Independent assortment; Extensions of Mendelian principles: Codominance, Incomplete dominance, Multiple Allelism
- Gene interactions- Epistasis, Collaboratory gene action, Duplicate genes, Complementary Gene action, Complementation Test.
- Pleiotropy. Phenocopy. Probability and Pedigree analysis; Sex limited and sex influenced characters.
- Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL. Extrachromosomal Inheritance, Maternal effect.

Unit II

- Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.
- Linkage maps, recombination, tetrad analysis (Ordered and unordered Tetrad analysis), mapping with molecular markers, mapping by using somatic cell hybrids. Linkage Group

Unit III

- Cytogenetics: Chromosome: structure and nomenclature, centromere and telomere
- Structural and numerical alterations of chromosomes: Deletion, duplication, Pericentric and Para centric inversion, Inversion heterozygotes, Inversion homozygotes. Reciprocal and non-reciprocal translocation, Homozygotes as well as Heterozygote Translocants. Ploidy (Aneuploidy and Euploidy) and their genetic implications.

Unit IV

- Mutation: Types, causes and detection, mutant types – lethal, conditional, Base substitution and frame shift Mutation.
- Biochemical, loss of function, Gain of function, Germinal verses Somatic mutants, Ames Test.
- Epigenetics: Introduction, methylation, histone modifications.
- Allele frequency, Gene Frequency, Hardy Weinberg Equilibrium
- Population genetics and its applications, Natural selection and random genetic drift.

References

1. Principles of Genetics by E. J. Gardner, M.J. Simmons, D. P. Snustand, 8th, John Wiley & Sons Ltd.

2. Principles of Genetics by R.H. Tamarin, 7th ed. Tata McGraw-Hill Publishing Comp. Ltd..
3. Genetics – A conceptual approach by B.A. Pierce. 6th ed. WH Freeman Company.
4. Lewin's Genes by J.E. Krebs, E.S. Goldstein and S.T. Kilpatrick. 12th ed. Jones and Bartlett Publishers Inc.
5. Concepts of Genetics by W.S. Klug, M.R. Cummings, C.A. Spencer, M.A. Palladino and D. Killian, 11th ed. Pearson Education

Course Outcomes:

CO1- To generate conceptual understanding of mendelian genetics, cytogenetics, epigenetics and population genetics.
CO2- To develop the skills for genetic mapping and interpreting hereditary diseases, their inheritance patterns, and pedigree analysis.
CO3- To apply the knowledge and skills acquired for genetic inheritance studies in plants, animals and prokaryotes.

M.Sc. ZOOLOGY SEMESTER I
CODE: MZO-105
SUBJECT NAME: Microbiology

Credits	L	P		
4	4	0	**Sessional**	**25**
			Theory Exam	**75**
			Total:	**100**

Course Objectives: To develop understanding of microbial diversity along with tools and techniques used in microbiology.

Unit I

- History of microbiology with special reference to contributions of A.V. Leeuwenhoek, Louis Pasteur, Edward Jenner, Robert Koch, Sergei Beijerinck, Winogradsky, Alexander Fleming, Joseph Lister and Paul Ehrlich.
- Introduction to microbial taxonomy: brief outline classification of eubacteria, archaea, fungi and protists; classical and molecular approaches in microbial taxonomy.
- Structure and morphology of eubacterial and archaeal cells. Structure and morphology of fungal cell

Unit II

- Nutrition: requirements, categories, uptake and media
- Growth: bacterial growth curve and mathematical model, isolation and maintenance of pure culture, factors affecting growth, measurement of growth.
- Reproduction in bacteria with emphasis on binary fission and budding; different strategies of reproduction in fungi

Unit III

- Sterilization techniques, disinfection and antisepsis.
- Mode of action of antibiotics, MIC assay, factors affecting antimicrobial action.

- Host pathogen interaction, types of toxins and their mode of action

Unit IV

- Brief history of virology, structure and composition of virus, classification (Baltimore and ICTV), cultivation of virus and enumeration assays.
- General life cycle of virus, one step growth cycle
- Morphology and lifecycle of T4, lambda, caulimovirus, banana bunchy top virus, reovirus, picornavirus and retroviruses. Molecular control of lysogeny

References

1. Jacquelyn G. Black. Microbiology-Principles and explorations 8 th edition: Publisher John Wiley & Sons 2012.
2. J.M. Willey, L.M. Sherwod and C.J. Wolverton. Prescott, Harley and Klein's Microbiology, McGraw Hill International Edition, 11th Edition.
3. Brock, Biology of Microorganisms, Pearson International Edition. 15th edition
4. M.J. Pelczar Jr., E.C.S.Chan, N.K. Krieg. Microbiology/ Tata McGraw Hill. 5th edition
5. R.Y. Stannier, J.L.Ingraham, M.L.Wheelis and P.R. Painter. Genereal Microbiology. Fifth Edition.Macmillan Press Ltd.
6. Atlas RM. Principles of Microbiology. 2ndedition. 1997

Course Outcomes (COs)

After successful completion of this course, a student will be able to:

CO 1: To develop conceptual understanding of microbial diversity, taxonomy and ultrastructure.

CO 2: To acquire skills in various techniques used in microbial study

CO 3: To apply the skills and knowledge in diagnostics, industrial biotechnology, microbial interactions and other related areas.

M.Sc. ZOOLOGY SEMESTER I
CODE: MZO-106
SUBJECT NAME: ZOOLOGY LAB COURSE-I

Credits	L	P		
6	0	12	Sessional	30
			Theory Exam	70
			Total:	100

Course Objectives: To develop skills in various biochemical, microbiological, genetics and statistical techniques.

Practicals

1. Estimation of protein concentration in a given sample by Lowry's method
2. Estimation of reducing sugars by DNSA method
3. Analysis of oils-iodine number of given samples
4. Analysis of saponification value of given sample
5. Extraction and estimation of Urease/Acid phosphatase from germinating mung bean seeds
6. To determine K_m and $V_{max}$of the enzyme Urease/Acid phosphatase
7. To perform separation of chloroplast by sucrose density gradient centrifugation
8. Preparation of temporary slides of mitosis using onion root tips
9. Estimation of DNA by Diphenylamine (DPA) method
10. Separation of amino acids using paper chromatography
11. Systematic tabular summarization of data (before analysis), measures of central tendency, measures of dispersion (using calculators)
12. Linear Regression Tests of significance (Mean, Standard Deviation, proportion, Correlation Coefficient)
13. Chi Square Test of Goodness of fit, test of independence of attributes, Analysis of Variance (One way and Two way)
14. Preparation of Graphs and statistical calculations using software
15. To perform simple staining and gram staining of given bacterial strains
16. Lactophenol cotton blue staining of given fungal samples
17. Isolation of microbes from soil sample
18. Turbidostatic estimation of bacterial growth curve
19. Preparation of metaphase chromosome
20. Study of sex chromatin from epithelial hair, buccal cells
21. Gene mapping exercises
22. Exercises on population genetics

*A minimum of sixteen practical should be done from the above-mentioned list.

**Addition or deletion of the lab experiments can be done as per the availability of resources in lab.

Course Outcomes (COs)

After successful completion of this course, a student will be able to:
CO1: To develop hands on training in various biochemical and enzymological techniques.
CO2: To acquire skills in microbial handling and cell cycle studies.
CO3: To analyze and interpret the data by applying statistical techniques

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-201
SUBJECT NAME: ANIMAL BIOTECHNOLOGY

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objectives: The course aims at developing concepts of animal cell tissue culture techniques and its applications.

Unit-I
Introduction and History of animal cell and tissue culture.Cell culture laboratory-design, layout and maintenance.Types of culture media and their composition techniques in animal cell culture: Disaggregation of tissue and setting up of primary culture, established cell line cultures, maintenance of cell lines. Biology of cultured cells and their characterization.

Unit-II
Introduction to stem cell culture, Isolation, culture and applications of stem cells (adult and embryonic), Induced pluripotency, Tissue and organ culture and their types, Application of Tissue engineering - skin, bone and neuronal tissues. Stem Cell Bank.

Unit-III
Gene knock out and mice models for tackling human diseases. Animal cloning: methods of cloning and their importance with reference to domestic animals. IVF- technology for livestock and humans. Transgenic animals: Construction of transgenic animals, Gene editing, gene correction, gene silencing, Applications of transgenic animals

Unit-IV
Applications of animal biotechnology: Bio-pharming, Molecular markers linked to disease resistance genes, Microsatellites, Application of RFLP in forensic, disease prognosis, genetic counselling and pedigree analysis, Cell culture based vaccines.
Bioethics: Ethical implication of human genome project and concerns regarding human genome diversity research. Good clinical practices, ethical and social issues of animal research and cloning; ethical and social issues of human cloning, organ transplantation and xeno transplantation

References:

1. Amanda CD and Freshney,RI (2021). Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. JohnWiley&SonsPublishers. 8th edition.
2. Glick BR and Patten CL (2017)Molecular biotechnology: principles and applications of recombinantDNA. JohnWiley&Sons.5th edition
3. Ballinic C.A., Philips J.P and Moo Young M.Animal Biotechnology. Pergamon press, New York. 1989.

4. Shantharam, D., Jane F Montgomery. Biotechnology, Biosafety & Biodiversity: Scientific & Ethical issues for Sustainable development. 1999
5. John Davis., Animal Cell Culture: Essential Methods (1st Ed.) Wiley-Blackwell and Sons publisher. 2011

Course Outcomes:

After successful completion of this course, a student will be able to:

CO1- To Develop the concepts for animalcell culture techniques

CO2- To develop an understanding of construction of transgenic animal, gene editing, and their applications.

CO3- To use the acquired skills for performing experiments and research for livestock and human

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-202
SUBJECT NAME: BIOTECHNIQUES

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: To learn various techniques used in biological sciences and their applications in different research works.

Unit I

- Microscopy: Light Microscopy Magnification, resolving power, Numerical aperture, Limit of Resolution, Brightfield, Phasecontrast, Fluorescence microscopy. Principle and applications of Electron Microscopy (SEM & TEM), Cryogenic Electron Microscopy, Confocal Microscopy, Atomic Force Microscopy
- Centrifugation Techniques: Principle of centrifugation, types of rotors, ultracentrifugation, analytical centrifugation, preparative centrifugation.

Unit II

- Spectrophotometric Techniques: BeerLambert's Law. Photometry, UV/VIS Spectrophotometry, Infrared spectroscopy, Raman Spectroscopy, Circular dichroism(CD), Xray crystallography and brief idea of NMR.
- Gas and liquid chromatography-based mass spectrometry, and surface plasma resonance methods.

Unit III

- Radioisotope technique, use in biological and molecular imaging
- Filtration techniques: Gross filtration, steri-pad filtration, membrane filtration (macro-filtration, micro-filtration, ultra-filtration), reverse osmosis, dialysis, their applications in industry. Merits and limitations

Unit IV

- Principles and applications of Chromatography. Ion exchange chromatography, Gel filtration chromatography, Hydrophobic interaction chromatography, Affinity chromatography, HPLC.
- Electrophoresis-Agarose Gel electrophoresis, Polyacrylamide Gel Electrophoresis (Native, SDS PAGE), 2-Dimensional Gel electrophoresis

References

1. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology by A. Hofmann and S.lClokie ,8th Ed.
2. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry by HaraldGanther, 3rdEd.
3. Crystallography Made Crystal Clear by Gale Rhodes, Academic Press, 3rdEd.
4. Molecular Biology and Biotechniques: the fundamental approach- A.S. Sameer, 2ndEd.
5. Biotechniques-Theory and Practice, S.V.S Rana, Rastogi Publication (1stEdition).
6. Principles of Immuno detection and Immunotechniques: Preview and Emerging Applications by Shelza Thakur, Navnit Kumar Mishra, Hardeep Singh Tuli, Anil K.Sharma (1stEdition)
7. Analytical Biochemistry & Separation Techniques by Dr. P. Palanivelu, IV Edition - Lab manual (IV Edition, 2009), Twenty first Century Publications 5. Techniques and Methods in Biology, Ghatak K.L. Prentice Hall India Learning Private Limited (2011)

Course Outcomes:

After successful completion of this course, a student will be able to:

CO1- To impart knowledge and application of various bioanalytical techniques

CO2- To develop an understanding of usage of different microscopic and spectroscopic techniques for various biological sample analysis.

CO3- To acquire skills for using various electrophoretic and chromatographic techniques for biological studies.

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-203
SUBJECT NAME: ECOLOGY AND ENVIRONMENTAL ZOOLOGY

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objectives: To generate an understanding of role, significance and interaction of biotic and abiotic factors and its applications in remediation and other biotechnological interventions

Unit I

- Introduction to ecology, environmental concepts – laws, limiting factors and ecological models.
- Nature of ecosystem, production, food webs, energy flow through ecosystem, resilience of ecosystem
- Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning
- Characteristics of a population; population growth curves; population dynamics and regulation; life history strategies (*R* and *K* selection), age structured populations.

Unit II

- Interspecific interactions: interspecific competition, herbivory, carnivory, pollination, symbiosis
- Ecological Impact of microbial interactions (special emphasis on nitrogen fixation and ruminants)
- Succession: types; mechanisms; changes involved in succession; concept of climax; models of succession (primary and secondary)
- Waste water treatment: sources, characterization, primary, secondary (aerobic and anaerobic) and tertiary treatment.
- Water quality assessment, bioindicators

Unit III

- Solid waste treatment : sources, treatment strategies (landfills, composting, vermicomposting)
- Radioactive waste characterization and disposal.
- Air quality monitoring and control
- Biodegradation of xenobiotics and recalcitrant molecules: simple aromatics, chlorinated polyaromatic petroleum products and pesticides. Role of degradative plasmids
- Bioremediation of oil spills, heavy metals
- Biofuels: biodiesel, biogas, bio hydrogen, bioethanol

References

1. Ecology: From Individuals to Ecosystems by Michael Begon, Colin R. Townsend, John L. Harper, Wiley-Blackwell (3rd Edition).
2. Ecology: Principles and Applications by J. L. Chapman and Michael Reiss, Cambridge University Press, U.K. (1st Edition).
3. Fundamentals of Ecology by E. P. Odum and G. W. Barrett, Brooks/Cengage Learning India Pvt. Ltd., New Delhi (5th Edition).
4. Concepts of Ecology by E. J. Kormondy, Prentice Hall of India, New Delhi (4th Edition).
5. Environmental Biotechnology-Theory and Applications by G M Evans, Furlong JC, 1st ed. John Wiley & Sons.
6. Environmental biotechnology: Concepts and Applications by H-J. Jordening, J. Winter,1st ed. John–Wiley and Sons.
7. Environmental biotechnology: Basic Concepts and Applications by I.S. Thakur (2011), I.K. Internationals Pvt Ltd. 2nd ed.

Course Outcomes:

After successful completion of this course, a student will be able to:

CO1- To understand and assimilate the concepts and specific terminology of environmental biotechnology and ecology

CO2- To develop concepts of pollution types, sources, effects and remediation methods

CO 3- To generate skills for developing green sustainable techniques.

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-204
SUBJECT NAME: GENETIC ENGINEERING AND INTRODUCTIORY BIOINFORMATICS

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective : The course aims to develop an understanding of the techniques used in gene manipulation and the tools utilized for computational analysis.

Unit I

- Recombinant DNA technology: Restriction and modification enzymes; Restriction Digestion- Partial and complete digestion, Linkers and adaptors.
- Vectors - Plasmids, Cosmids, bacteriophage and other viral vectors, bacterial and yeast artificial chromosomes
- Expression vectors, shuttle vectors, Plasmid incompatibility, Selectable and Screenable markers
- Selection of transformed and recombinant cells, Insertional inactivation of genes, Ti plasmid and Agrobacterium mediated Gene transfer, Functions of different Vir genes.

Unit II

- The construction of cDNA and Genomic libraries. Genomics and its application, Expressed sequence tags, Human genome project- strategies and implications
- Gene therapy: principles, strategies, DNA sequencing methods: Maxam and Gilbert's chemical and Sanger's chain termination methods, and Pyrosequencing; Polymerase chain reaction and its application in research, TA cloning, brief idea of next generation sequencing.

Unit III

- Introduction to primary Databases: Nucleotide sequence databases-GenBank, EMBL, DDB; Protein Sequence Databases- UniProtKB, UniProt, TrEMBL, Swiss-Prot; Literature Databases- PubMed, PLos, BioMed Central
- Introduction to Secondary or Derived Databases- PDB, CSD, MMDB, SCOP, CATH, FSSP, CSA, KEGG ENZYME, BRENDA
- Sequence motifs Databases: Prosite, ProDom, Pfam, InterPro; Organism specific database (OMIM/OMIA, SGD, WormBase, PlasmoDB, FlyBase, TAIR)

Unit IV

- Nucleic acid and protein sequence information, composition and properties, Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM 250, BLOSUM 62, global and local sequence alignment, similarity searching (FASTA and BLAST)
- Identification of genes in genomes, primer designing, Phylogenetic analysis with reference to nucleic acids and protein sequences using PHYLIP, DISTANCES, and GROWTREE, Identification of ORFs, Identification of motifs.

References

1. Gene Cloning and DNA Analysis: An Introduction by T.A. Brown, 7th ed Wiley Blackwell Press.
2. Principles of Gene Manipulation and Genomics by S.B Primrose and R. Twyman, 7th ed, Blackwell Press.
3. Molecular Cloning: a laboratory manual , vol 1-4, M.R. Green and J.Sambrook, 4th ed, Cold Spring Harbour Laboratory Press,
4. Introduction to Bioinformatics by A.M.Lesk, 3rd ed., Oxford Press
5. Bioinformatics: Sequence and Genome Analysis by D.W. Mount, 2nd ed., Cold Spring Harbour Laboratory Press

Course Outcomes:

After completion of this course, the student will be able to

CO-1- To understand the use of tools and techniques for manipulation and analysis of genomic sequences.

CO-2- To develop basic concepts of Bioinformatics and its significance in biological data analysis

CO-3- To apply the skills acquired in performing experiments and research.

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-205
SUBJECT NAME: IMMUNOLOGY

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: This course aims at developing conceptual understanding of the human immune system, regulation and its various responses.

Unit I

Cells and organs of immune system.Primary, secondary and tertiary lymphoid organs.Types of immunity - Innate and adaptive, Humoral and cell-mediated, Active and passive.

Pathogen associated molecular pathway: Toll like receptor, Clonal selection theory. Immunological memory, Antigens and immunogens, B and T cell epitopes; Haptens.

Structure and functions of antibodies.Classes of immunoglobulins.CDRs, Valence, affinity and avidity.Antibody variants - Isotypes, Allotypes and Idiotypes.

Unit II

The immunoglobulin genes: organization and assembly; generation of immunological diversity; Allelic exclusion. Major histocompatibility complex (MHC): structure and organization of MHC.

Antigen processing and antigen presentation. T cell Receptor: Superantigens. B cell activation and maturation.T cell development and activation. Cytotoxic T cell mediated killing.

Complement system and mechanism of its fixation. Complement deficiencies.

V(D)J recombination, somatic hypermutation and class switch recombination of immunoglobulins: mechanism and regulation

Unit III

Immunological tolerance.Autoimmunity and associated disorders (Grave's disease, Myasthenia gravis, Multiple sclerosis and Rheumatoid arthritis).

Allergy and hypersensitivity, types of Hypersensitivity.Transplantation immunology - Graft rejection, graft versus host reaction.

Immune response to infectious diseases – viral (influenza, AIDS), bacterial (tuberculosis), protozoal (malaria)

Techniques of antigen-antibody interactions: RIA, ELISA, ELISPOT assay, immunofluorescence microscopy

Unit IV

Role of cytokines, lymphokines and chemokines.

Vaccine and its different types with emphasis on COVID-19 vaccines.

Hybridoma Technology: Production of murine monoclonal antibodies (MoAbs)-Fusion strategies, HAT Selection

Strategies for production of human MoAbs-Humanization and antigenization of MoAbs-Chimeric, CDR-grafted

References

1. Punt J, Stranford SA, Jones PP, and Judith AO (2019) Kuby immunology. WH Freeman. 8th edition.
2. Abbas AK, Lichtman AH, and Pillai S (2016) Cellular and Molecular Immunology. Saunders. 9th edition.
3. Male DK, Brostoff J, Roth D, and Ivan R (2012) Immunology. Gower Medical Publishing London.8th edition.
4. Gupta SK (2010) Essentials of Immunology. Arya Publication.2nd edition.
5. Khan FH (2009) The Elements of Immunology. Pearson Education India. 1st edition

Course Outcomes:

CO1-To develop the concept of immunity and various mechanisms for immune responses regulation and tolerance.

CO2-To understand the reasons for immunization, vaccination and role of immune system in transplantation.
CO3-To acquire the skills of techniques based on antigen-antibody interactions.

M.Sc. ZOOLOGY SEMESTER II
CODE: MZO-206
SUBJECT NAME: ZOOLOGY LAB COURSE-II

Credits	**L**	**P**	**Sessional**	**30**
6	**0**	**12**	**Theory Exam**	**70**
			Total:	**100**

Course Objective:The students will adapt with practical knowledge of Immunology, Genetics, Ecology and Environmental biotechnology

1. Determination of total hardness of water sample
2. Determination of alkalinity of water sample
3. To estimate BOD and COD values of waste water
4. Bacteriological analysis of water sample
5. To perform Differential Leucocyte Count
6. To perform Ouchterlony Double Diffusion assay to the study of antigen-antibody reaction.
7. ABO Blood group testing of the provided sample
8. Determination of antibiotic titer using ELISA
9. ABO Blood group testing of the provided sample
10. To perform Widal test
11. To perform blood cell culture
12. To perform freezing and thawing of cells
13. Determination of cell viability using trypan blue method
14. To perform cell counting by hemocytometer
15. Extraction of genomic DNA and its estimation using spectrophotometer
16. Plasmid isolation by alkaline lysis method and detection using electrophoresis
17. Preparation of competent cells
18. Restriction digestion of plasmid DNA and detection of digestion profile using electrophoresis.
19. Transformation of *E. coli* with plasmid and calculation of transformation efficiency
20. Database search: use and analysis of BLAST tool for DNA and protein sequences
21. Primer designing and *in silico*PCR

Course Outcome: At the end of laboratory course, students will be able to:

CO 1- Understood the basic Immunological aspects to be performed in the laboratory.

CO 2- Learnt to analyze genetic problems and will be able to approach a research problem statistically.
CO 3-Understood and perform cell counting, centromere mapping, freezing and thawing of cells

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-301
SUBJECT NAME: METABOLISM

Credits	L	P	Sessional	25
4	4	0	Theory Exam	75
			Total:	100

Course Objective:

To provide students with a comprehensive understanding of the biochemical processes that underlie the conversion of nutrients into energy and the synthesis of biomolecules.

Unit-I

- Glycolysis, citric acid cycle, pentose phosphate pathway, gluconeogenesis, glycogenesis and glycogenolysis, Disorders of carbohydrate metabolism.
- Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase.

Unit-II

- Catabolism of amino acids (urea cycle), glucogenic and ketogenic amino acids; disorders of amino acid metabolism.
- Fatty acid metabolism; Alpha, Beta and omega-oxidation of Fatty acids, Ketone bodies metabolisms. Disorders of lipid metabolism.
- Fatty acid synthesis, biosynthesis of cholesterol and mevalonate pathway.

Unit-III

- Nucleotide metabolism: de novo synthesis and breakdown of purine and pyrimidine nucleotides, regulation, salvage pathway
- Inhibitors of nucleotide metabolism, Disorders of nucleic acid metabolism
- Production of ROS and role of NADPH and glutathione protection from ROS.

References:

1.Biochemistry and Molecular Biology, Elliott and Elliott, Oxford University press, New York, USA (4th edition).
2. Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, McGraw Hill, New York, USA. (28th edition)
3. Biochemistry, Voet and Voet, John Wiley (4th edition).
4. Nelson DL Cox, MM Lehninger's Principal of Biochemistry (7th edition)

Course Outcomes:

CO-1- To develop conceptual understanding of various catabolic and anabolic processes in living system.
CO-2- To understand the significance of different pathways in maintaining homeostasis.
CO-3- To apply the concepts obtained to design experiments and data analysis

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-302
SUBJECT NAME: ANIMAL BEHAVIOUR

Credits	**L**	**P**	**Sessional**	**25**
3	**3**	**0**	**Theory Exam**	**75**
			Total:	**100**

Course Objective: This course enables the understanding of animal behaviour along with the current theories and evidences for a broad range of behavioral topics.

Unit-I

History of the study of animal behavior, concepts and objectives of behaviour, mechanism of behavior: Neural control of behavior, sensory processes and perception, ecology of senses. Complex behavior- Instinct and learning, Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM. Fixed action pattern- characteristics and evolutionary features.Mimicry, mimetic releaser and code breakers.

Unit-II

Primary and secondary orientation; kinesis and taxis. Learning and cognition: habituation, classical conditioning, operant conditioning, latent learning, social learning. Homeostasis and behaviour: motivational system and their physiological basis, motivational conflict and decision making, displacement activity.

Unit-III

Reproductive Behaviour: Evolution of sex, reproductive strategies, mating systems, courtship, sperm competition, sexual selection and parental care. Hormones and behaviour; pheromones and behaviour; Biological rhythms: Circadian, circannual, tidal/lunar, ultradian, infradian rhythms, synchronization of biological rhythms, phase shift. Photoperiodism with reference to birds and mammals - human circadian rhythms.

References:

1. Aubrey Manning and Marian Stamp Dawkins (2012) An Introduction to Animal Behavior, Cambridge University Press. 6th Edition
2. John Alcock, (2009) Animal Behaviour: An Evolutionary Approach, Sinauer Associate Inc., USA.9th Edition

3. Dustin R. Rubenstein and John Alcock (2018) Animal Behaviour, Sinauer Associate Inc., USA. 11th Edition

CO1:Acquire a clear understanding about behavior patterns in animals
CO2: Understand the basis on different behavior pattern found in animals
CO3:Explain the basic concepts of reproductive behavior, Biological rhythmswith reference animals.

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-303
SUBJECT NAME: MOLECULAR AND APPLIED ENDOCRINOLOGY

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course is planned to give comprehensive understanding of the responses to hormones and the mechanism of signalling.

Unit I

Discovery of hormones as chemical signals for control and regulation of physiological processes.Nature of hormonal actions.Techniques for quantitation of hormones.Design and development of hormonal assays.

Structure of peptide and protein hormones.Purification and characterization of hormones.Structure-Function relationships in different hormones.

Phylogenic analysis of hormonal structures and functions. Storage and secretion of hormones: molecular mechanisms of regulation.

Unit II

Discovery of receptors in target tissues.Mechanisms of hormone action and signal attenuation.

Structural requirements for successful hormone-receptor interactions.Receptor antagonists and their applications.Metabolism of hormones by target and non-target tissues.

Pharmacokinetics of hormones.Hormones and behavior- cellular and molecular actions of semiochemicals.

Unit III

Hormones as therapeutic agents.Current developments in design and production of hormonal contraceptives.

Recombinant protein hormones-production and application in regulation of fertility in farm animals and humans.

Evolution of chemical communication in animal systems.Unsolved problems in hormonal biology.

References:

1. Williams Textbook of Endocrinology by Melmed et al., Elsevier.
2. Handbook of endocrinology, 2nd Ed. by Gass G.H. and Kaplan H.M (Editors). Routledge Publications
3. Essentials of Endocrinology by Hadley

Course Outcome: On the completion of course, students will be able to:

CO1: To Demonstrate the nature of different kinds of hormones
CO2: To apply the working mechanism of different hormones and their effects
CO3: To Understand the strategies of recombinant hormone production

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-304
SUBJECT NAME: STRUCTURE AND FUNCTIONS OF NON-CHORDATES

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: Aim of this course is to provide in-depth knowledge of invertebrates in context to their structural and physiological differences which are the basis of their classifications and help them to survive.

Unit I

Introduction to invertebrates with their general characters, Basic body plan, Concept of invertebrata v/s Vertebrata and Non-Chordata v/s Chordata;
Organization of coelom, Concept and structure of Acoelomate, Pseudocoelomates and Coelomates.Protostomia and Deuterostomia, Metamerism in Annelida, Pseudometamerism.
Minor Phyla: Concept and significance, Organization and general characters of Acoelomate, Pseudocoelomates and Coelomates minor phyla (with special emphasis on Ctenophora, Rotifera, Endoprocta, Ectoprocta, Phoronida, Sipunculida and Echiuroidea).

Unit II

Locomotion: Flagella and ciliary movement in Protozoa, Hydrostatic movement in Coelenterata, Annelida and Echinodermata;
Nutrition and Digestion: Patterns of feeding and digestion in lower metazoan, Filter-feeding in Polychaeta, Mollusca and Echinodermata;
Respiration: Organs of respiration: Gills, lungs, trachea,skin,Cloacal chamber, Buccopharyangeal area etc., Respiratory pigments, Mechanism of respiration

Unit III

Excretion: Organs of excretion: Coelom, coelomoducts, Nephridia and Malpighian tubules, Mechanism of excretion and osmoregulation
Nervous system: Primitive nervous system: Coelenterata and Echinodermata, Advanced nervous system: Annelida, Arthropoda (Crustacea and Insecta) and Mollusca (Cephalopoda), Trends in neural evolution.

Unit IV

Invertebrate larvae: Larval forms of free living invertebrates, Strategies and Evolutionary significance of larval forms, Conservation of invertebrates.

Introduction to insects: Mouthparts of Insects, Mechanism of insect flight and hovering, Metamorphosis in insects, Hormonal control of moulting; Economic importance of Invertebrates; Various Adaptations in Invertebrates

References:

1. Kotpal, R.L. (2019). Modern text book of Zoology: Invertebrates. Rastogi Publications. 11th Edition
2. David Hickman, Jr., Cleveland; Roberts, Larry; Keen, Susan; Larson, Allan; Eisenhour (2021).Animal Diversity. McGraw Hill Education, 9th Edition.
3. Barnes, R.S.K., Calow, P.P., Olive, P.J., Golding, D.W. and Spicer, J.I., (2009). The invertebrates: a synthesis. John Wiley & Sons, 3rd Edition
4. Moore, J., (2006). An introduction to the invertebrates.Cambridge University Press. 2nd Edition
5. Pechenik, J. A. (2015). Biology of the Invertebrates. McGraw Hill, 7th Edition
6. Ruppert and Barnes, R.D. (2006). Invertebrate Zoology, Holt Saunders International Edition, 8th Edition

Course Outcome: On the completion of course, students will be able to:

CO1: demonstrate the foundation of invertebrate classification and the basis of systematic position of various species
CO2: explain the structural variations among invertebrates with respect to different phyla and their major orders.
CO3: understand the physiology of different invertebrate species which helps them to adapt as per their habitat and environmental changes.

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-DE001
SUBJECT NAME: APPLIED ZOOLOGY

Credits	L	P		
3	3	0	**Sessional**	**25**
			Theory Exam	**75**
			Total:	**100**

Course Objective: The course will introduce the utilization of invertebrate and vertebrates in various commercial applications.

Unit I

Speciesofhoneybeeandtheirsocialorganization;Methodsofbeekeeping;economicimportance of honey;Life cycle of lac; Cultivation of Lac; Enemies of lac cultivation andeconomic importance; Life cycle of silk moth; Rearing of silk worm; Disease of silk worm;Status of sericulture industry in India

Unit II

Habitat of foul; Fowl House; Food and feeding of Fowl; Principles of poultry breeding;Rearing of Chickens; Disease of poultry; Processing andpreservation of eggs; Fish culture;breeding pond and fish seed; types of hatching pits; Nursery and rearing ponds; Methods offishing; preservation of fish; Fish culture and water pollution and Polyculture;

Pearl Producing Molluscs, Pearl Formation, Programming of Pearl Industry;

Unit III

Applied animal nutrition: Principles of animal nutrition, Animal husbandry and nutrition requirements, Feeding standards and productivity, Factors affecting feed consumption Feed preparation and processing: Hot and cold processing methods, feed processing for ruminants and non-ruminants. Artificial insemination in cattle, Induction of early puberty and synchronization of estrus in cattle, ICSI, preparation of semen straws; Pharmaceuticals from animals and their use in animal welfare

References:

1. DunhamR.A.(2004).*AquacultureandFisheriesBiotechnologyGeneticApproache*s.CABI publications, U.K.
2. Pedigo, L.P. (2002). *Entomology and Pest Management*, Prentice Hall
3. G.S.ShuklaandV.B.Upadhyay(2017)EconomicZoology:AtextbookforUniversitystudents, Fifth Edition, Rastogi publication, Meerut.
4. Pond, W. G., Church D. C., Pond K. R. and Schoknecht P. A. (2004) Basic Animal Nutrition and Feeding, 5theditionn. John Wiley and Sons, New York.

Course Outcomes (COs)

After successful completion of the course on, a student will be able to

CO1:Understand the basis on different behavior pattern found in animals
CO2: Explain the basic concepts of sericulture, apiculture, lac culture and other animal industries along with economics of pest management techniques.
CO3: Awareness about use of certain animals and their products for human welfare *vis-à-vis*animal welfare will be created.

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-DE002
SUBJECT NAME: CHRONOBIOLOGY

Credits	**L**	**P**	**Sessional**	**25**
3	**3**	**0**	**Theory Exam**	**75**
			Total:	**100**

Course Objectives: This course aims towards developing an understanding of the biological clock and its implications in animal behaviour.

Unit -I

Introduction, History and Milestones, Clocks, Rhythm and Calendar, The biological timing system: Concepts and methods, Types: Ultradian, circadian and circannual rhythms.
Characteristics of rhthym: Free running rhythms, Entrainment and masking in the natural and artificial environment, *Zeitgebers:* Photic and non-photic, Parametric and non-parametric entrainment, Phase shift, Phase response curves (PRC) and phase transition curves (PTC).

Unit-II

Proximate and Ultimate factors affectingcircannual rhythms, Circannualcontrol of seasonal processes, Photoperiodism: Concepts and photoperiodic time measurement models, Seasonalprocesses and photoperiodic control mechanisms.

Unit-III

Biological clocks and human health and diseases, Clock dysfunction and lifestyle related disorders, Chronopharmacology, chronomedicine, chronotherapy.

References:

1. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J.DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
2. Circadian Medicine: Christopher Colwell (ed.) Wiley-Blackwell (2015)
3. Circadian Physiology: Roberto Refinetti, CRC Press (3rded) 2016 Biological Timekeeping: Clock, Rhythms and Behaviour, Vinod Kumar (ed. 2017)

Course Outcomes (COs)

After successful completion of the course, a student will be able to
CO 1: Develop the concept of biological clock and the different terminologies used.
CO2: Understand the effect of seasons on the rhythmns
CO3: Acquire the understanding of the impact of biological clock and rhythm on human and animal health

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-DE003
SUBJECT NAME: COMPARATIVE PHYSIOLOGY

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course enables the learner to understand how physiological processes in groups of unrelated animals have evolved to cope with similar environmental challenges.

Unit-I

Systems of circulation, Peripheral circulation, Regulation of heart beat and blood pressure, Transport and exchange of gases, Neural and chemical regulation of respiration, Gas transfer in air and water, Gas exchangers Circulatory and respiratory responses to extreme conditions, Acid –base balance, regulation of body pH basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance, stress and hormones.

Unit-II

Thermoregulation- Heat balance in animals, Adaptations to temperature extremes, torpor, Aestivation and hibernation, Counter current heat exchangers Physical, chemical, neural regulation,

Osmoregulation- Osmoregulation in aquatic and terrestrial environments, Extra-renal osmoregulatory organs, Patterns of nitrogen excretion.

Stress Physiology Concept of Stress and Strain, Stress hormones and stress regulatory mechanisms.

Unit-III

Neuroanatomy and integrated function of the nervous system; Photoreception,

Chemoreception, Mechanoreception; Echolocation, Endogenous and exogenous biological rhythms

Chromatophores- Types and Functional Modifications vis-a-via different animals (Invertebrates & Vertebrates) & control; Behavioural significance and its application; Contractile elements, cells and tissues among different phylogenic groups; Muscle structure and function-correlation;

Electric organs **(**myogenic lineage)-Electroplaxes, Electric discharge, Organogenesis, Electroception, functional significance in animals

References:

1. C.L. Prosser. Comparative Animal Physiology. W.B. Saunders & Company.
2. R. Eckert. Animal Physiology: Mechanisms and Adaptation. W.H. Freeman & Company.
3. W.S. Hoar. General and Comparative Animal Physiology
4. Schiemdt-Nielsen. Animal Physiology: Adaptation and Environment. Cambridge.
5. C.L. Prosser. Environment and Metabolic Physiology. Wiley-Liss, New York.
6. David Randall, Warren Burggren, Kathleen French: Eckert Animal Physiology
7. Guyton, A.X., Text Book of Medical Physiology, 7th edition, Saunders Company (1986).

Course Outcome: On the completion of course, students will be able to:

CO1: Demonstrate how different physiological adaptations allow animals to live and succeed in their environment

CO2: Understand the anatomical and physiological processes of a wide range of animal species

CO3: Explain the role of nervous system in sensing the environment.

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-DE004
SUBJECT NAME: FISHERIES AND AQUACULTURE

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course will make the learner to understand the breeding techniques and nutritional requirements of the economically important fishes.

Unit I

General description of fish; Account of systematic classification of fishes (upto order); Classification based on feeding habit, habitat and manner of reproduction,

Inland Fisheries; Marine Fisheries; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Indian Fisheries law and regulations

Unit II

Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish; Management of finfish hatcheries; Preparation and maintenance of fish aquarium; Preparation of compound diets for fish; Role of water quality in aquaculture; Fish diseases: Bacterial, viral and parasitic; Preservation and processing of harvested fish, Fishery by-products; Transgenic fish, Zebra fish as a model organism in research.

Unit III

The potential scope of Aquarium Fish Industry as a Cottage Industry; Exotic and Endemic species of Aquarium Fish; Study of different species of Aquarium fish and biology (Breeding, Feeding economic importance etc) of exotic and endemic fish; Use of formulated feeds, Types of formulated feed, Formulation and preparation of feed, Advantages and disadvantages of formulated feed; Common characters and sexual dimorphism of Fresh water and marine aquarium fish such as Guppy, Molly, Sword tail, Gold fish, Angel fish, Blue morph, Anemone fish and Butterfly fish

References:

1.Handbook of Fisheries and Aquaculture. Published by Indian Council of Agricultural Research

2.Aquaculture: An introductory text by Stickney, Robert R. CABI publication

3. Aquaculture Landscapes: Fish farms and the Public realm by Ezban, M. Routledge Publication.

Course Outcome: On the completion of course, students will be able to:

CO1: recognize the suitable and economically important aquacultural species

CO2: understand the importance of aquaculture in nutrition security, poverty elevation and employment generation

CO3: identify the useful aquaculture systems for sustainable aquaculture development

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-DE005
SUBJECT NAME: INSECT VECTOR AND DISEASES

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course is designed to provide in-depth knowledge on how the insects acts as a carrier in transmitting the diseases and the various strategies of controlling them.

Unit I

General features of Insects: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation; Morphological features; Head- eyes, types of Antennae; Insect sense organs (mechano-, photo- and chemoreceptors)

Unit II

Basic introduction of Carrier and Vectors (mechanical and biological transmission by vectors); Natural Reservoirs for Disease (any one example of biological and environmental-soil and water each); Vectorial capacity; Factors that define parasite-vector specificity; Key features of orders with insect as vectors- Diptera, Siphonaptera, Siphunculata, Hemiptera

Bugs as insect vectors; Blood sucking bugs; Chagas Disease; Bed bugs as mechanical vectors; Control and prevention measures

Unit III

Brief description of Dipterans as important insect vectors- Mosquitoes, Sand fly, House flies; Study of mosquito borne disease- Malaria, Study of Fly borne disease- Leishmaniasis- Cutaneous and Visceral; Study of house fly as important mechanical vector, Myiasis, Control of house fly

Fleas as important insect vectors; Study of Flea- borne diseases- Plague and Typhus Fever; Overview of Flea control

Human louse (Head, Body and Pubic Louse) as important insect vectors; Study of Louse-borne disease- Louse borne typhus fever, Trench fever, Vagabond's disease, Phthiriasis; Control of human louse

References:

1. Basic and Applied Entomology by K.C. Kumawat and S.R. Kumawat. Astral Publications
2. The Insects-structure and functions Ed.S.J.Simpson and A.E.Douglas. Cambridge University Press

Course Outcome: On the completion of course, students will be able to:

CO1: Demonstrate the morphological features of insects
CO2: Understand the key factors causing variations in the vector capacity of different insects
CO3: Explain the impact of insect world on the life of humans and other animals

M.Sc. ZOOLOGY SEMESTER III
CODE: MZO-305
SUBJECT NAME: ZOOLOGY LAB COURSE-III

Credits	**L**	**P**		
6	**0**	**12**	**Sessional**	**30**
			Theory Exam	**70**
			Total:	**100**

Course Objective:The students will adapt with practical knowledge of Structure and functions of chordates, developmentalbiologyand evolutionary biology

1. Permanent Preparation of: *Euglena, Paramecium*
2. Study of prepared slides/specimens of *Entamoeba, Giardia, Leishmania, Trypanosoma, Plasmodium, Fasciola, Cotugnia, Taenia, Rallietina, Polystoma, Schistosoma, Echinococcus, Enterobius, Ascaris and Ancylostoma*
3. Study of the following specimens: *Nereis, Pheretima, Hirudinaria, Palaemon, Cancer, Limulus, Palamnaeus, Scolopendra, Julus, Periplaneta, Apis, Chiton, Dentalium, Pila, Unio, Loligo, Sepia, Octopus, Pentaceros, Ophiura, Echinus, Cucumaria, Antedon, Balanoglossus.*
4. Permanent mount of wings and mouth parts of honey bee and cockroach.
5. Extracting Nematodes from Soil Samples
6. Slides of plant nematodes.
7. Dissections: through multimedia/models
8. Cockroach: Central nervous system
9. Life history of silkworm, honeybee and lac insect.
10. To perform experiment for Identification of histological slides of lymphoid tissue - Spleen, thymus, lymph node and bone marrow
11. Study of endocrine glands (Pituitary, Adrenal, Ovary, Testis)
12. Estimation of cholesterol by spectrophotometric method
13. To determine glucose concentration in blood sample
14. Determination of blood creatinine level.
15. Estimation of blood urea.

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www.onlinelabs.in

www.powershow.com

https://vlab.amrita.edu
https://sites.dartmouth.edu

**Addition or deletion of the lab experiments can be done as per the availability of resources in lab.

Course Outcomes (COs)

After successful completion of this course, a student will be able to:
CO1: To develop hands on training in various biochemical and enzymological techniques.
CO2: To acquire skills in performing and identification of histological slides of tissue
CO3: To interpret the life cycle of certain animals and their products for human welfare

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-401
SUBJECT NAME: DEVELOPMENTAL BIOLOGY

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course aims to generate an understanding of the developmental patterns of the embryological growth of various animals.

Unit I
Basic concepts of developmental biology and model systems , Cell division, cell differentiation, signaling, patterning; Evolution of developmental patterns
Vertebrates model organism- *Xenopuslaevis*, chicken, mammals, zebrafish; invertebrate model organism- *Drosophila melanogaster*, Sea urchin, *Caenorhabditiselegans*.
Unit II
Embryonic development and Morphogenesis: Early embryonic development of vertebrates and invertebrates: structure of the gametes– the sperm, the egg; cleavage and gastrulation; axes and germ layers
Morphogenesis: cell adhesion, cleavage and formation of blastula, gastrulation, neural tube formation, cell migration; Axis specification in Drosophila: role of maternal genes, patterning of early embryo by zygotic genes- gap genes, pair– rule genes, segment polarity genes, homeotic selector genes- bithorax and antennapedia complex.
Unit III
Organogenesis and Postembryonic development: Development and patterning of vertebrate limb, homeobox genes in patterning, signaling in patterning of the limb
Insect imaginal discs–organizing center in patterning of the leg and wing, the homeotic selector genes for segmental identity; insect compound eye; Postembryonic development: growth, cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence

Regeneration: Epimorphic regeneration of reptile (salamander) limb; Morphollaxis regeneration in hydra; embryonic stem cells and their applications

Unit IV

Endocrinology: Histology of endocrine glands- pineal, pituitary, thyroid, parathyroid, pancreas, and adrenal glands; and functions of hormones secreted by them

Male reproductive system – Structure of Testes, Biosynthesis of testosterone, Regulation and functions

Female reproduction system – Structure of Ovary, Biosynthesis of estrogen, Feedback regulation and functions;

Female Reproductive Cycle– Estrous, Menstrual, Placental hormones–parturition – Lactation.

References:

1. Michael J.F. Barresi and Scott F. Gilbert, (2020). Developmental Biology, Sinauer Associates Inc., Massachusetts, USA. 12th Edition
2. Wolpert, L., Beddington, R., Brockes, J., Jessell, T., & Lawrence, P. (2019). Principles ofDevelopment Oxford University Press. New York. 6th Edition
3. Analysis of Biological Development, Kalthoff, (2000), McGraw-Hill Science, New Delhi, INDIA. 2nd Edition
4. Slack, J. M. (2012). Essential developmental biology.John Wiley & Sons. 3rd Edition
5. Wolpert, L., Tickle, C., & Arias, A. M. (2015). Principles of development. Oxford University Press, USA. 5th Edition
6. Mac E. Hadley and Jon E. Levine (2009) Endocrinology. Pearson Education, 6th Edition.
7. Tortora, G.J. & Grabowski, S. (2020) Principles of Anatomy & Physiology. XI Edition John Wiley & sons, 16th Edition

Course Outcome: On the completion of course, students will be able to:

CO1: Develop a systematic and organized learning about the concepts of growth and development.
CO2: Explain the concepts of embryological development and morphogenesis in animals
CO3: Understand the process of organogenesis and post embryonic development.
CO4: Describe biological processes and their importance for living organisms.

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-402
SUBJECT NAME: EVOLUTIONARY BIOLOGY

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course aims to generate an understanding of the evolutionary patterns of various animals.

Unit I

Life's Beginnings: Chemogeny, RNA world, Biogeny, Origin of photosynthesis, Evolution of eukaryotes; Historical review of evolutionary concept: Lamarckism, Darwinism, Neo-Darwinism, Evidences of Evolution: Fossil record- types of fossils, transitional forms,

geological time scale, evolution of horse, Molecular - universality of genetic code and protein synthesizing machinery, three domains of life, neutral theory of molecular evolution, molecular clock, example of globin gene family, rRNA/cyt c

Unit II

Evolutionary forces upsetting H-W equilibrium. Natural selection (concept of fitness, selection coefficient, derivation of one unit of selection for a dominant allele, genetic load, mechanism of working, types of selection, density-dependent selection, heterozygous superiority, kin selection, adaptive resemblances, sexual selection

Unit III

Micro evolutionary changes (inter-population variations, clines, races, Species concept, Isolating mechanisms, modes of speciation—allopatric, sympatric, Adaptive radiation / macroevolution (exemplified by Galapagos finches); Extinctions, Back ground and mass extinctions (causes and effects), detailed example of K-T extinction

Origin and evolution of man, Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from Dryopithecus leading to Homo sapiens, molecular analysis of human origin, Phylogenetic trees, Multiple sequence alignment, construction of phylogenetic trees, interpretation of trees

References:

1. Ridley,M (2004). Evolution, Blackwell publishing 3rd Edition
2. Hall, B.K. and Hallgrimson, B (2008). Evolution.Jones and Barlett Publishers. 4th Edition
3. Futuyma, D. J., & Kirkpatrick, M. (2017). Evolution, Sinauer Associates. 4th Edition
4. Muehlenbein, M. P. (Ed.). (2010). Human evolutionary biology.Cambridge University Press. 1st Edition
5. Bradshaw, J. L. (2014). Human evolution.Psychology Press. 1st Edition

Course Outcomes (COs)

After successfully completion of this course students will be able to:

CO1: Understand and explain the main forces of evolution along with evidences of evolution.

CO2: Comprehend the knowledge population genetics and consequences of selection, mutation,migration, inbreeding, genetic drift, an important evolutionary force.

CO3: Explain the concepts of macro evolution and micro evolution.

CO4: Get complete understanding about human evolution

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-403
SUBJECT NAME: STRUCTURE AND FUNCTION OF CHORDATES

Credits	L	P		
4	4	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: Aim of this course is to provide in-depth knowledge of vertebrate classification and the basis of their structural and physiological differences in relation to different biological systems.

Unit I

Introduction to Chordates with their general characters, Origin of Chordates, Concept of Protochordate or pre-vertebrates, Classification of Vertebrates upto orders.
Integument and its derivatives: Development, general structure and functions of skin and its derivatives, Glands, scales, horns, claws, nails, hoofs, feathers and hair

Unit II
Skeletal system: Form, function, body size and skeletal elements of the body, Comparative account of jaw suspensorium, Vertebral column, Limbs and girdles
Digestive system: Dentition, Stomach, Digestive Glands, Anatomy of gut in relation to feeding habits- herbivores, carnivores and omnivores, Comparative physiology of digestion and absorption; **Respiratory system:** Characters of respiratory tissue, Internal and External Respiration, Comparative physiology of respiratory systems with special emphasis on respiratory organs

Unit III
General plan of circulation in various groups: Components of Blood, General plan of circulation in reptiles, birds and mammals, Evolution of heart, aortic arches and Portal systems, Comparative physiology of circulatory systems
Evolution of Urinogenital system in vertebrates: Structure and functions of different types of kidneys, Urino-genital ducts, Comparative physiology of excretory systems, Flight adaptation in birds, Migration in fish and Birds

Unit IV
Nervous system: Comparative anatomy of the brain in relation to its functions, Comparative physiology of nervous systems with special emphasis on anatomy of spinal cord, Nerves-Cranial, Peripheral and Autonomous nervous systems
Sense organs: Simple receptors, Organs of Olfaction and taste, Lateral line system, Electroreception

References:
1. Kotpal, R. L. (2019). Modern Text Book of Zoology: Vertebrates. Rastogi Publications, 4th Edition
2. David Hickman, Jr., Cleveland; Roberts, Larry; Keen, Susan; Larson, Allan; Eisenhour (2021).Animal Diversity. McGraw Hill Education, 9th Edition.
3. Young, J. Z. (2004). The Life of Vertebrates.Oxford university press. 3rd Edition
4. Pough, F. H., Janis, C. M., &Heiser, J. B. (2013). Vertebrate life.Pearson Higher Ed. 9th Edition.
5. Hildebrand, M., Goslow, G. E., & Hildebrand, V. (1998). Analysis of vertebrate structure, Wiley, 3rd Edition
6. Kardong, K. V. (2019). Vertebrates: comparative anatomy, function, evolution. McGraw-Hill Education. 8th Edition

Course Outcome: On the completion of course, students will be able to:

CO1: Demonstrate how chordates differs from non-chordates
CO2: Explain the structural variations among vertebrates with respect to different phyla and their major orders.
CO3: Understand the role of different biological systems in the adaptions.

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-404
SUBJECT NAME: ZOOLOGY LAB COURSE-IV

Credits	**L**	**P**	**Sessional**	**30**
6	**0**	**12**	**Theory Exam**	**70**
			Total:	**100**

Course Objective: The course aims towards developing students knowledge and understanding in vertebrate diversity

1. Protochordates (Museum specimens and slides) – Salpa sexual, Salpa-sexual, Botryllus, Herdmania.
2. Fishes (Museum specimens and slides) - *Rhinobatus, Chimaera, Acipenser, Amia, Periopthalmus, Tricanthus, Notopterusnotopterus, Scatophagus, Aargus, Trichurus, Mastacembalusarmatus, Exocoetus*(flying fish), *Diodonhyterix, Echeneis, Neucrates.*
3. Amphibians (Museum specimens and slides) –*Necturus, Siren, Ichthyophis, Geganophis, Rhacophorus, Ranatigrina, Amblystomauraetyphlus, Cryptobranchus, Axolotl Larvae, Salamander, Amphiuma, Trilon.*
4. Reptiles (Museum specimens and slides) – Chameleon, *Phrynosoma, Chelonemydas.*
5. Birds (Museum specimens and slides) – Indian Oriole, Indian Koel (male), India koel (female), Indian tailor birds, Kite, jungle fowl.
6. Mammals (Museum specimens and slides) – Indian otter, Marmoset, Loris, Bat (*Megadermalyra),* Pangolin, Echidna,*Ornithorhynchus*, Hedgehog, Scaly-ant eater, Porcupine, Mongoose.
7. Skull and lower jaw of Chelonia, Crocodile, Bird, Carnivore-mammal (dog), Herbivore mammal (horse).
8. Comparative Osteology of Vertebrates (Frog, Chicken, Rat, Rabbit etc.): Girdles, Limb-bones
9. To prepare stained/unstained slide of placoid scales.
10. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpoleexternal and internal gill stages)
11. Study of whole mounts of developmental stages of chick through permanent slides: Primitive streak (13 and 18 hours), 21, 24, 28, 33, 36, 48, 72, and 96 hours of incubation (Hamilton and Hamburger stages)
12. Study of the developmental stages and life cycle of *Drosophila*
13. Histological slides of various organs and systems during development using stained serial sections
14. Preparation of permanent slide of procured animal tissue for histological analysis
15. Study of fossils from models
16. Evolution of horse and human from models
17. Demonstration of role of natural selection and genetic drift in changing allele frequencies using simulation studies
18. Graphical representation and interpretation of data of height/ weight of a sample of 100 humans in relation to their age and sex.

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https://sites.dartmouth.edu

**Addition or deletion of the lab experiments can be done as per the availability of resources in lab.

Course Outcome: At the end of laboratory course, students will be able to:

CO1: Identify and distinguish vertebrate diversity
CO2: Understand the diversity of invertebrates in terms of their classification and characteristic features
CO3: Develop an understanding of embryological development

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-405
SUBJECT NAME: DISSERTATION WORK

Credits	**L**	**P**	
4		**8**	
		Total:	**100**

Course Objective: This aims towards developing in depth review of literature on a research topic focused towards detailed understanding and its presentation as a comprehensive criticism.

Course Outcome: Upon completion of the course the student shall be able to:
CO1: Develop literature searching and database searching skills
CO2: Acquireskills incompiling and interpreting research data
CO3: Acquire skills in writing research documents

M.Sc. ZOOLOGY SEMESTER IV
CODE: MMT-DE002
SUBJECT NAME: VIROLOGY

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objective: The course aims at inculcating an in-depth knowledge of various acellular agents and their impact on human health.

Unit I

- Evolution of viruses,
- Viral tropism, factors responsible for viral tropism, Immune aversion mechanisms of virus, mechanisms in virus latency, transmission of virus
- Virus host interactions – acute, chronic/persistent, latent, transforming, abortive and null infections Virus induced cell death. Viral virulence and its alteration
- Virus induced tumours

Unit II

- Structure, genome, and life cycle of influenza virus, corona virus, parvovirus, dengue virus, flavivirus, baculovirus.
- Structure, genome, and life cycle of Giant viruses associated with protist (mama and mimi virus) and virophages (Sputnik, Mavirus).
- An introduction to archaeal and fungal viruses.
- Other infectious agents: viroids, satellites and prions

Unit III

- Advanced technologies for detecting virus,
- Recombinant viruses for gene therapy,
- Antiviral vaccines and chemotherapy
- Eukaryotic virus vectors
- Economic impact of viruses and viral epidemiology- an overview

References

1. Understanding Viruses by Teri Shors Jones. 3rd edition. Jones and Bartlett Learning, USA. 2016.
2. Principles of Virology, Molecular biology, Pathogenesis and Control by S.J. Flint, L.W. Enquist, R.M. Krug, V.R. Racaniello, A.M. Skalka. 4th edition. ASM press, USA. 2015
3. Virology: Principles and Applications by J. Carter and V. Saunders. 2nd edition. John Wiley and Sons, UK. 2013.
4. Introduction to Modern Virology by N.J. Dimmock, A.L. Easton and K.N. Leppard. 6th edition. Wiley-Blackwell Publishing. 2007.
5. Basic Virology by E.K. Wagner, M.J. Hewlett, D.C. Bloom. 3rd edition. Wiley-Blackwell Publishing. 2007.

6. Virology by J.A. Levy, H.F. Conrat and R.A. Owens. 3rd edition. Prentice Hall, USA. 2000.

Course Outcomes (COs)

After successful completion of the course, a student will be able to

CO1: Students will be able to understand the structure and transmission of viral particles
CO2: Students will be able to evaluate the viral cell behaviour in different diseases
CO3: Students will be able imply the use of viral cells in different immunological applications

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-DE003
SUBJECT NAME: GENOMICS AND PROTEOMICS

Credits	L	P		
3	3	0	Sessional	25
			Theory Exam	75
			Total:	100

Course Objectives : The course aims towards generating knowledge in application of different strategies for studies of genome and protein diversity

Unit I

- Introduction to Genomics, Anatomy of prokaryotic and eukaryotic genome,
- content of genome, C-value paradox, Cot curve analysis, repetitive DNA, tools to study genome
- Applied Genomics Strategies for major genome sequencing projects, approaches and assembly methods, NGS methods and advantages, gene analysis and annotation.

Unit II

- Transcriptomics and expression profiling Genome expression analysis, RNA content and profiling, genetic mapping, Microarray (cDNA and protein microarray)
- Introductory proteomics-Importance of proteomics, strategies in analysis of proteome: 2-DPAGE. Mass spectrometry, Protein sequencing method (Edman degradation, MALDI TOF/TOF).
- Protein solubility and interaction with solvents and solutes, activity of proteins.

Unit III

- Quantitation proteomics–ICAT, SILAC, iTRAQ, applications of quantitation proteomics.
- Proteomic profiling for host-pathogen interaction, Understanding proteomics for post translational modifications.
- Application of proteomics for drug discovery. Biomarkers and drug targets identification. Validation of drug targets and assessment of its toxicology

References:

1. Proteomics by T. Palzkill, 1st Ed Kluwer Academic Publishers, New York, USA.
2. Protein Microarray Technology by D. Kambhampati, 1st Ed. Wiley-VCH VerlagGmbHWeinheim, Germany.
3. Introduction to Genomics by A.M. Lesk, 3rd Ed. Oxford University press,UK.3rdEdition
4. Metabolome Analysis: An Introduction by S.G. Villas-Boas, 1st Ed. Wiley-Blackwell, USA.
5. Concepts in Plant Metabolomics by B.J. Nikolau and E.S.Wurtele. 1stEd.Springer, USA.
6. A Primer of Genome Science by G. Gibson and S.V. Muse. 3rdEd.Sinauer Associates.
7. Genome by T.A. Brown .4thEd.Garland SciencePublishers.4th Edition

Course Outcomes (COs)

After successful completion of this course, a student will be able to:

CO1: Develop an understanding of the basics of genomics and proteomics.

CO2: Generate an understanding of the tools and techniques for generating data

CO3: Analyze the information generated for potential applications.

M.Sc. ZOOLOGY SEMESTER IV
CODE: MZO-DE006
SUBJECT NAME: ENVIRONMENTAL TOXICOLOGY

Credits	**L**	**P**	**Sessional**	**25**
3	**3**	**0**	**Theory Exam**	**75**
			Total:	**100**

Course Objective: The course aims towards generating detailed understanding of the physiological mechanisms of toxin entry and spread in animals.

Unit- I

Definition, history, scope & sub-divisions of toxicology.

Dose-effect and dose-response relationship- acute toxicity, chronic toxicity reversible & irreversible effects.

Classification of toxic agents, natural toxins, animal toxins, plant toxins, food toxins, genetic poisons and chemical toxins.

Factors affecting toxicity – species and strain, age, sex, nutritional status, hormones, environmental factors, circadian rhythms.

Absorption and distribution of toxicants-portals of entry-skin, gastro intestinal tract, gills and respiratory system.

Unit- II

Bio-distribution, biomagnification biotransformation of xenobiotics- brief introduction to Phase-I and Phase-II reactions.

Reactions of toxins with target molecules- Covalent binding, Non-covalent binding, Hydrogen abstraction, Electron transfer, Enzymatic reactions

Basics of organ toxicity- Target organs, Organ selectivity and specificity

Brief idea of cutaneous, pulmonary, hepato-renal, reproductive and endocrine toxicity.

Unit-III

Mechanisms of heavy metal toxicity- Induction of metallothionein, heat shock proteins, cyto skeletal effects, heamporphyrin metabolism, lipid peroxidation

Toxicity of trace elements- Iodine, iron, zinc, copper, manganese, selenium, molybdenum, and cobalt.
Characteristics and mechanism of action of Organochlorines, Organophosphorus insecticides, Carbamates, Pyrethroids
other plant origin bio-insecticides, Properties of few individual insecticides i.e. DDT, HCH (BHC), Lindane, Endosulfan, Parathion, Malathion, Method of testing chemicals on insect and evaluation of toxicity.

References:

1. Toxicology and Risk Assesssment: A Comprehensive Introduction, Greim H.,and Snyder, R. (ed), John Wiley and Sons, UK
2. The Complete Book of pesticide management, Whitford, F., Wiley Interscience, John Wiley and Sons, UK

Course Outcomes (COs)

After successful completion of the course, a student will be able to:
CO1: Develop understanding of the parameters used in assay and monitoring of toxin and its response
CO2: Acquire concepts of the mechanism of toxicity induced by various compounds/metals
CO3: Generate skills for designing experiments for toxicity testing and analysis