आईएफटीएम विश्वविद्यालय, मुरादाबाद, उत्तर प्रदेश
IFTM University, Moradabad, Uttar Pradesh
NAAC ACCREDITED

SCHOOL OF SCIENCES

DEPARTMENT OF ZOOLOGY

MASTER OF SCIENCE (ZOOLOGY)

TWO YEAR PROGRAMME

[W. E. F. ACADEMIC SESSION: 2020 - 21]

IFTM UNIVERSITY
N.H.-24, Lodhipur Rajput, Delhi Road, Moradabad, Uttar Pradesh-244001
www.iftmuniversity.ac.in

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SCHOOL OF SCIENCES
DEPARTMENT OF ZOOLOGY

Study & Evaluation Scheme of
Master of Science (Zoology)
[Session 2020-21]

Programme	**:**	**Master of Science (Zoology)**
Course Level	**:**	**PG Course**
Duration	**:**	**Two Year (Four Semester) Full Time**
Medium of Instruction	**:**	**English**
Minimum Required Attendance	**:**	**75%**
Maximum Credits	**:**	**80**

Programme Outcomes (POs):

The mission of the program is to teach and learn the significance of fauna in biology related to animals of single cell to multicellular systems. It covers biochemistry, biotechnology, immunology, Developmental Biology, and Molecular Genetics apart from classical subjects like invertebrates, chordates and their ecology and evolution. This Program gives confidence to students from multiple disciplines to experience research in the field of advanced Zoology. These subjects will produce tremendous enhancement in the quality of living with a safer and more resourceful to this world.

M.Sc. (ZOOLOGY) YEAR I; SEMESTER I

S.N.	Course Code	Course Title	Periods			EVALUATION SCHEME				Total	Credits
						Internal Exam			External Exam		
			L	T	P	MSE	AS +AT	Total			
THEORY											
1.	MZO 101	Genetics and Cytogenetics	3	1	0	10+10	05+05	30	70	100	4
2.	MZO 102	Principles of Gene Manipulation	3	1	0	10+10	05+05	30	70	100	4
3.	MZO 103	Mammalian Physiology & Metabolism	3	1	0	10+10	05+05	30	70	100	4
4.	MZO 104	Structure & Function of Invertebrates	3	1	0	10+10	05+05	30	70	100	4
PRACTICALS / PROJECT											
5.	MZO 151	Lab 1 based on MZO101&MZO102	-	-	4	-	-	30	70	100	2
6.	MZO 152	Lab 2 based on MZO103&MZO104	-	-	4	-	-	30	70	100	2
		TOTAL	**12**	**04**	**08**	**-**	**-**	**-**	**-**	**600**	**20**

M.Sc. (ZOOLOGY) YEAR I; SEMESTER II

S.N.	Course Code	Course Title	Periods			EVALUATION SCHEME				Total	Credits
						Internal Exam			External Exam		
			L	T	P	MSE	AS +AT	Total			
THEORY											
1.	MZO 201	Developmental Biology	3	1	0	10+10	05+05	30	70	100	4
2.	MZO 202	Systematics, Biodiversity and Evolution	3	1	0	10+10	05+05	30	70	100	4
3.	MZO 203	Immunology	3	1	0	10+10	05+05	30	70	100	4
4.	MZO 204	Animal Behavior and Chronobiology	3	1	0	10+10	05+05	30	70	100	4
PRACTICALS / PROJECT											
5.	MZO 251	Lab 1 based on MZO 201&MZO 202	-	-	4	-	-	30	70	100	2
6.	MZO 252	Lab 2 based on MZO 203&MZO 204	-	-	4	-	-	30	70	100	2
		TOTAL	**12**	**04**	**08**	**-**	**-**	**-**	**-**	**600**	**20**

M.Sc. (ZOOLOGY) YEAR II; SEMESTER III

S.N.	Course Code	Course Title	Periods		EVALUATION SCHEME					Total	Credits
					Internal Exam				External Exam		
			L	T	P	MSE	AS +AT	Total			
THEORY											
1.	MZO 301	Principles of Ecology	3	1	0	10+10	05+05	30	70	100	4
2.	MZO 302	Computational Biology, Biostatistics and Bioinformatics	3	1	0	10+10	05+05	30	70	100	4
3.	MZO 303	Structure and function of chordata	3	1	0	10+10	05+05	30	70	100	4
4.	MZO 304	General Endocrinology	3	1	0	10+10	05+05	30	70	100	4
PRACTICALS / PROJECT											
5.	MZO 351	Lab 1 based 0nMZO301 & MZO 302	-	-	4	-	-	30	70	100	2
6.	MZO 352	Lab 2 based 0nMZO303 & MZO 304	-	-	4	-	-	30	70	100	2
		TOTAL	**12**	**04**	**08**	**-**	**-**	**-**	**-**	**600**	**20**

M.Sc. (ZOOLOGY) YEAR II; SEMESTER IV

Students will select any one of the TWO streams each stream consisting of three papers. Besides this, each student will complete a practical and a dissertation.

Stream I: Fish Biology

S.N.	Course Code	Course Title	Periods		EVALUATION SCHEME					Total	Credits
					Internal Exam				External Exam		
			L	T	P	MSE	AS +AT	Total			
THEORY											
Stream I: FISH BIOLOGY											
1.	MZO 401	Evolution and Functional Anatomy of Fish	3	1	0	10+10	05+05	30	70	100	4
2.	MZO 402	Aquatic Resources and Their Conservation	3	1	0	10+10	05+05	30	70	100	4
3.	MZO 403	Aquaculture	3	1	0	10+10	05+05	30	70	100	4
PRACTICALS / PROJECT											
4.	MZO 451	Fish Biology Lab	-	-	4	-	-	30	70	100	4
5.	MZO 452	Dissertation	-	-	4	-	-	-	-	200	4
		TOTAL	**09**	**03**	**08**	**-**	**-**	**-**	**-**	**600**	**20**

M.Sc. (ZOOLOGY) YEAR II; SEMESTER IV

Stream II: Cytology and Cytogenetics

S.N.	Course Code	Course Title	Periods			EVALUATION SCHEME				Total	Credits
						Internal Exam			External Exam		
			L	T	P	MSE	AS +AT	Total			
THEORY											
Stream II: Cytology and Cytogenetics											
1.	MZO 401 A	Extra Nuclear Cytology	3	1	0	10+10	05+05	30	70	100	4
2.	MZO 402 A	Nuclear Cytology and Cytogenetics	3	1	0	10+10	05+05	30	70	100	4
3.	MZO 403 A	Cytogenetical Techniques	3	1	0	10+10	05+05	30	70	100	4
PRACTICALS / PROJECT											
4.	MZO 451 A	Cytogenetics Lab	-	-	4	-	-	30	70	100	4
5.	MZO 452 A	Dissertation	-	-	4	-	-	-	-	200	4
		TOTAL	**09**	**03**	**08**	**-**	**-**	**-**	**-**	**600**	**20**

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 101: Genetics and Cytogenetics

Objective: The course is designed to revise basic concepts of Genetics and then move on to advanced concepts. Some key aspects include the mechanism of inheritance, gene structure and function, sex chromosomal and autosomal anomalies, aspects of human genetics, etc. will be covered. A strong emphasis will be laid on the modern tools and techniques used in genetics.

Unit-1: Mendel's laws and their chromosomal basis; extension of Mendel's principles: allelic variation and gene function- incomplete dominance and co-dominance, allelic series, testing gene mutations for allelism; gene action- from genotype to phenotype– penetrance and expressivity, gene interaction, epistasis, pleiotropy; nature of the gene and its functions: evolution of the concept of the gene, fine structure of gene (rII locus); methods of gene mapping: 3- point test cross in *Drosophila*, gene mapping in humans by linkage analysis in pedigrees. **(10 Sessions)**

Unit-2: Gene mutation and DNA repair: types of gene mutations, methods for detection of induced mutations, P- element insertional mutagenesis in *Drosophila*, DNA damage and repair; regulation of gene activity in *lac* and *trp* operons of *E. coli*, general introduction to gene regulation in eukaryotes at transcriptional and posttranscriptional levels, organization of a typical eukaryotic gene, transcription factors, enhancers and silencers, non-coding genes. **(10 Sessions)**

Unit-3: Sex determination and dosage compensation: sex determination- in humans, *Drosophila* and other animals; dosage compensation of X-linked genes– hyper activation of X-linked gene in male *Drosophila*, inactivation of X-linked genes in female mammals. **(06 Sessions)**

Unit-4: human genetics- karyotype and nomenclature of metaphase chromosome bands; chromosome anomalies and diseases- chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilms' tumor); genetic analysis of complex traits - complex pattern of inheritance, quantitative traits, threshold traits; human genome and mapping. **(10 Sessions)**

Unit-5: Genetics and cancer: oncogenes- tumor inducing retroviruses and viral oncogenes; chromosome rearrangement and cancer; tumor suppressor genes- cellular roles of tumor suppressor genes, pRB, p53, pAPC, genetic pathways to cancer. **(06 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to:

- Understand how DNA encodes genetic information and the function of mRNA and tRNA
- Apply the principles of Mendelian inheritance.
- Understand the cause and effect of alterations in chromosome number and structure.

- Relate the conventional and molecular methods for gene manipulation in other biological systems.
- Discuss and analyse the epigenetic modifications and imprinting and its role in diseases.

Suggested Literature:

1. Principles of Genetics, Snustad and Simmons, (4th Ed. 2005), John Wiley & Sons, USA

2. Modern Genetic Analysis: Integrating Genes and Genomes, Griffiths, J.F., Gelbart, M., Lewontin, C. and Miller, W. H. Freeman and Company, New York, USA

3. Genetics, J. Russell, Benjamin-Cummings Publishing Company, San Francisco, California, USA

Online Resources

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://swayam.gov.in/courses/4922-genetics-and-genomics
- www.pdfdrive.com/zoology -books.html

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 102: Principles of Gene Manipulation

Objective: This course gives an insight into the direct manipulation of DNA to alter the characteristics of an organism in a particular way. It envisages concepts, mechanisms, biological designs, functions and evolutionary significance of genetic modification or manipulation in special organisms and also discusses the recent advance in recombinant DNA technology.

Unit-1: Basic recombinant DNA techniques, cutting and joining DNA molecules, restriction modification systems, various enzymes used in recombinant DNA technology, application of recombinant DNA technology. **(10 Sessions)**

Unit-2: Restriction maps and mapping techniques; nucleic acid probes, blotting techniques, DNA fingerprinting, footprinting, methyl interference assay. Polymerase chain reaction– methods and applications. **(8 Sessions)**

Unit-3: Basic biology of cloning vectors: plasmids, phages, single stranded DNA vectors, Cosmids and other advanced vectors. Gene cloning strategies: methods of transforming *E. coli* and other cells with rDNA; methods of selection and screening of transformed cells; construction of genomic and cDNA libraries; strategies of expressing cloned genes; phage display. **(10 Sessions)**

Unit-4: Principles of DNA sequencing, automated sequencing methods; synthesis of oligo-nucleotides, primer design; micro-arrays; confocal microscopy; changing genes- directed evolution, protein engineering in microbes **.** **(8 Sessions)**

Unit-5: Manipulating genes in animals: gene transfer to animal cells, genetic manipulation of animals, transgenic technology, genetically modified organisms: gene knockouts, mouse disease models, gene silencing, gene therapy, somatic and germ- line therapy. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to:

- Gain knowledge and skill in the fundamentals of biotechnology, interactions and interdependence of physiological and biochemical processes.
- Get exposed to various processes used in industries.
- Develop an understanding of the fundamental molecular tools and their applications of DNA modification and cloning.
- Develop future course of their career development in higher education and research with a sound base.
- Apply their knowledge with problem solving approach to recommend strategies of genetic engineering for possible applications in Biotechnology and allied industry.

Suggested Literature:

1. Recombinant DNA: Genes and Genomics – a short course, Watson et al., W. H. Freeman and Company, New York, USA

2. Principles of Gene Manipulation and Genomics, Primrose, S. B. and Twyman, R. M., (7th Ed. 2006), Blackwell Publishing, West Sussex, UK

3. Molecular Biotechnology: Principles and application of recombinant DNA, Bernard R. and Jack, ASM Press, Herndon, USA

Online Sources:

- https://www.youtube.com/user/cecedusat/featured.
- National Institute of Science Communication and Information Resources (NISCAIR) (http://www.niscair.res.in/) and National Science Digital Library (NSDL) (www.nsdl.niscair.res.in).
- National Digital Library of India (NDL India; https://ndl.iitkgp.ac.in/).
- www.pdfdrive.com/zoology -books.html
- http://gsi.semmelweis.hu/files/ebook/Genetics%20genomics_en.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 103: Mammalian Physiology & Metabolism

Objective: The course deals with various physiological functions in mammals. It also gives an account of the metabolic/ biochemical pathways and the probable impact of environment on them. The course provides an insight into the structure and function of organ systems in humans and their involvement in body metabolism towards maintenance of homeostasis.

Unit-1: Internal Transport and Gas Exchange – 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. **(8 Sessions)**

Unit-2: Osmoregulation in aquatic and terrestrial environments, Kidney functions and diversity, Extra-renal osmoregulatory organs, Patterns of nitrogen excretion. Thermoregulation - Heat balance in animals, Adaptations to temperature extremes, torpor, Aestivation and hibernation, Counter current heat exchangers. Adaptations to Stress- basic concept of environmental stress, acclimation, acclimatization, avoidance and tolerance, stress and hormones. **(10 Sessions)**

Unit-3: Sensing the Environment- photoreception, chemoreception, mechanoreception, echolocation, Endogenous and exogenous biological rhythms, Chromatophores and bioluminescence. Feeding mechanisms and their control, effect of starvation. Muscle physiology – striated and smooth muscle, Adaptations of muscles for various activities, Neuronal control of muscle contraction, Electric organs. **(8 Sessions)**

Unit-4: A broad outline of metabolic pathways and their linkage, metabolism of primary metabolites – monosaccharides, lipids, amino acids and nucleotides. Nature of enzymes – kinetics, physico – chemical characterization, regulation of enzyme activity. Metabolic basis of nutrition, metabolic basis of specialized tissue function, metabolic disorders, metabolic basis of diagnostics, metabolism and adaption with one example, regulation of metabolism at molecular, cellular and organismic levels, enzymes and receptors as drug targets. **(10 Sessions)**

Unit-5: Endocrinology: Classification of Hormones. General principles of Hormone action, Biosynthesis & secretion of hormones, Hormones & reproduction. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Understand the physiology at cellular and system levels.
- Understand the mechanism and regulation of breathing, oxygen consumption and determination of respiratory quotient.
- Understand how mammalian body gets nutrition from different biomolecules.
- Understand the process of digestion and excretion.
- Understand the organization of nervous system and process of nerve conduction.
- Understand the process of vision and hearing.

- Understand the process of muscle contraction.
- Learn the determination of hemoglobin content, blood groups and blood pressure.

Suggested Readings:

1. General and Comparative Animal Physiology, Hoar W. S. (ed), Prentice Hall, India
2. Comparative Physiology (Handbook of Physiology): Vol. 1, 2, Dantzler, W.H. (ed.) Oxford University Press, New York, USA
3. Animal Physiology: Adaptation and Environmental, Nelson K. S. (ed) Cambridge University Press, Cambridge, UK
4. Biochemistry and Molecular Biology, Elliott and Elliott, Oxford University press, New York, USA (Indian edition)
5. Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA
6. Practical Biochemistry – Principles and Techniques, Wilson and Walker, Cambridge University Press, Cambridge, UK

Online Resources

- www.digitalbookindex.org
- www.kalyanipublication.co.in
- *www1.biologie.uni-hamburg.de*
- www.freebookcentre.net
- https://www.easybiologyclass.com
- https://www.pdfdrive.net/plant-and-animal-physiology-e1735854.html

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 104: Structure & Function of Invertebrates

Objective: The course would provide an insight to the learner about the existence of different life forms on the Earth, and appreciate the diversity of animal life. It will help the student to understand the features of Kingdom Animalia and systematic organization of the animals based on their structural and functional affinities.

Unit-1: Protozoa: Detailed classification (upto order); Locomotion, Reproduction and Parasitism with a brief account of the causative agents of the following disorders of human i.e. Kala-azar, diarrhea, sleeping sickness, malaria. **(8 Sessions)**

Unit-2: Porifera: Detailed classification (upto order); canal system and their types and Skeleton in sponges. **(6 Sessions)**

Unit-3: Coelentrata: Detailed classification (upto order);Polymorphism in Siphonophores, coral reefs C types, theories of coral reef formation, distribution and its conservation

Minor Phyla: Brief account and affinities of Rotifera, Acanthocephala, Sipunculoidea. **(8 Sessions)**

Unit-4: Annelida: Detailed classification (upto order); Morphology and type study of Leech. Adaptive radiation in Polycheata, Metamerism in Annelida.

Mollusca: Detailed classification (upto order); Torsion in Gastropoda. Pearl industry. **(8 Sessions)**

Unit-5: Artropoda: Detailed classification (upto order); Brief account and affinities of Onychophora, Parasitism in Crustacea, larval forms in crustacean, mouth parts of insects

Echinodermata: Detailed classification (upto order); larval forms, water vascular system. **(8 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to:

- Learn about the importance of systematics, taxonomy and structural organization of animals.
- Appreciate the diversity of non-chordates living in varied habit and habitats.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities. ·

Suggested Readings:

1. Ruppert, E.E. and R.D. Barnes 1994. Invertebrate Zoology. Saunders.
2. Pecenik, J.A. 1999. Biology of Invertebrates (4th Ed). MacGraw-Hill Higher Education Publishing Co
3. Barrington, E.J.W. 1974. Invertebrate: Structure and Function. ELBS.
4. Brusca, R.C. and G.J. Brusca 1990. Invertebrates. Sinauer Associates Inc.
5. Wallace, R.L. and K.T. Walter 1996. Invertebrate Zoology: A Laboratory Manual. Prentice Hall

Online Resources

- http://www.iaszoology.com/insect/
- http://download.nos.org/srsec314newE/PDFEL35B.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 151: Lab 1 based on MZO 101 & MZO 102

Objective: This is the only laboratory course taught independently of lecture courses. It has full hands on approach to expose the students to modern techniques and methodologies. The diverse techniques from microscopy to spectroscopy, calorimetry, chromatography ELISA, tissue culture to cloning etc. are included to make the student well versed with these protocols and methods.

List of Experiments: **(20 Sessions)**

A. Genetics and Cytogenetics:

1. Study of mutant phenotypes of *Drosophila.*
2. Demonstration of law of segregation using *Drosophila* mutants.
3. Study of law of independent assortment.
4. Demonstration of sex- linkage by using white mutation of *Drosophila.*
5. Demonstration of dosage compensation in *Drosophila* males and females.

B. Principles of Gene Manipulation:

1. Plasmid DNA isolation: minipreps.
2. Agarose gel electrophoresis of isolated plasmid.
3. DNA quantization and purity of DNA.
4. Restriction enzyme digestion of plasmid DNA.
5. Purification of DNA from an agarose gel.
6. Vector and insert ligation.
7. Preparation of competent cells and storage.
8. Transformation of *E. coli* with standard plasmids, calculation of transformation efficiency.

Course Outcomes:

After successfully completing this course, the students will be able to:

- Understand the purpose of the technique, its proper use and possible modifications/ improvement.
- Learn the theoretical basis of technique, its principle of working and its correct application.
- Learn the construction repair and adjustment of any equipment required for a technique.
- Learn the accuracy of technique.
- Learn the maintenance laboratory equipments/ tools, safety hazards and precautions.
- Understand the technique of cell and tissue culture.
- Learn the preparation of solution of given percentage and molarity.
- Understand the process of preparation of buffer. Learn the techniques of separation of amino acids, proteins and nucleic acids.

Suggested Literature:

1. A manual of practical zoology: biodiversity, cell biology, genetics & developmental biology part 1 (M.M. Trigunayat).

Online Resources

- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (I Semester)

MZO 152: Lab 2 based on MZO 103 & MZO 104

Objective: The main objective of this course is to aware the students about mammalian physiological processes and metatolislm. The student will get better understanding of the concept studied by them in theory course and correlate with experimental observation.

List of Experiments: **(20 Sessions)**

A. Mammalian Physiology & Metabolism:

1. Demonstration of tetany, action current and fatigue in muscle.
2. To study the effect of load on muscle contraction.
3. Titration of an amino acid, an acidic dye and an organic acid to determine the pKa value.
4. Preparation of a 'Good' buffer.
5. Estimation of a sugar, an amino acid, a vitamin, a nucleotide/nucleic acid by appropriate chemical and biological methods.
6. Kinetic characterization of any one enzyme.
7. Zymogram for any one enzyme.
8. Affinity chromatography using either a lectin or a textile dye.

B. Structure & Function of Invertebrates

1. To study the nervous system of Prawn, *Pila*

2. **Permanent mounting material**-Gemmules, Spicules, *Obelia, Hydra, Taenia* scolex, *Cyclops, Daphnia, Gammarus, Bugula,* Mouthparts - Cockroach, Mosquito, Housefly, Honeybee, Gill plate – *Pila, Unio*

3. Spotting:

a. Phylum Protozoa- *Paramecium, Euglena, Volvox, Noctiluca, Trypanosoma, Leishmania, Polystomella, Plasmodium, Opalina, Balantidium, Vorticella,* Conjugation in *Paramecium*

b. Phylum Porifera- *Leucosolenia, Euspongia, Euplectella, Hyalonema, Sypha, Clathrina, Grantia, Poterion, Cliona, Chalina, Halichondria, Ciona,* L.S. Sycon,T.S. Sycon, L.S. *Grantia*

c. Phylum Coelentrata- *Obelia* colony, *Obelia* medusa, *Hydra, Millipora, Diphyes, Physalia, Porpita, Aurelia, Tubipora, Alcyonium, Gorgonia, Pennatula, Metridium, Adamsia, Favia, Fungia, Madrepora, Meandrina,* Hydra W.M., Hydra L.S., Hydra T.S. of testis and ovary, *Tubularia, Sertularia, Companularia, Eudendrum*

d. Phylum Platyhelminthes- *Fasciola hepatica, Taenia solium, Planaria, Echinococcus, Fasciola* larva- Miracidium, Sporocyst, Redia, Cercaria, Taenia- Mature segment and Gravid segment,

e. Phylum Aschelminthes- *Ascaris lumbricoides, Ascaris,* T.S.- male and female

f. Phylum Annelida- *Nereis, Heteronereis, Pheretima*, *Polynoe, Eunice, Syllis, Aphrodite, Chaetopterus, Sabella, Arenicola, Amphitrite, Terebella, Serpula, Spirorbis, Pontobdella, Hirudenaria,* Earthworm T.S. through Pharynx, Gizzard, Typhlosolar region, *Nereis*-Parapodium,

g. Phylum Arthropoda- Prawn, *Lepas, Balanus, Sacculina, Squilla, Astacus, Euparagus, Hippa, Carcinus, Scolopendra, Julus, Limulus, Gryllus*, Praying mantis, Dragon fly, *Nepa, Belostoma, Cicada, Gammarus, Cyclops, Daphnia, Lucifer*, *Mysis,* Zoea larva, Megalopa larva

h. Phylum Mollusca- *Pila, Mytilus, Chaetoderma, Chiton, Dentalium, Patella, Haliotis, Aplysia, Doris, Teredo, Octopus, Sepia, Loligo, Nautilus, Pecten, Pinctada, Unio-* Glochidium larva

i. Phylum Echinodermata- *Asterias, Antedon, Ophiothrix,* T.S. Arm- Starfish, Pedicellaria of starfish, Bipinnaria larva

j. Minor Phyla- *Bugula*

Course Outcomes:

After successfully completing this course, the students will be able to:

- Understand the physiology at cellular and system levels.
- Understand evolutionary history and relationships of different non-chordates through functional and structural affinities. ·

Suggested Readings:

1. A manual of Practical Zoology Chordates Dr. P. S. Verma, S. Chand Publication
2. Practical Zoology- Invertebrates, Dr. P. S. Verma, S. Chand Publication

Online Resources

- https://en.wikipedia.org/wiki/Invertebrate
- https://en.wikipedia.org/wiki/Vertebrate
  https://www.diffen.com/difference/Invertebrate_vs_Vertebrate

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (II Semester)

MZO 201: Developmental Biology

Objective: The course explains the sequence of events starting with a single cell to the production of a very complex organism. The course not only describes how embryos develop (embryology), but also highlights how the processes of development are brought about by changing individual cells into specialized cells with specific functions (the cellular level), and how genes within the genome of the organism drive and guide these changes (the molecular level). It also deals with a comparative account of development in some select groups of animals.

Unit-1: History and basic concepts: the origin of developmental biology- cell theory, mosaic and regulative development, discovery of induction, genetics and development; basic concepts of developmental biology- cell division, cell differentiation, signaling, patterning; model systems: vertebrates model organism- *Xenopus laevis*, zebrafish; invertebrate model organism- *Drosophila melanogaster*, *Caenorhabditis elegans;* identification of developmental genes: spontaneous and induced mutation, mutant screening, developmental mutations in *Drosophila*. **(8 Sessions)**

Unit-2: 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*; origin of anterior- posterior and dorsal-ventral patterning- role of maternal genes, patterning of early embryo by zygotic genes; segmentation genes- the gap genes, the pair– rule genes, the segment polarity genes, the homeotic selector genes- bithorax and antennapedia complex. **(8 Sessions)**

Unit-3: General concepts of organogenesis: development of chick limb- eye, heart and brain; insect imaginal disc– determination of wing and leg imaginal discs, organizing center in patterning of the wing, butterfly wing development, the homeotic selector genes for segmental identity; insect compound eye– morphogenetic furrow, ommatidia, signaling, eyeless gene. **(10 Sessions)**

Unit-4: Postembryonic development: growth- cell proliferation, growth hormones; aging- genes involved in alteration in timing of senescence; regeneration– epimorphic regeneration of amphibian (salamander) limb, requirement of nerves for the proliferation of blastema cells; embryonic stem cells and their applications. **(8 Sessions)**

Unit-5: Medical implications of developmental biology: genetic errors of human development- the nature of human syndromes– pleiotropy, genetic heterogeneity, phenotypic variability, mechanism of dominance; gene expression and human disease– inborn errors of nuclear RNA processing, inborn errors of translation; teratogenesis- environmental assaults on human development- teratogenic agents like alcohol, retinoic acid etc. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Develop critical understanding how a single-celled fertilized egg becomes an embryo and then a fully formed adult by going through three important processes of cell division, cell differentiation and morphogenesis.
- Understand how developmental processes and gene functions within a particular tissue or organism can provide insight into functions of other tissues and organisms.
- Realize that very similar mechanisms are used in very diverse organisms; and development is controlled through molecular changes resulting in variation in the

expression and function of gene networks.

- Understand how the field of developmental biology has changed since the beginning of the 19th century with different phases of developmental research predominating at different times.
- Examine the evolutionary history of the taxa based on developmental affinities.
- Understand the relevance of developmental biology in medicine or its role in development of diseases.

Suggested Readings:

1. Developmental Biology, Gilbert, (8th Ed., 2006) Sinauer Associates Inc., Massachusetts, USA.
2. Principles of Development, Wolpert, Beddington, Brockes, Jessell, Lawrence, Meyerowitz, (3rd Ed., 2006), Oxford University Press, New Delhi, INDIA.
3. Analysis of Biological Development, Kalthoff, (2nd Ed., 2000), McGraw-Hill Science, New Delhi, INDIA.

Online Resources

- https://study.com/academy/topic/basics-of-developmental-biology.html
- https://gurukpo.com/Content/Bsc-biotech/Development_Biology.pdf
- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (II Semester)

MZO 202: Systematics, Biodiversity and Evolution

Objective: The course provides information about the patterns and processes of evolution above the species level. Besides elaborating the process of speciation, it also categorically differentiates between the three methods of phylogenetic analysis *viz*., evolutionary systematics, phonetics and cladistics.

Unit-1: An overview of evolutionary biology, concept of organic evolution during pre- and post-Darwin era; evolution and molecular biology- a new synthesis; from molecules to life, life originated from RNA, introns as ancient component of genes **(5 Sessions)**

Unit-2: The universal common ancestor and tree of life, three domain concept of living kingdom; molecular phylogeny– history, terms, definition and limitations, construction of phylogenetic trees using molecular data, construction of phylogenetic trees by using 16S rRNA gene sequences and concept of speciation in bacteria. **(5 Sessions)**

Unit-3: Molecular divergence and molecular clocks and molecular drive; complication in inferring phylogenetic trees; origin and diversification of bacteria and archea; diversification of genomes; the nature of bacterial and archeal genomes; origin of genomes by horizontal gene transfer; role of plasmid, transposons, integrons and genomic islands in DNA transfer. **(8 Sessions)**

Unit-4: Origin and diversification of eukaryotes- origin of cells and first organisms; early fossilized cells; evolution of eukaryotic cell from prokaryotes- a case of symbiosis; evolution of eukaryotic genomes; gene duplication and divergence. **(8 Sessions)**

Unit-5: Mode of speciation- factors responsible for speciation; tempo of evolution; Taxonomic hierarchy, binomial nomenclature, systematics- definition and role in biology, biological classification- theories and objectives, types of taxonomy, taxonomic diversity- definition and types, origination and extinction, rates of change in origination and extinction, causes of extinction, causes of differential rates of diversification, current status and future of biodiversity; human evolution- human evolutionary history; placing humans on tree of life; genomics and humanness; current issues in human evolution. **(10 Sessions)**

Course Outcomes:

After completing this course, the students will be able to:

- Understand the complexities of character coding.
- Understand the similarities and differences of different types of data.
- Understand the uses and limitations of phylogenetic trees.
- Appreciate the complexities and difficulties of various species concepts.
- Gain a basic grasp on the rules and philosophy of nomenclature.
- Know about the steps required to do systematic.

Suggested Readings:

1. Evolution, Barton, N. H., Briggs, D. E.G., Eisen, J. A., Goldstein, A. E., Patel, N. H., Cold Spring Harbor Laboratory Press, New York, USA
2. Evolution, Hall, B. K. and Hallgrimsson, B., Jones and Bartlett Publisher, Sudbury, USA
3. Evolution, Futuyma, D. J., Sinauer Associates, Inc., Sunderland, USA
4. What Evolution Is, Mayr, E., (2001), Basic Books, New York, USA

Online Resources

- https://www.coursera.org/learn/genetics-evolution
- http://www.dphu.org/uploads/attachements/books/books_5451_0.pdf
- https://oer.galileo.usg.edu
- http://www.biologycorner.com

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (II Semester)

MZO 203: Immunology

Objective: The immune system is incredibly complex. This course is hence designed to enable understanding the molecular and cellular basis of the development and function of the immune system and identification of its biological, clinical and therapeutic implications.

Unit-1: Overview of the immune system: components of the immune system, principles of innate and adaptive immunity, the recognition and effector mechanisms of the adaptive immunity- antigen and immunogenicity, clonal selection theory. **(6 Sessions)**

Unit-2: Antigen recognition by immune cells: Adaptive immunity- antibody structure, antigen recognition by B lymphocytes, TCR, antigen recognition by T- cells, co- receptors, structure and function of MHC complex; generation of lymphocyte antigen receptors- generation of diversity in immunoglobulins, T- cell receptor gene rearrangement, structural variations in immunoglobulin constant regions. **(10 Sessions)**

Unit-3: Antigen processing and presentation to T lymphocytes- antigen presenting cells, generation of T- cell receptor ligand, and MHC restriction, role of CD1 in antigen presentation; Innate Immunity- pattern recognition in the innate immune system, role of TLRs in innate immune response, complement and innate immunity, induced innate response to infection. **(8 Sessions)**

Unit-4: Effector mechanisms and regulation of immune responses: Signaling through immune system receptors- antigen receptor structure and signaling pathways, other signaling pathways that contribute to lymphocyte behavior; development and survival of lymphocytes- B lymphocyte development and survival, humoral immune response, T lymphocyte development and survival, production of effector T- cells, cytotoxic T- cell effector mechanisms; NK and NKT cell functions; mucosal immunity; immunological memory; regulation of immune response: cytokines and chemokines, complement system, leukocyte activation and migration, APC regulation of the immune response, T- cell mediated regulation of immune response, Immunological tolerance and anergy. **(8 Sessions)**

Unit-5: Immunity in health and disease: introduction to infectious disease, innate immunity to infection, adaptive immunity to infection, evasion of the immune response by pathogens; immunodeficiency diseases- inherited immunodeficiency diseases, acquired immune deficiency syndrome; allergy and hypersensitivity- IgE and allergic reactions, hypersensitivity diseases; autoimmunity- responses to selfantigens, transplant rejection- responses to alloantigens; manipulation of immune responses, vaccines; evolution of immune system- evolution of innate immune system, evolution of adaptive immune system. **(10 Sessions)**

Course Outcomes:

After completing this course, the students will be able to

- Describe the basic mechanisms, distinctions and functional interplay of innate and adaptive immunity.
- Relate to errors occurring during development leading to congenital disorders and human diseases.
- The students will be able to identify the cellular and molecular basis of immune responsiveness and understand how the innate and adaptive immune responses coordinate to fight invading pathogens.

Suggested Readings:

1. Kuby Immunology, Richard, Thomas, Barbara, Janis, (5th Ed., 2003), W. H. Freeman and company, New York, USA.
2. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, (6th Ed., 2005), Garland Science Publishing, New York, USA.
3. Immunology, David, Brostoff and Roitt, (7th Ed., 2006), Mosby & Elsevier Publishing, Canada, USA.

Online Resources

- https://en.wikipedia.org/wiki/Immunology
- http://www.dphu.org/uploads/attachements/books/books_5451_0.pdf
- http://missinglink.ucsf.edu/lm/immunology_module/prologue/prologue_syllabus_2008.PDF

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (II Semester)

MZO 204: Animal Behavior and Chronobiology

Objective: The course aims to explain the natural behaviour patterns, how the behaviour varies among individuals and species (wild, domestic, and captive), how current and past environments and ecology influence not only behaviour, but also the underlying gene-environment interactions that shape it.

Unit-1: Introduction - definition, historical out line, patterns of behaviour, objectives of behaviour, mechanism of behaviour, asking questions. Reflexes- reflex action, types of reflexes, reflex arch, characteristics of reflexes and complex behaviour. Orientation primary and secondary orientation; kinesis – orthokinesis, klinokinesis; taxis – different kinds of taxis; sun-compass orientation, dorsal- light reaction. **(8 Sessions)**

Unit-2: Eusociality, social organization in honey bee, polyphenism and its neural control, flower recognition, displacement and translocation experiment, various type of communications, production of new queen and hive, swarming, honey bee as super organism. Fixed action pattern: mechanism, deprivation experiment, controversies. FAP- characteristics and evolutionary features. Learning and instincts: conditioning, habituation, sensitization, reasoning. Communication-chemical (pheromones), visual, light, audio. **(8 Sessions)**

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Unit-3: Innate releasing mechanisms: key stimuli, stimulus filtering, supernormal stimuli, open and closed IRM, mimetic releaser, code breakers. Homeostasis and behaviour: motivational system, physiological basis of motivation, control of hunger drive in rat and thirst drive in goat, role of hormone, motivational conflict and decision making, displacement activity, models of motivation, measuring motivation. Hormones and pheromones influencing behaviour of animals, biological systems & Biological clocks. **(10 Sessions)**

Unit- 4: Adaptive functional significance of biological clocks. studying biological clocks; Biological Rhythms - Ultradian, Tidal/ Lunar, Circadian and Circannual rhythms; Temperature effects and compensation; Perception of natural zeitgeber signals; Organization of circadian system in multicellular animals; Concept of central and peripheral clock system; Circadian pacemaker system in invertebrates with particular reference to *Drosophila*; Circadian pacemaker system in vertebrates with particular reference to rodents; Suprachiasmatic nucleus (SCN) as the main vertebrate clock; concept of core and shell. **(10 Sessions)**

Unit- 5: Photoreception and photo-transduction; The physiological clock and measurement of day length; Role of photic and non-photic cues in seasonality; The relevance of biological clocks for human welfare - Clock function (dysfunction). **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Learn a wide range of theoretical and practical techniques used to study animal behaviour.
- Develop skills, concepts and experience to understand all aspects of animal behaviour.
- Objectively understand and evaluate information about animal behaviour and ecology

encountered in our daily lives.

- Understand and be able to objectively evaluate the role of behaviour in the protection and conservation of animals in the wild.
- Consider and evaluate behaviour of all animals, including humans, in the complex ecological world, including the urban environment

Suggested Readings:

1. Mechanism of Animal Behaviour, Peter Marler and J. Hamilton; John Wiley & Sons, USA
2. Animal Behaviour, David McFarland, Pitman Publishing Limited, London, UK
3. Animal Behaviour, John Alcock, Sinauer Associate Inc., USA
4. Perspective on Animal Behaviour, Goodenough, McGuire and Wallace, John Wiley & Sons, USA
5. Exploring Animal Behaviour, Paul W. Sherman & John Alcock, Sinauer Associate Inc., Massachusetts, USA
6. An Introduction to Animal Behaviour, A. Manning and M.S Dawkins, Cambridge University Press, UK

Online Resources

- http://www.dphu.org/uploads/attachements/books/books_5451_0.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-I Year (II Semester)

MZO 251: Lab 1 based on MZO 201 and MZO 202

Objective:

The course explains the basic principles and concepts underlying the developmental processes at the level. This will help the students to know the development process thoroughly. The course shall also make the students aware about the possible scopes of the subject which include research works.

List of Experiments: **(20 Sessions)**

A. Developmental Biology

1. Study of life cycle of *Drosophila melanogaster*.
2. Study of embryogenesis in *Drosophila* and pattern of gene expression in embryogenesis by in situ hybridization technique.
3. Dissection and study of Grasshopper
4. Study of Homeotic gene mutations.
5. Chick Embryology: Demonstration of chick embryo of 18, 24, 28, 33, 36, 42, 72 hrs.

B. Systematics, Biodiversity and Evolution

1. Isolation of Genomic DNA from a bacterium and its quantification.
2. Designing primers for 16S rRNA gene sequence.
3. Amplification of 16S rRNA gene sequences by using genomic DNA as well as by colony boiling method.
4. Purification of 16S rRNA gene.
5. Sequence of 16S rRNA gene; editing the sequence, multiple alignments, construction of phylogenetic trees and interpretation of results.
6. Dot blot hybridization of different eubacterial species and interpretation of results.

Course Outcomes:

After successfully completing this course, the students will be able to:

- Understand the developmental process effectively.
- Know about construction of phylogenetic tree to understand the evolutionary process.

Suggested Readings:

1. A manual of Practical Zoology Chordates Dr. P. S. Verma, S. Chand Publication
2. Practical Zoology, S.S. Lal

Online Resources

- https://study.com/academy/topic/basics-of-developmental-biology.html
- https://gurukpo.com/Content/Bsc-biotech/Development_Biology.pdf
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad
Master of Science Programme
M. Sc. (Zoology)-I Year (II Semester)

MZO 252: Lab 2 based on MZO 203 and 204

Objective: This course was designed to improve knowledge and understanding of the requirements of good laboratory practices which encompasses facility and equipment requirements, documentation requirements, roles and responsibilities and outsourcing services.

List of Experiments: **(20 Sessions)**

A. **Immunology:**

1. Dissection of primary and secondary immune organs from mice:
a. Preparation of single cell suspension from bone marrow and spleen (spleenocytes) of mice.
b. Cell counting and viability testing of the spleenocytes prepared.
2. Preparation and study of phagocytosis by spleenic/peritoneal macrophages.
3. Raising polyclonal antibody in mice, serum collection and estimating antibody titre in serum by following methods:
a. Ouchterlony (double diffusion) assay for Antigen -antibody specificity and titre.
b. ELISA
4. Antibody purification from the serum collected from immunized mice: affinity purification/chromatography.
5. Immunoelectrophoresis.
6. Demonstration of Western blotting:
a. Protein estimation by Lowry's method /Bradford's method
b. SDS-PAGE.
c. Immunoblot analysis.
7. Blood group test.
8. Counting of R.B.Cs and W.B.Cs
9. Widal test

B. Animal Behavior:
1. To study the geotaxis behaviour of earthworm.
2. To demonstrate the phenomenon of phototaxis in earthworm.
3. To demonstrate the phenomenon of phototaxis in housefly.
4. To demonstrate the phenomenon of chemotaxis in *Paramecium*.

Course Outcomes:
After successfully completing this course, the students will be able to

- Apply practical skills in science courses with the understanding of general laboratory practices
- Use various micro techniques used in Zoology.
- Apply various techniques to study animal tissues.
- Explore various research issues and their solutions

Suggested Readings:

1. Practical Immunology by Hay Frank C.
2. Practical Zoology S. S. Lal

Online Resources

- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 301: Principles of Ecology

Objective: This course will take students on a journey through the physical workings of the Earth, the interactions between species and their environments. The course highlights on some of the important aspects *viz.* growth and survival of populations and communities in different habitats, energy flow in the ecosystems, interactions between the communities, exclusion of niches and consequences of changing environment on the biodiversity.

Unit-1: Introduction to ecology, environmental concepts – laws and limiting factors, ecological models. Characteristics of population, population size and exponential growth, limits of population growth, population dynamics, life history pattern, fertility rate and age structure. Competition and coexistence, intra-specific and inter-specific interactions, scramble and contest competition model, mutualism and commensalism, prey-predator interactions, community structure and succession. **(10 Sessions)**

Unit-2: Nature of ecosystem, production, food webs, energy flow through ecosystem, biogeochemical cycles, resilience of ecosystem, ecosystem management. The biosphere, biomes and impact of climate on biomes. **(8 Sessions)**

Unit-3: Environmental Stresses and their management, global climatic pattern, global warming, atmospheric ozone, acid and nitrogen deposition, coping with climatic variations. Major classes of contaminants. Uptake, biotransformation, detoxification, elimination and accumulation of toxicants. Factors influencing bioaccumulation from food and trophic transfer. Pesticides and other chemical in agriculture, industry and hygiene and their disposal. Impact of chemicals on biodiversity of microbes, animals and plants. Bioindicator and biomarkers of environmental health. Biodegradation and bioremediation of chemicals. **(10 Sessions)**

Unit-4: Biodiversity – assessment, conservation and management, biodiversity act and related international conventions. Sustainable development, natural resource management in changing environment. **(8 Sessions)**

Unit-5: Molecular ecology, genetic analysis of single and multiple population, phylogeography, molecular approach to behavioural ecology, conservation genetics. **(4 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Know the evolutionary and functional basis of animal ecology.
- Understand what makes the scientific study of animal ecology a crucial and exciting.
- Engage in field-based research activities to understand well the theoretical aspects taught besides learning techniques for gathering data in the field.
- Analyse a biological problem, derive testable hypotheses and then design experiments and put the tests into practice.
- Solve the environmental problems involving interaction of humans and natural systems at local or global level.

Suggested Readings:

1. Field Sampling: Principles and Practices in Environmental Analysis, Conklin, A.R. Jr., (2004), CRC Press.
2. Principles and Standards for Measuring Primary Production, Fahey, T.J. and Knapp, A.K., (2007), Oxford University Press, UK
3. Ecological Modeling, Grant, W.E. and Swannack, T.M., (2008), Blackwell.
4. Fundamental Processes in Ecology: An Earth system Approach, Wilkinson, D.M., (2007), Oxford University Press, UK

Online Resources

- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-coursebiology-science/v/crash-course-biology-123
- https://en.wikipedia.org/wiki/Population_ecology
- https://www.tutorialspoint.com/environmental_studies/environmental_studies_ecological_pyramid.html

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 302: Computational Biology, Biostatistics and Bioinformatics

Objective: The course is aimed at introducing the application of bioinformatics and statistics in biology. The course gives an insight into the key concepts and methods used in bioinformatics; and computer storage, retrieval, analysis, visualization and distribution of information data related to biological macromolecules like DNA, RNA and proteins. It provides foundation on statistical methods to enable students to compute and interpret basic statistical parameters. As an interdisciplinary field it integrates biology, computer science, chemistry and statistics together sequence analysis structure analysis and functional analysis of biological data.

Unit-1: Basic components of computers– hardware (CPU, input, output, storage devices), Software (operating systems), Application software; Introduction to MSEXCEL- use of worksheet to enter data, edit data, copy data, move data; Use of in- built statistical functions for computations of mean, S. D., correlation, regression coefficients etc., Use of bar diagram, histogram, scatter plots, etc., Graphical tools in EXCEL for presentation of data; Introduction to MS- WORD word processor- editing, copying, moving, formatting, table insertion, drawing flow charts etc; Introduction to Power Point, image and data handling. **(10 Sessions)**

Unit-2: Biostatistics- population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, tabulation, bar diagram, histograms, pie diagram, mean, median, mode, quartiles and percentiles, variance, standard deviation, coefficient of variation; Probability and distributions- definition of probability (frequency approach), independent events. **(8 Sessions)**

Unit-3 Addition and multiplication rules, conditional probability, examples- bernoulli, binomial, poisson and normal distributions; bivariate data- scatter plot, correlation coefficient (r), properties (without proof), interpretation of r, linear regression: Fitting of lines of regression, regression coefficient, coefficient of determination; hypothesis, critical region, and error probabilities, tests for proportion, equality of proportions, equality of means of normal populations when variances known and when variances are unknown: chi-square test for independence, P- value of the statistic, confidence limits, introduction to one way and two- way analysis of variance. **(8 Sessions)**

Unit-4: The era of computerized biology information, review of relevant definitions in molecular biology, overview of challenges of molecular biology computing, proteins, secondary structure and folding, RNA secondary structures, introduction to phylogenetic analysis; introduction to bioinformatics; introduction to genomics and proteomics databases- nucleic acid sequence database: Genbank, UCSC, ENSEMBL, EMBL, DDBJ, protein sequence databases: Swiss- prot, PDB, BLAST, PSI- BLAST (steps involved in use and interpretation of results) and HMMER, BLAST vs FASTA, file formats- FASTA, GCG and ClustalW. **(10 Sessions)**

Unit-5: Databank search- data mining, data management and interpretation, multiple sequence alignment, genes, primer designing; Protein modeling, protein structure analysis, docking, ligplot interactions, phylogenetic analysis with the program PHYLIP, DISTANCES, GROWTREE etc.; introduction to computational genomics and proteomics- basics of designing a microarray, image analysis and normalization, annotations, protein prediction tools- protein secondary structure, molecular modeling, identification and characterization of protein mass fingerprint, world- wide biological databases, Introduction to programming languages such as “C”. **(06 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Know the theory behind fundamental bioinformatics analysis methods.
- Be familiar with widely used bioinformatics databases.
- Know basic concepts of probability and statistics.
- Describe statistical methods and probability distributions relevant for molecular biology data.
- Know the applications and limitations of different bioinformatics and statistical methods.
- Perform and interpret bioinformatics and statistical analyses with real molecular biology data.
- Acquire knowledge of various databases of proteins, nucleic acids. Primary, secondary and composite databases. BLAST, FASTA, DOT PLOT.
- Make phylogenetic predictions or prediction of structure of proteins and nucleic acids.
- Develop understanding in Primer designing.
- Understand data mining tool and its practical application in a case study.
- Apply the knowledge in future course of their career development in higher education and research.

Suggested Readings:

1. Principles of Biostatistics, Pagano M., Gauvreau, K, (2000), Duxbury Press, USA
2. Bioinformatics for Dummies, Claverie J. M., Notredame C., (2nd Ed., 2007), Wiley Publishing, Inc., New York, USA
3. Bioinformatics: Sequence and Genome Analysis, Mount, D. W. (2nd Ed., 2001), Cold Spring Harbor Laboratory Press, New York, USA.

Online Resources

- www.pdf.com
- www.digitalbookindex.org
- https://oer.galileo.usg.edu
- http://www.biologycorner.com

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 303: Structure and Function of Chordata

Objective: The main objective of the course is to acquire knowledge on the animal classification based on characters. This will also help the students to study the comparative anatomy of various vertebrates.

Unit-1: Brief account of *Petromyzon* and *Myxin*e, *Pyrosoma*, *Doliolum*, *Salpa.* **(8 Sessions)**

Unit-2: Evolution and Phylogeny of fishes, fins and locomotion in fishes, air bladder and weberian ossicles of fishes. **(8 Sessions)**

Unit-3: Origin of Tetrapoda, origin and evolution of reptiles, temporal regions in reptiles and its role in classification, dianosours, palate in birds. **(8 Sessions)**

Unit-4: Comparative Anatomy: Integument, digestive, respiratory, heart, brain, reproductive system, brain, skeleton (limbs and girdles)**.** Animals to be studied: *Scoliodon. Varanus,* Fowl and Rabbit. **(12 Sessions)**

Unit-5: Origin & Evolution of Man, Prototheria & Metatheria, Dentition in Mammals, Aquatic Adaptations in Mammals. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- Understand the process of evolution through the comparative study of vertebrates.
- Study about diversity in animals making students understand about their distinguishing features.
- Understand different classes of chordates, level of organization and evolutionary relationship between different subphyla and classes, within and outside the phylum.

Suggested Readings:

1. A text-book of zoology, Volume II, Parker, T.Z., Haswell, W.A.
2. Modern Text Book Of Zoology Vertebrates by Kotpal R. L.
3. The life of vertebrates, Young, J.Z.

Online Resources

- https://www.itis.gov/
- https://en.wikipedia.org/wiki/Vertebrate
- https://www.diffen.com/difference/Invertebrate_vs_Vertebrate

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 304: General Endocrinology

Objective: The course will provide the information on endocrine system with emphasis on the structure of hypothalamus and anterior pituitary. The associated hormones and the related disorders will be explained.

Unit-1: Concept of endocrinology: introduction to the endocrine system. Phylogeny & Ontogeny of endocrine system. **(4 Sessions)**

Unit-2: Comparative aspects of endocrine physiology in Mammals. Evolution of pituitary gland; Physiological actions of pituitary hormones. Urophysis and action of its hormone(s). Evolution of discrete adrenal gland; Synthesis of corticosteroid, structural diversity of glucocorticoids among vertebrates, role of glucocorticoid in gluconeogenesis. **(8 Sessions)**

Unit-3: Evolution of renin-angiotensin system, hormonal control of water and electrolyte balance; Catecholamine biosynthesis, its storage and release mechanism, physiological actions of adrenal medullary hormones; Importance of adrenocortical and adrenomedullary interaction. **(8 Sessions)**

Unit-4: Evolution of thyroid gland. Thyroid hormone synthesis and its regulation, paradigms of thyroid hormone action in poikilotherms and homeotherms. A comparative account of parathyroid gland and ultimobranchial body/C cells, synthesis of parathyroid hormone, calcitonin and of vitamin D3; benthic organisms and source of vitamin D; hormonal regulation of calcium and phosphate homeostasis. **(10 Sessions)**

Unit-5: Hormonal control of feeding behaviour and gastrointestinal tract functioning including acid release, gall bladder contraction and relaxation, pancreatic enzyme secretion, and GI tract motility; Pancreatic hormones and glucose homeostasis; hormones, vitellogenesis and the evolution of viviparity. **(8 Sessions)**

Course Outcomes:

After completing this course, the students will be able to

- Understand neurohormones and neurosecretions.
- Learn about hypothalamo and hypapophysial axis.
- Understand about different endocrine glands and their disorders.
- Understand the mechanism of hormone action.

Suggested Readings:

1. Comparative Vertebrate Endocrinology, Bentley, P. J., Cambridge University Press, UK
2. Vertebrate Endocrinology, Norris D. O., Elsevier Academic Press,
3. Hand Book of Physiology, American Physiological Society, Oxford University Press, Section 7: Multiple volumes set.
4. The Insects: Structure and Function, Chapman, F.R., The English Language Book Society (ELBS) and The English Universities Press Ltd.
5. The Principles of Insect Physiology Wigglesworth, V. B., ELBS and Chapman and Hall.
6. Endocrinology by Hadley

Online Resources

- http://nptel.ac.in/courses/102104042/#
- http://www.dphu.org/uploads/attachements/books/books_1984_0.pdf

- http://www.uvm.edu/~bio1and2/lab/Lab%20manuals%20Spring%202012/Animal%20Physiology.pdf
- https://www.pdfdrive.net/plant-and-animal-physiology-e1735854.html

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 351: Lab 1 based on MZO 301 & MZO 302

Objective: The primary aim of the syllabus is to sensitize the students about the paramount role and importance of nature. The study of Ecology imparts us the knowledge about the judicious use of existing ecological resources for sustainable development. This will provide a better knowledge to students about soil profile as well as ecological succession. Practical knowledge of computers and biostatistics will be helpful for students in their research work.

List of Experiments: **(20 Sessions)**

A. Principles of Ecology

1. Physical and chemical characteristics of soil.

2. Assessing influence of light, temperature and moisture on plant germination and growth/animal behavior and growth.

3. Assessing influence of soil nutrient status on plant germination and growth.

4. Assessment of density, frequency and abundance of plants/animal in a community using various techniques i.e. transect, quadrate etc.

5. Comparison of stands/communities and ordination.

6. Profile diagrams.

7. Biomass and reproductive allocation under various environments.

8. Nutrient uptake and budget for various communities/Food chain assessment.

9. Decomposition of various organic matters and nutrient release mechanisms/role of arthropods and other micro-, and macrofauna in decomposition.

10. Understanding ecosystem succession by studying various stages of vegetation/community assemblages' development.

11. Molecular techniques in laboratory.

12. Insect diversity in soil.

B. Computational Biology, Biostatistics and Bioinformatics

1. Use of excel sheet for data processing.

2. Use of search engines like Scopus, Science direct for reference material collection and management.

3. Nucleic acid and protein sequence databases.

4. Data mining for sequence analysis.

5. Web– based tools for sequence searches and homology screening.

6. Primer designing for gene amplification and gene cloning.

7. Annotations: ORF finder, Use of ARTEMIS or any other suitable software.

8. Construction of phylogenetic trees for DNA and proteins.

9. Introduction to microarray technology.

10. Identification of peptide finger print by nano LC- MS/MS and database search using MASCOT and OMSSA.

Course Outcomes:

After successfully completing this course, the students will be able to

- Know basic concepts of probability and statistics.
- Describe statistical methods and probability distributions relevant for molecular biology data.
- Know the applications and limitations of different bioinformatics and statistical methods.
- Apply the basic operations of spreadsheet applications
- Operate various software resources with advanced functions and its open office substitutes.

Suggested Readings:

1. Practical Ecology- by K. S. Rao
2. Practical Methods in Ecology- by Peter A. Henderson

Online Resources

- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (III Semester)

MZO 352: Lab 1 based on MZO 303 & MZO 304

Objective: By this course the student will acquire knowledge on the animal classification based on characters. They may get the fundamentals knowledge on feeding, locomotion and other vital processes of vertebrates. Students will know the functioning of endocrine system.

List of Experiments: **(20 Sessions)**

A. Structure and Function of Chordata

1. Study of Museum specimens:
   -**Cyclostomes**: *Petromyzon*, *Myxine*, Ammocoete larva of *Petromyzon*
   -**Fishes**: Echeneis, Tetradon (Globe fish), Stegostoma, Pterois, Anguilla, Diodon, Ostracion, Sphryna, Trygon (Sting Ray), Astrape (Electric Ray), Hippocampus, Pristis, Syngnathus, Acipensor, Anabas.
   -**Amphibi**a: Siren, Alytes, Axolotl larva, Rhacophorus, Bufo, Hyla, Ambystoma, Ichthyophis, Salamander, Pipa
   -**Reptiles**: Draco, Geeko, Calotes, Ophiosaurus, Phryanosoma, Typhlops, Chameleon, Mabuia, Viper, Tree snake, Hydrophis, Krait, Crotalus, Dendrophis, Naja
   -**Mammal:** Squirrel, Bat. *Pangolin, Platypus, Echidna* Model
2. Study of slides:
   Whole mount: *Pyrosoma, Botryllus, Oikopleura, Doliolum, Salpa*
3. Study of Bones (Osteology):
   Appendicular and axial skeleton of Frog, Varanus, Fowl and Rabbit

B. General Endocrinology

1. Dissection of retro-cerebral complex (endocrine system) in insects (e.g., cockroach/any other insect).
2. Effect of hormone mimic on the metamorphosis and other bio-characteristics of lepidopteran insect (e.g., *Spodoptera litura*).
3. Dissection of endocrine system in crustaceans (neurohaemal organ).
4. Annelids (Earthworm brain/CNS) and molluscs (Brain/Optic glands in *Octopus*).
5. Pituitary cytology: a comparative study following histology, histochemistry and immunocytochemistry.
6. Adrenalectomy in rat.
7. Effect of adrenalectomy on glycogen assay.
8. Effect of metyrapone and saline administration on adrenal cortex following light microscopy.
9. Thyroidectomy in rats.
10. Effect of thyroidectomy and thyroid hormone replacement therapy on ecdysis and testicular functions in reptiles.
11. Steroid and thyroid hormone assay by ELISA
12. Calcium estimation following fluorometry in PTH/Calcitriol treated rats.
13. Effect of orexigenic and anorexigenic hormones on feeding behaviour of rats.
14. Induction of vitellogenesis in a seasonally breeding non-mammalian vertebrate.

Course Outcomes:

After successfully completing this course, the students will be able to

- Classify the animal species based on the morphological and anatomical features
- Compare the functional morphology of vertebrates and invertebrates.
- Learn about hypothalamo and hypapophysial axis.

Suggested Readings:

1. Vertebrate Endocrinology, Norris D. O., Elsevier Academic Press,
2. Endocrinology by Hadley
3. R.L. Kotpal, (2016). Modern Text Book of Zoology Vertebrates, Rastogi Publications.

Online Resources

- http://nptel.ac.in/courses/102104042/#
- http://www.dphu.org/uploads/attachements/books/books_1984_0.pdf
- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

Stream I: Fish Biology

MZO 401: Evolution and Functional Anatomy of Fish

Objective: This course will provide an increased understanding of the evolutionary origins of the major fish taxonomic classes, genetic and environmental factors regulating reproduction in fishes and various 'modes' of reproduction in fishes.

Unit-1: Origin, diversity and distribution- origin and evolution of major groups of fishes, classification of fishes, bio geographical distribution, methods employed in phylogenetic studies and fish identification, fish barcoding. Air Bladder and Weberian ossicles of Fishes; Lateral line system, Identification of fresh water fishes. **(8 Sessions)**

Unit-2: Fish as a research model. Structure of Fins, median fin, caudal fins, paired fins, origin of paired fins, homeostasis- aquatic and aerial respiration, lymphoid organs, gas transport, Growth and age of Fish, various method for determining age and Growth in fishes. **(8 Sessions)**

Unit-3: Sensory systems– photoreception, chemoreception, mechanoreception, electroreception. Adaptations to environmental extremes- temperature, pressure, stressors. Growth and metabolism-regulation of food intake by neuropeptides and hormones,Feeding habit of Teleost, Feeding intensity, method for food analysis, digestion and absorption of food. **(10 Sessions)**

Unit-4: Defense mechanism– integument and Immune system, development of immune system, cells and tissues of the fish immune system, modulators of fish immune responses, humoral and cell mediated immune defense, fish antibody molecules and their effector functions. Reproduction-reproductive strategies, environmental and endocrine factors regulating reproductive cycles, hormonal and molecular mechanisms of oogenesis, spermatogenesis, oocyte maturation and spermiation, fertilization, mechanism of sex determination, maternal factors in early development. **(10 Sessions)**

Unit-5: Endocrines- piscine endocrine glands,Cell type and hormones of pituitary gland, neuroendocrine regulation of pituitary gland, osmoregulation, patterns of migration, orientation and homing, schooling, feeding, background adaptations, parental care its significance, nest building and other means of protecting eggs and young ones. **(8 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- To obtain a thorough understanding of the production process of fish by products and future research.
- Learn the fish culture techniques.
- Understand the anatomy and structure of fishes.

Suggested Readings:

1. Kamaleswar pandey and. Shukla, J.P. (2005) Fish and Fisheries, Rastogi Publications, Meerut.
2. Yadav, M (2003) Economic Zoology. Discovery Publishing House, Rastogi Publications, Meerut.
3. Shanmugam, K. (1992) Fishery Biology and Aquaculture, Leo Pathippagam, Chennai.
4. Biology of Fishes, Bone, Q. and Moore, R., Talyor and Francis Group, CRC Press, U.K.
5. The Physiology of Fishes, Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK

6. The Senses of Fish Adaptations for the Reception of Natural Stimuli, von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, INDIA

Online Resources

- https://www.aquariumconnection.com/pdf/fw_disease_rx.pdf
- http://www.guammarinelab.org/publications/uogmltechrep104.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO 402: Aquatic Resources and Their Conservation

Objective: The course deals with a knowledge of how abiotic factors influence adaptive capabilities in fishes, have greater insight into how growth is regulated in fishes, how conservation of fishes takes place and how pollution effect the health of the fish.

Unit-1: Riverine fisheries- important river systems and their hydrological conditions, flora and fauna with special reference to fisheries, dams and their impact on riverine fisheries, fish ladders, interlinking of rivers and likely impact on fisheries. Cold water fisheries - ecology of hill streams, biology of important cold water fishes of India, recreational fishing. Lakestrine fisheries - origin of lakes and lake morphology, light, temperature and density relationship in the lacustrine ecosystems, heat energy and water movements, oxygen and other dissolved gases in lakes, pH and redox potential, fisheries profile and potential of major Indian lakes.

Unit-2: Estuarine fisheries- major estuarine systems of India, hydrography, flora and fauna with special reference to fisheries. Marine fisheries – coastal and deep sea fisheries, permanent and seasonal stratification, upwelling, the photic zone, control of primary production by light and nutrients availability, chemical properties of sea water, biology of important fishes (sardine, mackerel, tuna), marine protected areas. Integrated resources- coastal wet lands, mangroves, coral reefs, sea grasses and their conservation.

Unit-3: Fishing techniques-- technologies for localizing catches- remote sensing, sonar, radar; crafts and gears. Stock assessment and management-- Natural markers- morphological analyses, environmental signals, genetic analyses; Applied markers- marking and tagging, Stock identification data analysis - stock composition analysis, age and growth, fecundity estimation, application of statistical methods in fisheries.

Unit-4: Fish conservation- fishing laws and regulation, permitting. Post harvest technology-- Fish spoilage, rigor mortis, rancidity, enzymatic spoilage, microbial spoilage; Fish preservation and processing- handling of fish at harvest/onboard, principles of fish preservations, methods of preservation, problems associated with fish preservations, quality control, fishery by-products.

Unit-5: Aquatic pollution- types and sources, impact of pollution on aquatic organisms, ecosystem analysis- bio-indicators, biomonitoring, environmental factors and fish health, Xenobiotics. Waste management- national and international standards. Extension services - basic principles and emerging issues of extension, role of information and communication technology in fisheries extension.

Course Outcomes:

After successfully completing this course, the students will be able to

1. To appreciate the economics of Fishery Biology
2. To gain thorough understanding of culture fisheries

Suggested Readings:

1. Computers in Fisheries Research, Megrey, B. A. and Moksness, E. (2009), Springer, USA

2. Biological Invasions in Marine Ecosystems Ecological, Management and Geographic Perspectives. Rilov, G. and Jeffrey, A. C. (2009), Springer-Verlag, GERMANY

3. Handbook of Fisheries and Aquaculture, Indian Council of Agricultural Research, ICAR, (2006), DIPA, New Delhi, INDIA
4. Shukla, G.S. and Upadhya, V.B. (2005) Economic Zoology, Rastogi Publications, Meerut, India.

Online Resources

- http://himachal.nic.in/WriteReadData/l892s/4_l892s/1402134883.pdf
- http://www.guammarinelab.org/publications/uogmltechrep104.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO 403: Aquaculture

Objective: Culture techniques of aquatic organisms form different aquatic resources (freshwater, estuarine and marine) are included in the third paper, Aquaculture. The environmental and nutritional requirements, reproduction and diseases of cultured species are the core parts of this paper. Various molecular techniques like transgenic fish production, genetic selection, hybridization, etc. are also included in this paper

Unit-1: Culture technology– freshwater (carps, catfishes, murrels, prawns), brackish water (asian sea-bass, milk fish, mullets, crabs, shrimps), mariculture (mussels, oysters, sea weeds), fish food organisms **(**algae; *Artemia*; zooplankton). Water Quality Requirements for Aquaculture- Role of temperature, pH, salinity, dissolved oxygen, ammonia, nitrite, nitrate, phosphate, Biological oxygen demand, Chemical oxygen demand. **(8 Sessions)**

Unit-2: Integrated farming - fish-cum-live tock farming, paddy-cum-fish farming, aquaculture engineering- aquahouse, hatchery, ponds, race ways, recirculating system, cage, pen. Fish seed technology - natural collection, bundh breeding, induced breeding, cryopreservation of gametes. Transport of finfish and shellfish- transport of eggs, fry, fingerlings and adults.

(8 Sessions)

Unit-3: Nutrition of aquatic animals - nutritional requirements of commercially important finfish and shellfish, dietary requirements of larvae and brooders, feed types, manufacture and ingredients, anit- nutritional factors in fish feed ingredients and their treatments, use of attractants and growth stimulants in fish feeds, alternative protein sources in aquaculture diets, feeding techniques, role of probiotics in nutrition. Setting up of display aquarium- freshwater and marine aquaria, selection of compatible species, breeding of aquarium fishes. **(8 Sessions)**

Unit-4: Role of genetics in aquaculture– gynogenesis, androgenesis, triploidy, tetraploidy, hybridization, sex reversal and breeding, production of transgenic fish, impact of GMOs on aquatic biodiversity. Fish health- infection and diseases in fish, common fish pathogens, routes of pathogen entry in fish, methods of colonization and spread of pathogens, immune - evasion mechanisms of fish pathogens. **(8 Sessions)**

Unit-5: Environmental impact of aquaculture- aquacultural wastes and future developments in waste minimization, environmental consequences of hypernutrification. Fish vaccines- strategy and use in aquaculture. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- To acquire knowledge on fish farming and breeding techniques.
- Gain more knowledge about fish byproducts and value added products.
- Disease diagnosis and treatment techniques

Suggested Readings:

1. Fishponds in Farming Systems, Zijpp, V. D., Verreth, J. A. J., Tri, L. Q., van Mensvoort, M. E. F., Bosma, R. H., and Beveridge, M. C. M., Wageningen Academic Publishers, Netherlands

2. Aquaculture Principles and Practices, Pillay, T. V. R., Blackwell Publishing, USA

3. Aquaculture and Fisheries Biotechnology Genetic Approaches, Dunham, R. A., CABI Publishing, USA

4. Shanmugam, K. (1992) Fishery Biology and Aquaculture, Leo Pathippagam, Chennai.

5. Jingran, V.G. (1983) Fish and Fisheries of India, 2nd Edition, Hindusthan Publications, New Delhi.

Online Resources

- https://www.aquariumconnection.com/pdf/fw_disease_rx.pdf
- http://www.guammarinelab.org/publications/uogmltechrep104.pdf
- https://oer.galileo.usg.edu
- http://www.biologycorner.com

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO 451: Fish Biology Lab

Objective: This course will provide an increased understanding of the evolutionary origins and anatomy of the major fishes. This will also provide the information about the environmental and nutritional requirements, reproduction and diseases of cultured species.

List of Experiments: **(20 Sessions)**

A. Evolution and Functional Anatomy of Fish

1. Phylogenetic analysis of bony fish: morphological analysis; mtDNA polymorphisms; comparison of protein sequences and construction of phylogenetic tree.
2. Display of visceral organs; preparation of fish skeleton; alizarine preparation.
3. Collection of body fluids (blood sampling; urine collection; gamete collection).
4. Study of various hematological parameters. Fish immune system – isolation of phagocytes and phagocytosis.
5. Comparative study of digestive enzymes of herbivore, carnivore and omnivore fishes;
6. Oxygen consumption in relation to body size/stress/anesthesia.
7. Extraction, isolation and characterization of plasma vitellogenin and egg-yolk proteins.
8. Surgical procedures (effect of hypophysectomy on osmoregulatory parameters; effect of gonadectomy on fish)
9. Visit to a fish market in Moradabad, identification of dominant finfish and documentation of shellfish.

B. Aquatic Resources and Their Conservation

1. Identification of Indian common fish faunal resources from cold water, warm water, brackish water, marine water and ornamental fishes.
2. Physico- chemical parameters of freshwater bodies.
3. Biological analysis of water and estimation of primary productivity.
4. Collection of phytoplankton and zooplankton from natural resources and their identification.
5. Study of benthic macroinvertebrates in natural water bodies.
6. Study of fishing gears and nets with the help of models.
7. Salinity tolerance in select fishes.
8. Determination of age and growth; gonadosomatic index.
9. Length-weight relationship and condition factor determination.
10. Experiments on chemoreception using different attractants and repellents.
11. Toxicity testing with zooplankton/fish.
12. Visit to a coastal/ mariculture farm and study the socio-economic status of the fisherman community.

C. Aquaculture

1. Estimation of hydrobiological parameters- temperature, pH, conductivity, salinity, dissolved oxygen, primary productivity, ammonia, nitrite, nitrate, phosphate, biological oxygen demand, chemical oxygen demand of nursery, rearing, stocking and breeding ponds.
2. Estimation of ovarian egg counts.
3. Culture of live food organisms and assay of nutritional quality of live food; estimation of population density of live food organisms.
4. Demonstration of breeding pools and hatcheries.
5. Induced breeding of Indian major carps and catfishes.
6. Identification of eggs, spawn, fry and fingerlings of cultivable fishes of India.
7. Collection and identification of aquatic weeds and aquatic insects.
8. Study of feeding habits of fishes by gut content analysis.
9. Aquarium design and maintenance.
10. Formulation and preparation of artificial fish food for Indian major carps and Prawns.
11. Analysis of proximate composition of fish and processed products.
12. Visit to freshwater/ marine fish farm.

Course Outcomes:

After successfully completing this course, the students will be able to

- Learn the fish culture techniques
- To acquire knowledge on fish farming and breeding techniques
- Gain more knowledge about fish byproducts and value added products.
- Disease diagnosis and treatment techniques

Suggested Readings:

1. Shanmugam, K. (1992) Fishery Biology and Aquaculture, Leo Pathippagam, Chennai.
2. Jingran, V.G. (1983) Fish and Fisheries of India, 2nd Edition, Hindusthan Publications, New Delhi.
3. Practical Zoology vertebrates P.S.Verma, S. Chand Publication

Online Resources

- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/ http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf
- http://himachal.nic.in/WriteReadData/l892s/4_l892s/1402134883.pdf
- https://www.aquariumconnection.com/pdf/fw_disease_rx.pdf
- http://www.guammarinelab.org/publications/uogmltechrep104.pdf

Note: Latest editions of all the suggested readings must be used

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

Stream II: Cytology & Cytogenetics

MZO-401 A: Extra Nuclear Cytology

Objective: This course will help the students to be well acquainted with the membrane structure and composition, transport, the cytoskeleton and cell movement and by structure and function of various cell organelles. This will enhance their knowledge and they would able to understand the functioning of cell. The general mechanism of cell division and their regulation through different check points will be thoroughly understood.

UNIT-l: Membrane structure and function: Structure of model membrane, lipid bi layer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, Electrical properties of membranes.

(8 Sessions)

UNIT-ll: Mitochondria: Structure, assemblies of respiratory chain and F0 F1 – ATPase, Oxidative phosphorylation: mechanism and chemiosmotic concept, Bioenergetics of ATP and other high energy phosphate compounds. **(8 Sessions)**

UNIT-lII: Golgi bodies: Morphology, Ultrastructure, Cytochemistry, Function and Origin. Ribosomes: Physical characterstics and Structure, Stoichimetry and Biogenesis.Endoplasmic reticulum: Configration of cytoplasmic membranes, Types of E.R .Granular and Agranular, Modification of agranular reticulum and Myeloid body. Lysosomes and related bodies: Morphology, Ultrastructure, chemistry and Origin of Lysosomes. Cytolysosome, Peroxisomes, Glycoxysomes and spherosomes. **(10 Sessions)**

UNIT-IV: Cytoskeleton, Microfilaments and microtubules – structure and dynamics, Microtubules and mitosis. Cilia and flagella, Cell movements – intracellular transport, role and kinesin and dyein, signal transduction mechanisms. **(8 Sessions)**

UNIT-V: Cell signaling: Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component systems, light signaling in plants, bacterial chemotaxis and quorum sensing. **(6 Sessions)**

Course Outcomes:

After successfully completing this course, the students will be able to

- To understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes and organelles.

- To understand how these cellular components are used to generate and utilize energy in cell.

Suggested Readings:

1. Alberts et al: Essential Cell Biology (1998, Garland)

2. Alberts et al: Molecular Biology of the Cell (2002, Garland)

3. DeRobertis & DeRobertis: Cell and Molecular Biology (1987, Lee & Febiger)

4. Lodish et al: Molecular Cell Biology (2007, Freeman)

5. Alberts et al: Molecular Biology of the Cell (2002, Garland)

6. Karp: Cell and Molecular Biology (2007, Wiley)

7. Pollard & Earnshaw: Cell Biology (2002, Saunders)

Online Resources

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO-402 A: Nuclear Cytology and Cytogenetics

Objective: The course provides a detailed insight into basic concepts of sub cellular structure and function. It also gives an account of the complex regulatory mechanisms that control cell function.

UNIT-l: Nucleus: Morphology and significance, Nuclear matrix and organization of interphase nucleus. Nuclear membrane: Ultrastructure, Nuclear pore and Annuli, Chemical composition, Origin and biogenesis of ribosomes. Nuclear transport: Role of pore complex on nuclear sap. Nucleolus: Morphology, Ultrastructure, Chemistry and Function. **(8 Sessions)**

UNIT-ll: Structure of chromatin, heterochromatin, euchromatin, Sex Chromatin and Dosages compensation. Chromosomes: Ultrastructure, Physical and Chemical organization of chromosome. Giant Chromosome: Salivary and Lampbrush and their significance. Structural and numerical alterations of chromosomes**:** Deletion, duplication, inversion, translocation, ploidy and their genetic implications. **(8 Sessions)**

UNIT-lll: Chromosomal polymorphism: Inversion, Translocation, Fusion and Dissociation polymorphism,Adaptive significance of inversion polymorphism. Chromosomal rearrangments with special reference to insects and mammals. **(8 Sessions)**

UNIT-lV: Cell division and cell cycle (Mitosis and meiosis, their regulation, steps in cell cycle, regulation and control of cell cycle). Extra chromosomal inheritance: Inheritance of Mitochondrial and chloroplast genes, maternal inheritance. **(8 Sessions)**

UNIT-V: Chromosomal theory of Sex Determination: Simple and multiple system, Genic balance mechanism and Dominant Y System. Human sex anomalies, autosomal disorders,Cancer and Chromosomes. Cytological aspects of fertilization: Transportation of gametes, gametic union, nuclear fusion and fertilisation. Cytology of parthenogenesis: Haplodiploidy, Thelytoky and cyelical Parthenogenesis. **(8 Sessions)**

Course Outcomes:

After completing this course, the students will be able to

- Understand the fundamental structure and functions of biomolecules
- Understand the functioning of nucleus and extra nuclear organelles and understand the intricate cellular mechanisms involved.

- Acquire the detailed knowledge of different pathways related to cell signaling and apoptosis thus enabling them to understand the anomalies in cancer.
- To acquire knowledge on the principles and practices of instrumental techniques.

Suggested Readings:

1. Bostock & Sumner: Eukaryotic Chromosome (1987, North-Holland)
2. Gardner et al: Principles of Genetics (1991, John Wiley)
3. Griffith et al: Modern Genetic Analysis (2002, Freeman)
4. Lewin, Genes VIII (2004, Wiley)
5. Lodish et al: Molecular Cell Biology (2007, Freeman)
6. Russell: Genetics (2002, Benjamin Cummings)
7. Snustad & Simmons: Principles of Genetics (2003, John Wiley)

Online Resources

- https://www.jove.com/science-education-library/9/cell-biology
- https://swayam.gov.in/courses/4922-genetics-and-genomics
- http://www.bionet.nsc.ru/ICIG/CHM/books/Hartl_Jones_Genetics.pdf
- http://www.bionet.nsc.ru/ICIG/CHM/books/Hartl_Jones_Genetics.pdf
- https://www.bio.bg.ac.rs/materijali_predmeta/med-eng-griffiths-an-introduction-togenetic-analysis.pdf

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO-403 A: Cytogenetical Techniques

Objective: It has full hands on approach to expose the students to modern techniques and methodologies. The diverse techniques from microscopy to spectroscopy, ultracentrifugation, ELISA, tissue culture to cloning etc. are included to make the student well versed with these protocols and methods.

UNIT-I: Microscopic techniques: Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze- fracture methods for EM, image processing methods in microscopy. **(8 Sessions)**

UNIT-II: Histochemical and Immunotechniques: Antibody generation, Detection of molecules using ELISA, RIA, western blot, immunoprecipitation, fluocytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH. **(8 Sessions)**

UNIT-III: Fixation and staining techniques: Non -chemical and chemical fixatives, chemistry of staining of acidic and basic dyes. Tissue culture techniques: Monolayer suspension, leucocyte cultures, factors affecting cell growth *in vitro.* **(8 Sessions)**

UNIT-IV: Cell fractionation techniques: Principle of centrifugation and ultracentrifugation, different types of ultracentrifugations (in brief) and their applications, structural parts of an analytical ultracentrifuge, ultracentrifugation and buoyant density. **(8 Sessions)**

UNIT-V: Radioisotopes : Principles and applications of tracer techniques in biology, radiation dosimetry, radioactive isotopes and half-life of isotopes, liquid scintillation counter, principles and applications of autoradiography. **(8 Sessions)**

Course Outcomes:

After completing this course, the students will be able to

- To acquire knowledge on the principles and practices of instrumental techniques
- Learn the construction repair and adjustment of any equipment required for a technique.
- Learn the accuracy of technique.
  Learn the maintenance laboratory equipments/ tools, safety hazards and

precautions.

Suggested Readings:

1. Anderson, Durston and Polle.1970. Thesis and Assignment writing. Wiley Eastern Ltd., New Delhi.

2. Comir and Peter Wood Ford.1979. Writing scientific papers in English. Pitman Medical Publishing Co., London.

3.

6. Day, R.A. 1994. How to write and publish a scientific paper. Cambridge University Press, London.

7. Palanichamy, S. and M. Shanmugavelu.1997. Research methods in biological sciences. Palani Paramount Publications, Tamil Nadu, India.

8. Wilson and Walker. 2000. Practical biochemistry - principles and techniques. Cambridge University Press.

9. Milton, J.S. 1992. Statistical methods in Biological and Health Sciences. McGraw Hill Inc., New York.

Online Resources

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://swayam.gov.in/courses/4922-genetics-and-genomics

Note: Latest editions of all the suggested readings must be used.

IFTM University, Moradabad

Master of Science Programme

M. Sc. (Zoology)-II Year (IV Semester)

MZO- 451 A Cytogenetics Lab

Objective: This is the only laboratory course taught independently of lecture courses. It has full hands on approach to expose the students to modern techniques and methodologies

Lists of Experiments: **(20 Sessions)**

A. Extra Nuclear Cytology:

1. Components and setting of the Compound microscope.
2. Cytological techniques for the demonstration of nucleus, chromosomes, mitochondria, Golgi bodies, ribosomes etc.
3. Sterilization of culture media by autoclave method
4. Sterilization of glassware by hot air oven
5. Preparation of stains and reagents for cytological examination.
6. Squash Preparation of onion root tip to demonstration of mitosis.
7. Cytochemical demonstration of Protein, Nucleic acid and Fat.
8. Preparation of feulgen stained chromosome in root tip cells.
9. Effect of colchicine on chromosome movements during mitosis.
10. Use of fluorescent dye to visualize cell components.
11. Fractionation of macromolecules from rat/mouse tissues

B. Cytogenetics

1. Preparation of chromosomes from Grasshoper for meiosis by squash method.
2. Temporary squash preparation of salivary gland chromosomes for the study of polytene chromosomes of larvae of *Chironomus/Drosophila*.
3. Study and preparation of metaphase karyotypes from photographs and permanent slides of *Drosophila*, grasshopper and man/rat.
4. Study of sex-chromatin Bar body from human buccal mucosa.
5. Demonstration of monohybrid and dihybrid cross with the help of beads.
6. Study of genetic disorders with the help of photographs and microscopic slides.
6. Study of permanent slides of polytene chromosomes, Lampbrush chromosomes, Sex Chromatin, metaphase chromosome, Anaphase chromosome, Grasshopper testes, Karyotype, Crossing over.

C: Genetics

1. Culturing of *E coli* on solid and liquid media
2. Demonstration of bacterial transformation using a suitable plasmid vector (with and without insert)
3. Handling of *Drosophila* and study of its life cycle
4. Examination of wild type (males and females) and mutants of *Drosophila*
5. Sex linked inheritance in *Drosophila melanogaster*

6. Linkage and crossing over in *Drosophila melanogaster*

D. Cytogenetical Techniques:

1. Study of different parts of binocular research microscope
2. Demonstration of Instruments - UV- VIS spectrophotometer, ultracentritugation, Microscopy.
3. Paraffin sectioning, Fixation of tissue blocks (e.g. intestine and stomach of rat or squirrel) Dehydration, clearing and embedding of tissue block in paraffin, Sectioning of paraffin blocks, stretching and spreading of sections on slides.
4. Histological staining of paraffin sections using haematoxylin and eosin method.
5. Estimations of fractionated molecules through spectrophotometric methods: Protein by Biuret/Folins method, DNA by diphenylamine method.
6. Demonstration of separation of subcellular organelles by differential centrifugation
7. Autoradiography detection of transcription in polytene chromosomes
8. Measurement of microscopic object using ocular and stage micrometers.
9. Separation of amino acids by paper chromatography
10. Preparation of various culture media and inoculation

Course Outcomes:

After completing this course, the students will be able to

- Understand the process of preparation of buffer. Learn the techniques of separation of amino acids, proteins and nucleic acids.
- Understand the purpose of the technique, its proper use and possible modifications/ improvement.
- Learn the theoretical basis of technique, its principle of working and its correct application.
- Learn the construction repair and adjustment of any equipment required for a technique.

Suggested Readings:

1. Ewing, G.W. 1988. Instrumental methods of chemical analysis, McGraw Hill Book Compan
2. Daniel, M. 1989. Basic biophysics for biologists. Agro-Botanical Publishers, India.
3. Skoog, A., Douglas, J. and Leary, J.J. 1992. Principles of Instrumental Analysis. Sanders Golden Sunberst Series, Philadelphia.

Online Resources

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://swayam.gov.in/courses/4922-genetics-and-genomics
- http://www.who.int/medical_devices/publications/manual_health_lab_tech/en/
- http://idsp.nic.in/WriteReadData/OldSite/manual_lab_techniques.pdf

Note: Latest editions of all the suggested readings must be used.