ACADEMIC CURRICULUM AND SYLLABI

POSTGRADUATE DEGREE PROGRAMME

MASTER OF SCIENECES

IN

ZOOLOGY

Three Years (Full-Time)

CHOICE BASED CREDIT SYSTEM

(For the Students Admitted from the Academic Year 2021 – 2022)

DEPARTMENT OF ZOOLOGY

SCHOOL OF BASIC SCIENCES

(Estd. Under SRMUS Act, 2013)

Shri Ramasamy Memorial University Sikkim

5th Mile, Tadong, Gangtok, East Sikkim- 737102, India

1. Departmental Vision Statement:
1. To create a world-class centre of advanced learning for research and skill development in the realm of Zoology.
2. To provide a learner-centric, outcome-based model of higher education in Zoology and allied biological sciences in the North-East and other region of India.
3. To make learning Zoology globally relevant in the ever-changing social, industrial, research and application scenario.

2. Departmental Mission Statement:
1. To prepare young learners to explore the concepts and ideas of origin, evolution, mechanism life-processes, and interaction between living and non-living factors in biology.
2. To cultivate skill-based learning in students enabling them to apply the acquired knowledge in analysing and evaluating problems and innovating scientific solutions.
3. To develop skilled human resources by empowering learners to be globally relevant, technologically competent and creative.
4. Create a niched knowledge base for sustenance of the unique North Eastern Himalayan biodiversity.
5. To cultivate scientific temperament along with sense of social responsibility, morality and unwavering ethics.

3. Program Objectives (PO):
1. To provide a platform for knowledge acquisition in biological sciences and foster academic excellence relevant to global standards.
2. To familiarize the students with the rich biodiversity of the North East Himalayas and envision sustainability.
3. To empower the learners to accomplish a high degree of academic achievement in the areas like Classical Zoology, Immunology, Genetics, Cell and Molecular Biology in light of research and application.
4. To foster employability in the realms of academic, applied, and entrepreneurial pursuits through classroom, lab and field-based training with special emphasis on socially relevant ethical framework.

SCHEME AND SYLLABUS FOR M.Sc. IN ZOOLOGY - CURRICULUM

Course Category	Course Code	Course Name	L	T	P	C
		SEMESTER-I				
C	MZOL2111	Biology of Non-Chordates	4	0	0	4
C	MZOL2112	Biosystematics, Biostatistics and Bioinformatics	4	0	0	4
C	MZOL2113	Evolution and Animal Behaviour	4	0	0	4
C	MZOL2114	Ecology and Environmental Science	4	0	0	4
CP	MZOL2115	Practical: Biology of Non-Chordates, Systematics, Biostatistics and Bioinformatics	0	0	4	2
CP	MZOL2116	Practical: Evolution, Animal Behaviour, Ecology and Environmental Science	0	0	4	2
		TOTAL				**20**
		SEMESTER-II	**L**	**T**	**P**	**C**
C	MZOL2121	Biology of Chordates	4	0	0	4
C	MZOL2122	Animal Physiology	4	0	0	4
C	MZOL2123	Biochemistry	4	0	0	4
C	MZOL2124	Reproductive and Developmental Biology	4	0	0	4
CP	MZOL2125	Practical: Biology of Chordates, Animal Physiology,	0	0	4	2
CP	MZOL2126	Practical: Biochemistry, Reproductive and Developmental Biology	0	0	4	2
		TOTAL				**20**
		SEMESTER-III	**L**	**T**	**P**	**C**
C	MZOL2131	Cell and Molecular Biology	4	0	0	4
C	MZOL2132	Genetics	4	0	0	4
C	MZOL2133	Immunology	4	0	0	4
CP	MZOL2134	Practical: Cell , Molecular Biology and Genetics	0	0	4	2
CP	MZOL2135	Practical: Immunology	0	0	4	2
Major Elective Theory (For Zoology Students only)						
E	MZOLE01	Applied Economic Zoology	4	0	0	4
E	MZOLE02	Biodiversity And Wildlife Conservation	4	0	0	4
E	MZOLE03	Entomology	4	0	0	4
E	MZOLE04	Parasitology And Immunology	4	0	0	4
E	MZOLE05	Advanced Fish Biology	4	0	0	4
Major Elective Practical (For Zoology Students only)						
EP	MZOLE06	Practical: Applied Economic Zoology	0	0	4	2
EP	MZOLE07	Practical: Biodiversity And Wildlife Conservation	0	0	4	2
EP	MZOLE08	Practical: Entomology	0	0	4	2
EP	MZOLE09	Practical: Parasitology And Immunology	0	0	4	2
EP	MZOLE10	Practical: Advanced Fish Biology	0	0	4	2
		TOTAL				**22**
		SEMESTER-IV	**L**	**T**	**P**	**C**
C	MZOL2141*****	Endocrinology	4	0	0	4
C	MZOL2142*****	Biophysics, Tools and Techniques in Biology	4	0	0	4
CP	MZOL2143*	Practical: Endocrinology, Biophysics, Tools and Techniques in Biology	0	0	4	2
PR	MZOL2144	Lab-Internships/Projects/Review of Published Literature (Internal Assessment, Dissertation and Seminar) for 3 months and 10 credits				10
PR	MZOL2145	Lab-Internships/Projects/Review of Published Literature (Internal Assessment, Dissertation and Seminar) More than 5 months and 20 credits				20
TOTAL						**20**
TOTAL CREDIT			**82**			

C- Core subject; **CP**- Core practical; **E**- Elective; **EP**- Elective practical; **PR**-Project;

In the final semester a student does 3 months 10 credits Lab-Internships/Projects/Review of Published Literature, MZOL2144 (Internal Assessment, Dissertation and Seminar) and MZOL41, MZOL42, MZOL2143 for a total of 20 credits.

If the student gets a full-semester project for a period of minimum 5 months MZOL41, MZOL42, MZOL2143 are not required, and MZOL2145 will be counted as a 20 credits subject.

SEMESTER I

Course Code	MZOL2111	Course Name	BIOLOGY OF NON-CHORDATES	Course Category	C		L	T	P	C
							4	0	0	4
Pre-Requisite			Nil	**Co-requisite**		MZOL2115				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the origin, evolution, cephalization and basic body plan of different invertebrate animals.	**1**	**H**									**H**	
CLO-2	Explain the locomotion, nerve coordination and control in different non-chordate animals	**3**	**H**										
CLO-3	Develop the proficiency on respiration, circulation and excretory mechanism on selected invertebrates.	**3**	**H**									**H**	
CLO-4	Distinguish the reproductive system and larval forms in selected non chordates animals.	**3**	**H**										
CLO-5	Interpret the bioactive compounds from different non chordates and its application.	**4**	**H**	**M**								**M**	
			H	**M**								**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: Origin, evolution and basic body plan:** Origin and evolution of non-chordates; Outline classification of non-chordates; Concepts of body Symmetry, Germ layers, Incomplete and Complete Digestive system, Coelom, Compartmentalization, Cephalization;	12	1, 2, 3
2.	**UNIT II: Locomotion, co-ordination, and control in non-chordates:** Locomotion- Amoeboid locomotion, Structure, and function of cilia and flagella; Locomotion in Annelida, Tube feet in Echinodermata; Nervous system- Nervous system in Earthworm and Cockroach; Giant nerve fibres in Cephalopods.	12	1, 3
3.	**UNIT III: Functional Biology of life-sustaining systems** Gas exchange and Respiration- Respiratory pigments: Haemoglobin, Hemocyanin, Chlorocruorin, Hemerythrins; Structure and function of- Book gills in horseshoe crabs, Gills in shrimps, Trachea in insects, Book Lungs in arachnid arthropods; Circulatory system-Open and closed circulatory systems in Cockroach and Earthworm; Feeding and digestion in non-chordates- Types of digestive systems- Vacuolar systems in protozoa, channel-network systems in sponges, gastrovascular cavities in jellyfish, digestive tracts in insects; Excretion- Contractile vacuole, Flame cells, Nephridium, Renal gland, Coxal gland, and Malpighian tubules.	12	1, 3, 4
4.	**UNIT IV: Reproduction and development** The general concept of asexual and sexual reproduction; Conjugation in *Paramecium*, MetagenesisinCnidaria; Hermaphroditism in Annelida; Larval forms in Annelida, Mollusca and Echinodermata; Regeneration in Hydra.	12	1, 3, 5
5.	**UNIT V: Bioactive compounds and application of non-chordates** Bioactive compounds in sponges; Nematocysts in Cnidaria and possible therapeutic potential of jellyfish venom; Bioluminescence in Crystal jellyfish *Aequorea victoria* and its application in research; Traditional uses and modern perspective of Leech therapy (Hirudotherapy); Use of *Limulus* amebocyte lysate in for the determination of bacterial endotoxins and its future alternatives; Maggot therapy.	12	1, 3, 5

Learning Resources	
Text Books	1. RL Kotpal; Modern Textbook of Zoology: Invertebrates, 12th Edition, (2019); RastogiPublications. 2. KorakKantiChaki, GautamKundu, SupritiSarkar; Introduction to General Zoology, Volume I, (2011); New Central Book Agency.
Ref. Books	1. Pechenik J. A.; Biology of the Invertebrates 7th Ed, (2019) McGraw Hill Education 2. Ruppert, Fox, Barnes; Invertebrate Zoology (2006), 8th Ed; Cengage Publishers 3. Wendy Moore, Stephen M. Shuster; Invertebrates, 3rdEd, Richard C. Brusca (2016) OUP USA 4. An Introduction to the Invertebrates (2006), Janet Moore; Cambridge University Press.

Course Code	MZOL2112	Course Name	BIOSYSTEMATICS, BIOSTATISTICS AND BIOINFORMATICS	Course Category	CP		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	Co-requisite		MZOL2115				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Define the basic principles of Systematics, classification and taxonomy.	**1**	**H**									**M**	
CLO-2	Interpret Phylogenetic relations using molecular phylogenetics.	**2**				**H**							
CLO-3	Solve mathematical and theoretical problems related to descriptive biostatistics.	**3**				**H**	**M**						
CLO-4	Analyze biological data using parametric and nonparametric tests.	**4**				**H**	**M**						
CLO-5	Evaluate DNA, RNA and protein sequences, molecular phylogeny and structure prediction using bioinformatics tools.	**5**				**H**							
			H			**H**	**M**					**M**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: Systematics, classification and taxonomy** Introduction to Systematics and Taxonomy; Concept of Typological species; Polytypic & Monotypic species; Species and other infraspecific taxa; Rank based and phylogenetic nomenclature; Rules of International Commission on Zoological Nomenclature (ICZN); Linnaean hierarchy, Groups, rankings; Characters and states; Theories of biological classification; Phenetics, Evolutionary Taxonomy, Cladistics; Tools of classification; Dichotomous keys.	12	1
2.	**UNIT II: Phylogeny and Molecular Phylogenetics** Concepts, terminology and common methods of phylogenetic analysis; Phylogenetic tree: Types and Construction; Distance and character-based methods; Introduction to Numerical taxonomy, Chemotaxonomy; Importance of Molecular Taxonomy and Phylogeny in the study of origin and evolution of species; Genetic polymorphism, Homology and Molecular Characters; Sequence alignments, different molecular markers in Molecular Phylogenetics; DNA Barcoding; Molecular clocks.	12	2
3.	**UNIT III: Descriptive Statistics** Introduction to Statistics, and Biological data analysis; Visual representation of data; Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal); Regression and Correlation; Introduction to statistical software.	12	3
4.	**UNIT IV: Statistical Sampling and Analysis** Sampling distribution; Statistical inference and hypothesis testing- Difference between parametric and non-parametric statistics, Confidence Interval, Errors, Levels of significance; Parametric tests: t-test; Analysis of variance; Nonparametric tests- X^2 test; Basic introduction to Multivariate statistics.	12	4
5.	**UNIT V: Introduction to Bioinformatics** Overview and scope of bioinformatics; Web resources, Data acquisition, Curation, annotation, quality control and access to data archives; Databases-types and applications, file formats, annotated sequence databases; Retrieval of biological data; Searching for similar sequences in databases, Introduction to computational tools used in molecular phylogeny analysis and visualization; Sequence alignment methods; Multiple Sequence Alignment of Nucleic acid and Proteins, Use of sequences to determine phylogenetic relationships, Basics of Protein structure prediction by homology modelling.	12	5

Learning Resources	
Text Books	1. Kapoor VC; Theory and practice of animal taxonomy, 6th Ed (2008); Oxford & IBH 2. G.G. Simpson; Principles of Animal Taxonomy (2012); Scientific Publishers 3. B Antonisamy, Prasanna S. Premkumar, Solomon Christopher; Principles and Practice of Biostatistics, Paperback (2017), Elsevier India 4. Banerjee Pranab Kumar; Introduction To Bio-Statistics (2007), S Chand & Company 5. Zhumur Ghosh; Bioinformatics: Principles and Applications (2008), OUP India. 6. Jin Xiong; Essential Bioinformatics (2007), Cambridge University Press
Ref. Books	1. Mayr E, Ashlock PD. 1991. Principles of Systematic Zoology. 2nd Ed., McGraw-Hill 2. Lesk; Introduction to Bioinformatics (2014) Oxford University Press 3. Paul M. Selzer, Richard J. Marhöfer, Oliver Koch; Applied Bioinformatics An Introduction (2018) 2e Springer 4. John E. Havel, Raymond E. Hampton, Scott J. Meiners; Introductory Biological Statistics, 4th Edition (2019), Waveland Press 5. Donald L. J. Quicke; Principles and Techniques of Contemporary Taxonomy (1993), Blackie Academic & Professional

Course Code	MZOL2114	**Course Name**	Evolution and Animal Behaviour	**Course Category**	CP		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre Requisite			Nil	**Co-requisite**		MZOL2116				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the concept and theories of origin of life and evolution.	**1**	**H**									**H**	
CLO-2	Describe the ideas of geological time scale and the events	**2**	**H**									**H**	
CLO-3	Express phylogenetic trees and molecular basis of evolution	**3**	**H**		**M**				**H**			**H**	**H**
CLO-4	Analyze various type of animal behaviour with brain hormone and genes	**4**	**H**									**M**	
CLO-5	Construct the ideas of different types social behaviour in animals	**5**	**M**	**H**		**H**							
			H	**H**	**M**	**H**			**H**			**H**	**H**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1	**UNIT I: Origin of life and theories of evolution** Origin of basic biological molecules; Abiotic synthesis of organic monomers and polymers; Concept of Oparin and Haldane; Experiment of Miller (1953); the first cell, Organic evolution concept and its evidence, Lamarckism, Darwinism and synthetic theory of Neo Darwinism, Methods of studying natural selection and Models of selection, Recognizing adaptations, Phenotypic variation and plasticity, Cultural evolution.	12	1
2	**UNIT II: Geological time scale and the events** The geological time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Mass extinction of species; Primate evolution and origin of human beings; Formation, types, and role of fossils in evolution.	12	2
3	**UNIT III: Molecular evolutionary biology** Concepts of neutral evolution, molecular divergence and molecular clocks; Construction of phylogenetic trees using molecular data, construction of phylogenetic trees by using 16S rRNA gene sequences and concept of speciation in bacteria; the nature of bacterial and archaeal genomes; origin of genomes by horizontal gene transfer; The role of plasmid, transposons, integrons and genomic islands in DNA transfer.	12	3
4	**UNIT IV: General concept of animal behaviour** Approaches in behavioural studies, Proximate and ultimate causation, Types of behaviour; Fixed action pattern (FAP), Instinct, Types of learning, Imprinting, Maintenance and body care activities, Forms of sleep, Escape and defence strategies, Development and genetic basis of behaviour, Hormone-brain relationship, Biological clocks, Circadian rhythm.	12	4
5	**UNIT V: Social Behaviour in animals** Altruism, reciprocal altruism, eusociality, group and kin selection, Territory and home range, Social dominance and hierarchy, Habitat selection and optimality of foraging; Communication and signals, Reproductive strategy, Courtship and breeding behaviour with examples in Fish/Birds, Female choice, Parental investment and reproductive success.	12	5

Learning Resources	
Text Books	1. Futuyma, D. J.; Evolution, Sinauer Associates, Inc., Sunderland, USA 2. Mayr, E.; What Evolution Is, (2001), Basic Books, New York, USA 3. John Alcock, Animal Behaviour: An Evolutionary Approach, 9th Edition. Sinauer Associate Inc., USA, 2009. 4. Aubrey Manning; An Introduction to Animal Behaviour South Asia Edition (2016) 6th Ed Cambridge University Press India Private Limited
Ref. Books	1. Barton, N. H., Briggs, D. E.G., Eisen, J. A., Goldstein, A. E., Patel, N. H.; Evolution, Cold Spring Harbor Laboratory Press, New York, USA 2001 2. Hall, B. K. and Hallgrimsson, B., Evolution, Jones and Bartlett Publisher, Sudbury, USA 3. Coyne and Orr; Speciation (2004, Sinauer) 4. Dodson; Evolution; Process and Product (1964, Reinhold Publishing Corp) 5. Freeman and Herron; Evolutionary Analysis (1998, Prentice-Hall) 6. Futuyma; Evolutionary Biology (1998, Sinauer) 7. Koonin and Galperin; Sequence-evolution-Function: Computational Approaches in Comparative Genomics (Kluwer Academic Publishers) 8. Animal Behaviour (11th Edition); Dustin R. Rubenstein and John Alcock, Sinauer Associate Inc., USA, 2018. 9. Gadagkar; Survival Strategies-Cooperation and Conflict in Animal Societies. Universities Press, 1998. 10. Drickamer & Vessey; Animal Behaviour –Concepts, Processes and Methods (2nd ed.), Wadsworth, 1986. 11. Goodenough et al; Perspectives on Animal Behaviour, Wiley, 1993.

Course Code	MZOL2113	Course Name	ECOLOGY AND ENVIRONMENTAL SCIENCE	Course Category	CP		L	T	P	C
							4	0	0	4
Pre Requisite				Co-requisite		MZOL2116				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Define the general concept and model of ecology	1	H									H	
CLO-2	Describe the structure and function of ecosystems	2	H									H	
CLO-3	Express the general concepts of environmental science and pollution	3	H		M				H			H	H
CLO-4	Analyze Natural resources and plan management strategies	4	H									M	
CLO-5	Construct plans for conservation and preservation of nature and wildlife	5	M	H		H							
			H	H	M	H			H			H	H

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1	**UNIT I: General concept and model of ecology** Introduction to ecology and laws of limiting factors; Characteristics of populations, size and exponential growth, limits of population growth, population dynamics, life history pattern (r and k selection), fertility rate and age structure; Population interactions, Concept of metapopulation-demes and dispersal; Ecological Niche; Development of Niche concept, competition model, mutualism and commensalism, prey-predator interactions, cyclic oscillations; Introduction to the concept of ecological modelling.	12	1
2	**UNIT II: Structure and function of Ecosystem** Nature of ecosystem and functions, primary production and decomposition, energy flow, biogeochemical cycles, biome types of India: alpine tundra, grassland, forest, desert, aquatic and wetlands (unique features, distribution, vegetation, faunal makeup and adaptations); Carbon footprint, Environmental Stresses and their management.	12	2
3	**UNIT III: General concept of Environmental Science and pollutions** Environmental Science: general Consideration; Environmental impact assessment and environmental monitoring; Environmental pollution: Types and sources of air, soil, water, and sound pollution; Effects of pollution on organisms, Control measures of pollution, Smog formation, Thermal inversion, Greenhouse gases and global warming, Ozone hole, Acid rain, Circulation of pesticides and radio-isotopes in ecosystems and biomagnification; Impact of chemicals on biodiversity of microbes, animals and plants; Global climatic pattern, atmospheric ozone, acid and nitrogen deposition.	12	3
4	**UNIT IV: Natural resources and management** Natural resources and their management, Renewable energy sources, Green revolution and its impact on agroecosystem, Sustainable agriculture, Organic farming, Green belt, Vermicomposting as a model of organic waste recycling, Bioindicator and biomarkers of environmental health.	12	4
5	**UNIT V: Conservation biology** Conservation Biology- Concept of conservation and preservation, Principles of Biodiversity and Conservation, Strategic species concept, Wildlife concept; Concept of RS/GIS technology	12	5

Learning Resources	
Text Books	1. Cunningham and Saigo; Environmental Science (5th Ed., McGraw Hill, 1999). 2. Odum; Fundamentals of Ecology 5th ed (2017).
Ref. Books	1. Michael Begon, Colin R. Townsend; Ecology: From Individuals to Ecosystems Paperback –2021 2. Thomas M. Smith, Robert Leo Smith; Elements of Ecology, 9th Edition; Pearson 3. Primark; A Primer of Conservation Biology (2nd Ed., Sinauer, 2004). 4. Raven, Berg, Johnson; Environment (Saunders. 1993). 5. Sharma; Ecology and Environment (7th Ed., Rastogi, 2000). 6. Turk and Turk; Environmental Science (4th Ed., Saunders, 1993). 7. Wright and Nebel; Environmental Science (8th Ed., Prentice-Hall, 2002). 8. Kormondy Edward J Concepts of Ecology (2017); Pearson Education

Course Code	MZOL2115	Course Name	PRACTICAL: BIOLOGY OF NON-CHORDATES, BIOSYSTEMATICS, BIOSTATISTICS AND BIOINFORMATICS	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2111, MZOL2112	Co-requisite						

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Identify and Analyze the selected specimen	**3**	**H**							**M**			**M**
CLO-2	Analyze the life cycle stages of disease causing helminths (platyhelminthus, nematodes)	**4**				**M**							**M**
CLO-3	Identify and Analyze the selected invertebrates through specimen (Annalids to Echinodermata)	**3**	**H**										**M**
CLO-4	Analyze statistical problems	**4**		**H**		**H**	**M**						
CLO-5	Construct phylogenetic tree from multiple sequence alignment using bioinformatics tools.	**5**		**H**		**H**	**M**						
			H	**H**		**H**	**M**			**M**			**M**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**Microscopy and study of protozoa** tification with reasons/Study of adaptive features of free-living and parasitic protozoa from prepared slides and photographs (Any 2 free-living and any 2 parasitic specimens): *a. Amoeba b.Euglena c.Paramecium* d. *Entamoeba*e. *Giardia* f. *Trypanosma*g.*Leishmania*h. *Plasmodium*	10	1,2,3
2.	ection, culture (Only for free-living protozoa), and mounting of protozoa. ly and Identification of preserved specimens/slides/photographs(2 specimens each from a. - c.) *b. Sycon(T.S. and L.S.), Hyalonema, Euplectella, Spongilla* *c. Obelia, Physalia, Millepora, Aurelia, Tubipora,Corallium, Alcyonium,* *d. Gorgonia, Metridium, Pennatula, Fungia, Meandrina, Madrepora*	15	3
3.	tification with reasons/Study of adaptive features of preserved specimens/ slides/ photographs:*Fasciola hepatica, Taeniasolium, Ascarislumbricoides* tification with reasons/Study of adaptive features (2 selected specimens each from a.-d.): *e. Annelids - Aphrodite, Nereis, Chaetopterus, Earthworm, Hirudinaria* *f. Arthropods-Limulus, Palaemon, Balanus, Eupagurus, Scolopendra, Peripatus,* *g. Mollusks-Dentalium,Patella,Chiton,Pila,Achatina,Pinctada,Sepia,Octopus, Nautilus* *h. Echinoderms -Asterias,Ophiura, Clypeaster, Echinus, Cucumaria, and Antedon* Anatomystudy(Major)-Nervoussystem,Reproductivesystem(Male&femalein *Periplaneta* sp.),(Minor)- Mouthparts &Salivaryapparatus in*Periplaneta*sp.(Subject to permission and availability)	15	4
4.	Preparation and Use of taxonomic keys of dichotomous (simple bracket) type. Basic statistical data analysis from the provided data sets- Correlation and regression analysis; Student's t-Test/ANOVA; Chi-square test;	10	5
5.	Data search and retrieval from databases, Basic Local Alignment Search Tool (BLAST). Pairwise and Multiple sequence alignment using CLUSTALW. Reconstruction of a phylogenetic tree using software(s) and online resources. (PHYLIP, MEGA, Etc.).	10	5

Learning Resources	
Text Books	3. Cunningham and Saigo; Environmental Science (5th Ed., McGraw Hill, 1999). 4. Odum; Fundamentals of Ecology 5th ed (2017).
Ref. Books	9. Michael Begon, Colin R. Townsend; Ecology: From Individuals to Ecosystems Paperback –2021 10. Thomas M. Smith, Robert Leo Smith; Elements of Ecology, 9th Edition; Pearson 11. Primark; A Primer of Conservation Biology (2nd Ed., Sinauer, 2004). 12. Raven, Berg, Johnson; Environment (Saunders. 1993). 13. Sharma; Ecology and Environment (7th Ed., Rastogi, 2000). 14. Turk and Turk; Environmental Science (4th Ed., Saunders, 1993). 15. Wright and Nebel; Environmental Science (8th Ed., Prentice-Hall, 2002). 16. Kormondy Edward J Concepts of Ecology (2017); Pearson Education

Course Code	MZOL2116	Course Name	PRACTICAL: EVOLUTION, ANIMAL BEHAVIOUR, ECOLOGY AND ENVIRONMENTAL SCIENCE	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2113, MZOL2114	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Identify fossils from photographs and built phylogenetic tree	2	H										
CLO-2	Identify various types of animal behaviour	3		H		H			M				
CLO-3	Analyze different types of animal behavior.	3										H	H
CLO-4	Analyze physico chemical properties of water and soil	4		H		H		M					
CLO-5	Construct a project report on field based community biodiversity and ecosystem analysis	5				H				H		H	H
			H	H		H		M	M	H		H	H

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**Evolution:** 1. Construction of a phylogenetic tree from supplied data 2. Study of fossils from models/ photographs. 3. Study of homology and analogy from models/ photographs.	12	1,2
2.	**Animal Behaviour** (Any three from 1 to 8, and 9): 1. Study of fish feeding behaviour in laboratory 2. Study of mimicry and colouration through photographs. 3. Territorial behaviour in stray dogs. 4. Behavioural studies in butterflies. 5. Study of social behaviour in insects 6. To study geotaxis/ phototaxis behaviour	12	1,2,3
3.	7. Study of circadian rhythm in human 8. Demonstration of different types of behaviour in animals using audio-visual aids. 9. Field visit and submission of reports on observed animal behaviour	12	3,4
4.	**Ecology and Environmental Science:** 1. Physical and chemical characteristics of soil; texture, pH, carbonate, nitrate and base. 2. Physico-chemical properties of water; total hardness, salinity, chloride, magnesium, phosphate.	12	4
5.	3. Estimation of autotrophs and heterotrophs in a terrestrial ecosystem; density, frequency and abundance of different species in the community. 4. Project report on a field visit (study of Community, Biodiversity, and Ecosystem).	12	5

SEMESTER II

Course Code	MZOL2121	Course Name	BIOLOGY OF CHORDATES	Course Category	C		L	T	P	C
							4	0	0	4
Pre-Requisite			Nil	**Co-requisite**		MZOL2124				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the character features and classification of selected chordates groups and its affinities.	**1**	**H**									**H**	
CLO-2	Demonstrate the Integumentary, skeletal and structural adaptation in different chordates animals.	**3**	**H**										
CLO-3	Describe the digestive system, circulatory system, nervous system and sense organs in selected chordates animals.	**3**	**H**									**H**	
CLO-4	Analyze the function of respiratory, excretory and reproductive systems in different chordates.	**3**	**H**										
CLO-5	Describe the regeneration and adaptation in selected chordates.	**4**	**H**	**M**								**M**	
			H	**M**								**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1	**UNIT I: Overview and classification of the chordates:** Outline classification of the chordates up to class; General characters of Hemichordata, Urochordata and Cephalochordata; Study of *Balanoglossus* and its affinities; *Herdmania* and its affinities; *Branchiostoma* (Amphioxus) and its affinities; Cyclostomata (Agnatha)General characters and study of *Petromyzon* and its affinities; Interrelationship of Ostracoderms and Placoderms.	12	1, 2, 3
2	**UNIT II: Integumentary System**, **Skeletal system and Structural adaptations:** Integumentary system in Chordates – Dermal and Epidermal derivatives of in mammals, Cell association and Glandular System; Skeletal system in reptiles: skull in reptiles: structural and evolutionary approach; Origin of jaw and modification of jawbones and types; functional and evolutionary significance; Jaw kinetics in relation to feeding mechanism; Origin of flight: flight adaptations (pigeon).	12	1, 3
3	**UNIT III: Digestive System, Circulation, Nervous System and Sense organs:** Anatomy of the digestive system in relation to feeding habits-herbivores, carnivores and omnivores in mammals; Heart and circulation in a foetal and a neonatal mammal; Nervous system and Cranial nerves in Aves; Sensory receptors and classification; Auditory system: Evolutionary changes and adaptive advantage	12	1, 3, 4
4	**UNIT IV: Respiratory, Excretory and Reproductive system:** Respiratory system and its functional requirements in Aquatic and terrestrial environments ;Respiration in Chondrichthyes and Osteichthyes; Accessory respiratory organs in fishes; Different types of excretory products in vertebrates- fishes to mammals; Study of Urino-genital system in amphibia; Study of *Reproductive organs in* reptiles; Types of the uterus in Eutheria.	12	1, 3, 5
5	**UNITV: Regeneration and adaptation in Chordates :** Regeneration and its types in chordates; Physiological and compensatory hypertrophy; regenerative ability in chordates; Origin of cells of regeneration- amphibia; Formation of pattern during amphibian limb regeneration; Aquatic adaptations in birds and mammals, cave adaptation, deep-sea adaptation.	12	1, 3, 5

Learning Resources	
Text Books	1. Kardong Kenneth V; Vertebrates: Comparative Anatomy, Function, Evolution, 4th Ed (2018).McGraw Hill Education India 2. R.L. Kotpal. A Textbook of Vertebrate Zoology (2019);Rastogi Publications
Ref. Books	1. Sinha, Adhikari and Ganguli: Biology of Animals, Vol. II (1988, New Central Book Agency) 2. Cleveland P. Hickman JR Larry ds. Roberts. Biology of Animals 3. EL Jordan; P.S. Verma; Vertebrate Zoology - 4. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animalsthrough time (5th ed 2002, Wiley - Liss) 5. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)

Course Code	MZOL2122	Course Name	ANIMAL PHYSIOLOGY	**Course Category**	CP		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre Requisite			Nil	**Co-requisite**		MZOL2124				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			O1 Disciplinary/ Professional Knowledge	**O2 Problem Analysis**	**O3 Design and Development of Solutions/ Policies**	**O4 Modern Usage tools**	**O5 Interdisciplinary Development**	**O6 Innovation and Entrepreneurship**	**O7 Ethics**	**O8 Individual or Team Work using effective communication**	**O9 Vocational and Industry Exposure**	**O10 Life-long learning**	**O11 Environment and sustainability**
CLO-1	Describe the basic principles of physiology	**1**	**H**										
CLO-2	Interpret the mechanism of Circulation and Respiration	**2**											
CLO-3	Interpret the Physiology of Digestion, Metabolism and thermoregulation	**3**	**H**	**M**								**M**	
CLO-4	Compare different type of physiological adaptations required for osmoregulation and mechanism of excretion.	**4**		**H**								**M**	
CLO-5	Analyze the principles of musculoskeletal and neural integration	**4**											
			H	**H**								**M**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1	**UNIT I: Principles of Physiology** Mechanistic and evolutionary approaches in physiology; Structure-function relationship, Adaptation, Acclimatization, Acclimation, homeostasis and feedback control systems, conformity and regulation;	12	1, 2, 3
2	**Unit II: Physiology of Circulation and Respiration** Circulatory system- Blood, plasma, blood corpuscles and formed elements, hematopoiesis, blood groups, respiratory pigments, anaemia and polycythaemia, blood coagulation and use of anticoagulants, blood circulation, heart structure and function, control of rhythmic excitation of heart, regulation of blood pressure; hypertension and ECG; lymphatic system; outline of cardiovascular diseases; Respiratory system- Gas exchange and transport; Acid-Base Balance; neural and chemical regulation of respiration ; Evolution of respiratory organs; Outline of common respiratory diseases.	12	1, 3
3	**UNIT III: Physiology of Digestion, Metabolism and thermoregulation** Digestive system- Feeding and Digestion; types of feeding; Control of the digestive system; nutrient uptake and transport; energy balance, BMR; Metabolism and its common disorders; Thermogenesis and thermoregulation.	12	1, 3, 4
4	**UNIT IV: Physiology of excretion and osmoregulation** Excretory system- Comparative physiology of excretion; mechanism of urine formation; micturition; Ionic and acid-base balance; Osmoregulation in aquatic and terrestrial environments;	12	1, 3, 5
5	**Unit V Physiology of Musculoskeletal and Neural Integration** Physiology of skeleton, muscles and movement; Diseases of Musculoskeletal system; Neuron structure and function, Transmission of nerve impulses, Introduction to Central and Peripheral Nervous System; Classes of Sensory Receptors; Physiology of Vision and Hearing.	12	1, 3, 5

Learning Resources	
Text Books	1. Eckert; Animal Physiology: Mechanisms and Adaptations 2Ed (Pb 2008); CBS Publishers 2. Schmidt-Nielsen; Animal Physiology: Adaptation and Environment Paperback 2002; Cambridge University Press
Ref. Books	1. Sherwood L. Animal Physiology from Genes to Organisms 2ed (Pb 2019) (2019); Cengage Learning Exclusive (CBS) 2. Guyton & Hall; Textbook Of Medical Physiology, 3E-South Asia Edition: Third South Asian Edition Paperback (2020)– 1 January 2020; Elsevier Health Science 3. Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks, Jason X.J. Yuan Ganong's Review of Medical Physiology 26th ed (2019) McGraw-Hill Education

Course Code	MZOL2123	Course Name	Biochemistry	Course Category	C		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	**Co-requisite**		MZOL2126				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the fundamental biochemistry of carbohydrates and buffers.	1	**H**				**H**					**M**	
CLO-2	Outline the biochemistry of protein and its importance.	2	**H**				**H**					**M**	
CLO-3	Interpret the types and role of lipids in biology.	2	**H**				**H**					**M**	
CLO-4	Analyze the enzyme activity and role of bioenergetics in the biological system.	4	**H**	**H**			**H**					**M**	
CLO-5	Explain different types of nucleic acids and vitamins and their role in the biological system.	5	**H**	**H**			**H**					**M**	
			H	**H**			**H**					**M**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
	UNIT I: Buffers and Carbohydrates Buffers: pH and buffers Water, biological importance; Stabilizing interaction-Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction ; Carbohydrates: Structure, classification and properties of functional groups; Metabolism of carbohydrates-glycolysis, citric acid cycle, gluconeogenesis-defect in carbohydrate metabolism	8	1
	UNIT II: Proteins Structure, classification of proteins based on the chemical structure, properties and function; General properties and classification of amino acids and physiological importance; Conformation of proteins (Ramachandran plot, secondary structure, domains, motif and folds); Protein metabolism – Metabolism of amino acids in general ; Defects in protein metabolism	8	2
	UNIT III: Lipids Classification of lipids - Structure and chemistry of single and compound lipids; metabolism of fats and fatty acids - Defects in lipid metabolism; Lipids in inflammation and disease	9	3
	UNIT IV: Enzymes and Bioenergetics Enzymes: Classification, properties of enzymes, Mode of enzyme action, Co-enzymes, the effect of substrate concentration, enzyme kinetics; Bioenergetics; oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.	10	4
	UNIT V: Nucleic acid and Vitamins Nucleic acids- DNA structure, types and properties, DNA and RNA synthesis- Mechanism of Replication- nucleotides – Different types of RNA – mRNA and rRNA, tRNA; Vitamins- Water and Lipid Soluble Vitamins - structure, classification, sources and deficiency diseases.	10	5

Learning Resources	
Text Books	1. Victor W.Rodwell(2018).Harper'sIllustratedBiochemistry,McGraw-Hill Education. 2. U. Satyanaryan, U.Chakrapani 2017. Biochemistry. Publisher: Elsevier, New Delhi. 3. Annie Ragland and N.Arumugam.(2015).BiochemistryandBiophysics,Saras Publications, Nagercoil, Tamil Nadu
Ref. Books	1. Nelson, D.L. and M.M. Cox. (2013). Lehninger Principles of Biochemistry, W.H. Freeman. 2. Jain, J. L. Jain, S. and Jain N. 2005. Fundamental of Biochemistry, S. Chand & Co. Ltd. New Delhi 3. Watson, J.D., Baker, T.A., Bell, S.P., Gann A., Levine, M. and Losick, R. (2008) Molecular Biology of the Gene, VI Edition, Cold Spring Harbor Lab. Press, Pearson Pub. 4. Freifelder, D. (2007). Physical Biochemistry W.H. Freeman & Co. 5. Lippincott Illustrated Reviews: Biochemistry, 7th Edition (2015) Lippincott Williams & Wilkins Denise R. Ferrier 6. Wiley Donald Voet, Judith G. Voet, Charlotte W. Pratt; Fundamentals of Biochemistry: Life at the Molecular Level (2016)

Course Code	MZOL2124	Course Name	REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY	Course Category	C		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	**Co-requisite**		MZOL2126				

ourse Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the structure of reproductive system	**1**	**H**									**H**	
CLO-2	Describe the process of fertilization and cleavage in development.	**2**	**H**										
CLO-3	Express the detailed process of gastrulation and organogenesis.	**3**	**H**										
CLO-4	Evaluate the developmental control of gene expression.	**4**	**H**										
CLO-5	Analyse the biotechnological approaches and medical implications in developmental biology.	**4**	**H**	**H**	**H**		**M**	**M**	**H**				**H**
			H	**H**	**H**		**M**	**M**	**H**			**H**	**H**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: Structure and function of male and female reproductive systems** Introduction to reproductive biology; Structure and function of the male reproductive system, Structure of male gametes, spermatogenesis and spermiogenesis, Androgens, inhibin and androgen binding proteins; Structure and function of the female reproductive system, Structure of male gametes, Influence of hormones on the development of ovarian follicles and oogenesis, reproductive cycles: oestrous and menstrual cycle, ovulation, atresia and corpus luteum formation; pregnancy and lactation; Contraception in males and females,	12	1
2.	**UNIT II: Concepts of fertilization and cleavage:** Cell division, cell differentiation, signalling, patterning; Evolution of developmental patterns, capacitation of spermatozoa, fertilization, cleavage and formation of blastula, The role of yolk in cleavage, implantation	12	2
3.	**UNIT III: Gastrulation and organogenesis** Gastrulation; axes and germ layers; concept and functions of the primary organizer, Embryonic induction in vertebrates: mesoderm induction, fate map and organizer concept, neural induction, Placenta and placentation, *Caenorhabditis elegans*: Early development and vulva formation; *Xenopus*: Organizer formation, mesoderm specification; Eye lens induction, limb development and regeneration in vertebrates.	12	3
4.	**UNIT IV: Developmental control of gene expression** Genes and development; Differential gene expression during germ layer formation; Role of maternal genes, patterning of the early embryo by zygotic genes- gap genes, pair-rule genes, segment polarity genes, homeobox genes, homeotic selector genes; Genetics of axis specification in Drosophila	12	4
5.	**UNIT V: Biotechnological approaches and medical implications in developmental biology:** Animal cloning; Gene editing technology and its future perspectives, Amniocentesis and Karyotyping and PCR based tests for detection of genetic defects, Amplification of free foetal DNA in maternal plasma, Infertility and assisted reproductive techniques; Cryopreservation of gametes, in vitro fertilization, Genetic errors and developmental syndromes in human, teratogens in embryonic development; Preservation of Umbilical Cord for stem cells.	12	5

Learning Resources	
Text Books	1. Scott F Gilbert; Developmental Biology: [Latest edition]. 2. Louis Wolpert; Principles of Development: [Latest edition].
Ref. Books	1. Austin, C.R. and Short, R.V. reproduction in Mammals. Cambridge University Press 2. Degroot, L.J. and Jameson, J.L. (eds). Endocrinology. W.B. Saunders and Company 3. Knobil, E. et al. (eds). The Physiology of Reproduction. Raven Press Ltd. 4. Hatcher, R.A. et al. The Essentials of Contraceptive Technology. Population Information Programme. 5. Essentials of Developmental Biology: JMW Slack [Latest edition]. 6. Patten's Foundation Of Embryology 6E Carlson; McGraw Hill Education

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Course Code	MZOL2125	Course Name	PRACTICAL: BIOLOGY OF CHORDATES, ANIMAL PHYSIOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2121, MZOL2122	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Identify the selected museum specimen and their adaptive features (Prochordates to mammals).	**3**	**M**	**H**		**H**						**M**	
CLO-2	Explain the cranial nerves and anatomical study in the selected animals.	**4**		**H**		**H**				**H**			**M**
CLO-3	Describe the birds respiratory, muscular and skeleton of different muscles through charts/model.	**3**		**H**		**H**						**H**	
CLO-4	Demonstrate histological tissue sections of mammals	**3**											
CLO-5	Analyze Bleeding, clotting time, blood film-staining and mounting, Blood cell count	**4**											
			M	**H**		**H**				**H**		**M**	**M**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	Identification with reasons/Study of adaptive features of museum specimens (representative animals) based on their adaptive features of all chordate groups (protochordates to mammals).	12	1,2
2.	Cranial Nerves of *Labeo* or chick (5th and 7th and 9th and 10^{th}; /Weberian osscicles).	12	3
3.	Anatomy (Reproductive, excretory, nervous and circulatory system) through dissections/demonstration (Models, Charts, Computer simulation): Fish, Chick and Rat/Mouse. Flight muscles, perching mechanism, air sacs and anatomy of the neck region in pigeon through charts/models/computer software. Osteology: Comparative study of skull of different vertebrates.	12	1,3
4.	Histological study and identification of- Mammalian Skin, Muscle, Parts of Gastrointestinal Tract, Liver, Pancreas, Bone, Artery, Vein, Lung, Kidney, Testes and Ovary. Measurement of Oxygen saturation, Blood glucose and Blood sugar, ECG (Demonstration)	12	4,5
5.	Bleeding and clotting time. Blood film-staining and mounting, Blood cell count.	12	5

Course Code	MZOL2126	Course Name	PRACTICAL: BIOCHEMISTRY, REPRODUCTIVE AND DEVELOPMENTAL BIOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2123, MZOL2124	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Demonstrate qualitative tests of functional groups of carbohydrates, proteins and lipids.	3	H	H		H							**H**
CLO-2	Analyze the action of salivary enzymes in different parameters and separation techniques of macromolecules.	4	H	H		H							
CLO-3	Distinguish the oestrus cycle and ovulation.	3	H	M		H							
CLO-4	Analyze the different developmental stages of chick embryo.	4	H	H		H							
CLO-5	Develop a study on *Drosophila* culture/Chick embryo.	5	M	H	M	H				H			H
			H	H	M	H				H			H

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	Qualitative tests of functional groups in carbohydrates, proteins and lipids. Determination of isoelectric pH of a protein.	12	1
2.	Effect of pH, temperature and inhibitors on the action of salivary amylase. Method of protein separation by SDS-PAGE demonstration. Paper electrophoresis of proteins.	12	2
3.	Germinal vesicle breakdown (GVBD) and ovulation in fish Study of estrus cycle in mice/rat.	12	3
4.	Study of different incubation stages of the chick embryo.	12	4
5.	Whole-mount preparation of chick embryo. Study of life cycle and developmental stages of *Drosophila melanogaster/* fish.	12	5

SEMESTER III

Course Code	MZOL2131	Course Name	CELL AND MOLECULAR BIOLOGY	Course Category	CP		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	**Co-requisite**		MZOL2134				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Define cell membrane, its structure, function and cell cycle.	**1**	**H**	**M**			**M**					**H**	**M**
CLO-2	Explain different cell signalling pathway and mode of communication	**2**	**H**										
CLO-3	Evaluate the cancer biology and stem cell biology along with its techniques.	**3**	**H**									**M**	
CLO-4	Demonstrate the different cell organelles and structure of genomes.	**3**	**H**										
CLO-5	Analyze the methods in modern molecular biology.	**4**	**H**	**M**									
			H	**M**			**M**					**H**	**M**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: General concept of the cell membrane and cell cycle** Cell theory; Structure of model membrane, lipid bilayer and membrane protein diffusion; membrane transport; electrical properties of membrane; Cell cycle control and its regulation; Commitment to cell division; Checkpoints in the mammalian cell cycle; Turnover of cellular components; Degradation of cytosolic proteins.	12	1
2.	**UNIT II: Cell signalling and communication** The general concept of cell signalling- cell junctions; adhesion of cell and molecules; extra-cellular matrix; Intercellular communication; mechanisms of cellular signalling; Second messenger systems; types of receptors; G-protein coupled receptors; Receptor tyrosine kinases; MAP kinase cascade; Desensitization of receptors; Survival and death pathways.	12	2
3.	**UNIT III: Stem cell and cancer biology** Introduction to Stem Cell Biology-concept, types, self-renewal, totipotency, pluripotency, differentiation, Isolation and characterization of stem cells; Techniques in stem cell biology; Use of stem cells in tissue repair; Mammalian cell culture and cytotoxicity; Apoptosis; Autophagy, Cellular senescence; General concepts and types of cancer; Oncogenes; Carcinogenic agents.	12	3
4.	**UNIT IV: Cell organelles and structure of genomes** General concepts of cellular organelles- mitochondria; nucleus; chromosome and its types, microsatellites; Genetic mapping of the locus; Human genome- characteristics and implications; Human genome project; Gene mapping –DNA markers: RFLP, AFLP, RAPD, VNTR, SNPs; DNA and RNA gene mapping.	12	4
5.	**UNIT V: Methods in Molecular Cell Biology** C-value paradox: unique and repetitive sequences in the eukaryotic genome; multiple gene families; The significance of genomic evolution in animals; Recombinant DNA technology-Polymerase chain reaction (PCR), genomic and cDNA libraries, genome analysis- Southern Blot hybridization and northern hybridization; preparation of probes, DNA sequencing.	12	5

Learning Resources	
Text Books	1. Alberts et al: Molecular Biology of the Cell (2002, Garland) 2. Karp: Cell and Molecular Biology (2007, Wiley)
Ref. Books	1. Molecular Cell Biology, Lodish et al., W.H. Freeman and Company (8th Ed. 2016) 2. Molecular Biology of the Cell, Alberts et al., W.W. Norton and Company (6th Ed. 2014) 3. Molecular Biology, Weaver R. F., McGraw-Hill Education (5th Ed. 2011)

Course Code	MZOL2132	Course Name	Genetics	Course Category	C		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	Co-requisite		MZOL2134				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Define the Mendelism, principles and extension, Pleiotropism, penetrance and extension, Epistasis and Phenocopy.	1	H								M	H	
CLO-2	Demonstrate the extra chromosomal DNAs, multiple allelism, X and Y linked gene and testicular feminization syndrome.	2	H	H							H	H	
CLO-3	Describe the linkage and crossing over, gene mapping, somatic cell hybridization.	4	H	H	M	H			H		H	M	
CLO-4	Analyze the different types of mutation and Microbial genetics,	4	H	H									
CLO-5	Describe the pedigree analysis, karyotype and genetic disorders.	4	H	M		H			H			H	
			H	H		H			H		H	H	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: Mendelism-Principles and Extension:** Mendel's laws and its experimental design- Dominance, segregation, independent assortment; Dominance relationship- simple dominance, co-dominance and incomplete dominance, Pleiotropism, penetrance and expressivity; Gene interactions and modified Mendalian ratios: Epistasis, mechanism of Epistasis and its molecular mechanism; lethal and sub-lethal genes; Phenocopy.	12	1
2.	**UNIT II: Extra-chromosomal Inheritance and sex determination:** Extra nuclear Genomes- Mitochondrial DNA (mt DNA) and Mitochondrial inheritance, homoplasmy and heteroplsmy; Chloroplast DNA (cp DNA), plasmids and viral genome; Maternal effect - Snail Coiling and Cytoplasmic inheritance in *Mirabilis*, and *Paramecium*; Polygenic inheritance, heritability and its measurements, Multiple allelism: ABO blood groups in humans, pseudoalleles- Rh blood group incompatibility; Genetic basis of sex determination in *Drosophila* and human beings, Y linked genes, X linked genes, Dosage compensation, and testicular feminization Syndrome.	12	2
3.	**UNIT III: Chromosomal Genetics and gene mapping :** Linkage and crossing over: Linkage, linkage groups, types of crossing over, sex-limited and sex-influenced characters, Cytological basis of crossing over- Sterns experiments in *Drosophila*, Tetrad analysis in *Neurospora*, Inheritance of linked genes- Coupling and Repulsion phase; Gene mapping in *Drosophila* using two-point and three-point test crosses with an emphasis on interference and coefficient of coincidence; Somatic cell hybridization.	12	3
4.	**UNIT IV: Mutation and Microbial genetics:**Molecular basis of gene mutation; mutant types- lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants; Induced mutation, The Ames test for mutagen/carcinogen detection; Overview of mutation detection methods; Microbial genetics: Methods of genetic transfers – conjugation (F+, F- and High-frequency recombinants strain HFR), transformation, transduction (generalized and specialized transduction) and sex-duction, mapping genes by interrupted mating, fine structure analysis of genes.	12	4
5.	**UNIT V: Human genetics:** The pattern of inheritance and pedigree analysis; Karyotype and nomenclature of metaphase, chromosome anomalies and diseases- Introduction to chromosomal anomalies in malignancy (chronic myeloid leukaemia, Burkitt's lymphoma, retinoblastoma and Wilms' tumour); Types of genetic disorders with examples; Introduction to epigenetic in cancer and its detection; Genetic counselling - Objectives, ethics and principles.	12	5

Learning Resources	
Text Books	1. Verma, PS. And Agrawal, VK., Genetics; S.Chand and Co.,New Delhi 2. Gupta, PK., Genetics;Rastogi Publication, Meerut 3. Peter J Russell, iGenetics: A Molecular Approach, 3rdEdnPearson India, 2016, Paperback, 4. Pawan Kumar Dhar, Human Genetics,2004, Jaypee brothers Publisher.
Ref. Books	1. Strickberger; Genetics, 3Rd Edn Pearson India, 2015, Paperback 2. Gardner, E.J., Peter & Simmons, M.J. and Snustad, D.P Principles of Genetics,. 8thEdn. John Wiley and Sons, New York, 2006. 3. William S Klug and Michael R Cummings; Concepts of Genetics; 10thEdn; Pearson Education India, 2016. 4. Lewin, Benjamin. Genes IX. John Wiley and Sons, New York, 2008. 5. Sarin,C., Genetics Tata McGraw Hill, New Delhi

Course Learning Outcomes:

Course Code	MZOL2133	Course Name	IMMUNOLOGY	**Course Category**	CP		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre Requisite				**Co-requisite**	MZOL2135					

ourse Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			O1 Disciplinary/ Professional Knowledge	**O2 Problem Analysis**	**O3 Design and Development of Solutions/ Policies**	**O4 Modern Usage tools**	**O5 Interdisciplinary Development**	**O6 Innovation and Entrepreneurship**	**O7 Ethics**	**O8 Individual or Team Work using effective communication**	**O9 Vocational and Industry Exposure**	**O10 Life-long learning**	**O11 Environment and sustainability**
CLO-1	Define the concepts of immunity	**1**	**H**				**M**						
CLO-2	Describe Antigen-antibody interactions	**2**	**H**										
CLO-3	Interpret the role of complement system, MHC complex and T-Cell receptors in immunity.	**3**	**H**										
CLO-4	Compare different effector mechanisms and regulation of immune responses	**4**		**H**									
CLO-5	Evaluate the role of immunity in health and disease	**5**		**H**	**M**		**H**					**H**	
			H	**H**	**M**		**H**					**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT I: Introduction to the immune system** Concepts of immunity; Evolution of immune system; overview of inflammation; antigen and antibody; innate and adaptive immunity; components of innate immunity; Pattern recognition in the innate immune system; TLRs and their role in innate immune response; The relation between innate and adaptive immunity; primary and secondary immune responses; theory of immunity.	12	1
2.	**UNIT II: Antigen-antibody interaction in the immune system** Antigenicity and immunogenicity; Structure and classification of antibodies; Antigen-antibody interactions- Affinity, avidity; precipitation and agglutination reactions RIA and ELISA; antibody-mediated effector functions; B cell and T cell epitopes; Antigenic determinants on immunoglobulins (Ig); monoclonal antibodies; generation of antibody diversity; Synthesis assembly and secretion of Ig; Basics of antibody engineering.	12	2
3.	**UNIT III: Complement system, MHC complex and TCR** Complement system- Function and components, complement activation, pathways, membrane attack complex; Major histocompatibility complex (MHC), MHC molecules and genes, antigen processing and presentation, MHC restriction; Activation and differentiation of B and T cells, B and T cell receptors; Humoral and cell mediated immune system; cell-mediated effector functions	12	3
4.	**UNIT IV: Effector mechanisms and regulation of immune responses** Cytokines- types and function, receptors, secretion, cytokine related diseases; Interferon therapy; Role of IFN-γ and TNF-α in chronic inflammation, anti-inflammatory agents, cytotoxic T Cells, natural killer cells (NK), antibody-dependent cell-mediated cytotoxicity; hypersensitivity- classification, medical aspects.	12	4
5.	**UNIT V: Immunity in health and disease** Immunological tolerance; Autoimmune diseases, examples of organ-specific and systemic autoimmune diseases, treatment; Transplantation Immunology- Basis of Transplantation, Acute, Hyperacute and chronic Graft rejection; immunosuppressive therapy; Tumour Immunology, immune response to viral, bacterial, parasitic, fungal diseases; Vaccine and its types, delivery systems; adjuvants; Immunology of AIDS and HIV; Adverse effects of immunological reactions to SARS-COV-2 infection.	12	5

Learning Resources	
Text Books	1. Kuby Immunology, Richard, Thomas, Barbara, Janis, W. H. Freeman and Company [Latest edition]. 2. Cellular and Molecular Immunology Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Elsevier Publishing [Latest edition].
Ref. Books	1. Immuno Biology- The immune system in health and disease, Janeway, Travers, Walport and Shlomchik, Garland Science Publishing [Latest edition]. 2. Essentials of Immunology, David, Brostoff and Roitt, Mosby & Elsevier Publishing [Latest edition]. 3. Fundamentals of Immunology William E. Paul, Lippincott Williams & Wilkins Publishing [Latest edition].

Course Code	MZOL2134	Course Name	PRACTICAL: CELL , MOLECULAR BIOLOGY AND GENETICS	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2131, MZOL2132	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Preparation and study of metaphase chromosomes from *Drosophila*/Grasshopper/onion root tip cells.	**3**	**M**	**H**		**H**							
CLO-2	Study of meiosis from grasshopper	**4**		**H**		**H**				**H**			
CLO-3	testes DNA isolation by Phenol-Chloroform method	**3**		**H**		**H**						**H**	
CLO-4	Quantification of DNA by UV-spectrophotometer DNA Agarose Gel Electrophoresis (demonstration).					**H**							
CLO-5	Classification of the chromosomal aberrations with respect to number, translocation and deletion.	**3**	**H**	**H**		**H**			**M**				**H**
			M	**H**		**H**			**M**	**H**		**M**	**M**

Course Code	MZOL2135	Course Name	PRACTICAL: IMMUNOLOGY	Course Category	CP		L	T	P	C
							4	0	0	4
Pre Requisite			MZOL2133	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Examine splenocytes and thymocytes, and single-cell suspension.	**1**				**H**							
CLO-2	Classify primary and secondary immune organs in mice from photographs	**2**											
CLO-3	Apply cell counting and viability testing.	**3**				**H**				**M**			
CLO-4	Analyze immuno-diffusion and immuno-electrophoresis	**4**				**H**				**H**			
CLO-5	Evaluate antigen-antibody binding experiments	**5**					**H**			**H**			
						H	**H**			**H**			

MAJOR ELECTIVE THEORY

(For Zoology students only, any one from the following options)

Course Code	MZOLE01	Course Name	APPLIED ECONOMIC ZOOLOGY	Course Category			L	T	P	C
							4	0	0	4
Pre Requisite				Co-requisite	MZOLE06					

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Demonstrate the economic importance of aquaculture, prawn and pearl culture methods, by-products of fishes and commercial value.	**1**	**H**					**H**			**H**		**M**
CLO-2	Develop skill on apiculture, vermiculture and Sericulture cultivation and rearing technology.	**2**	**H**			**M**		**H**			**H**		
CLO-3	Apply fundamental concept of dairy farm production, cattle farm, sheep farm and its importance.	**3**	**H**					**H**			**H**		
CLO-4	Evaluate the importance of poultry industry, by-product of poultry, and common diseases.	**4**	**H**					**H**			**H**		**M**
CLO-5	Construct the tools and techniques of livestock management, economic importance of leather industry.	**5**	**H**					**H**			**H**		**M**
			H			**M**		**H**			**H**		**M**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**UNIT - I Economic importance of aquaculture** Fish Culture- General Introduction to pisciculture techniques of induced breeding, Commercial culture of Catla and Catfish; By-Products of fishes and its commercial values; preservation - processing and export techniques adopted in fish culture; Prawn culture -Culture techniques of freshwater (*Macrobrachium rosenbergii*) and Marine water (*Penaeus monodon*); preservation - processing and export techniques adopted in Prawn culture; Pearl culture- formation of pearls and their types, the significance of pearls.	12	1
2.	**UNIT - II Economic importance of worms and insects** Vermiculture- Vermiculture and its types of composting; Economic Entomology- Useful Insects of commercial values; Apiculture - Species of Honeybees, honey composition, honey extraction, Economics of Apiculture and management; Sericulture–Types and secretion of silks; The life cycle of silkworms, Nature and economic importance of Sericulture in India.	12	2
3.	**UNIT III: Economic importance of Dairy farms** General concepts of dairy farm and management; Milch breeds; Draught breeds, Dual-purpose breeds and New Crossbreeds of Cows and Buffaloes in India; Hybrid species of cattle; Sheep farming: Indigenous and Exotic breeds of Sheep; different types of dairy products.	12	3
4.	**UNIT IV Economic importance of Poultry industry** Introduction to poultry management; Morphology of different breeds of Chicken - Brooding and Rearing of Chicks-Processing of Egg, Meat and By-Products of Poultry; feeding habit and common diseases of poultry; Poultry medicines; Integrated poultry-fishery management.	12	4
5.	**UNIT V Strategies for Livestock management** Transgenic Animal Technology; tools and techniques for livestock management; Genetic Improvement for best breeds; Economic importance of Leather; types of leather and management Wool types and its management; collection and management of fur from different animals.	12	5

Learning Resources	
Text Books	1. Sukla, G.S. and Upadhyay, V.B., 2000 Economic Zoology - ISBN - 81-7133-137-8 Rastogi Publications, Meerut, India. 2. JawaidAhsan and Subhas Prasad Sinha, 2000 A Handbook on Economic Zoology-ISBN-81-219-0876-O S. Chand & Co., Ltd., New Delhi.
Ref. Books	1. Ashok Kumar and Premmohan Nigam, 1991 Economic and Applied Entomology; Emkay Publications, New Delhi. 2. Shammi, Q.J. and Bhatnagar, S., 2002 Applied Fisheries: ISBN-81-7754-114-5Agrobios (India), Jodhpur - India. 3. Major Hall, C.B. 2005 Ponds and Fish culture - ISBN-81-7754-146-3 Agrobios (India), Jodhpur - India. 4. Keith Wilson, N.D.P., 2005 A Handbook of Poultry Practice - ISBN-81-7754-O-69-6 5. Agrobios (India), Jodhpur - India.

Course Code	**MZOLE02**	**Course Name**	BIODIVERSITY AND WILDLIFE CONSERVATION	**Course Category**	C		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre-Requisite			Nil	**Co-requisite**		MZOLE07				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define biodiversity and its importance in an ecosystem.	**1**	**H**					**H**			**H**		**M**
CLO-2	Outline the threats to biodiversity and its mitigation.	**2**	**H**			**M**		**H**			**H**		
CLO-3	Interpret the basic concept of wildlife and its population census and management.	**3**	**H**					**H**			**H**		
CLO-4	Explain the different types of wildlife conservation and habitat management.	**4**	**H**					**H**			**H**		**M**
CLO-5	Discuss the concept of the protected area for biodiversity and its legal framework.	**5**	**H**					**H**			**H**		**M**
			H			**M**		**H**			**H**		**M**

Summary of Course Content

S. No	**Course Content**	**Hours**	**Alignment to CLO**
	UNIT I: Biodiversity: patterns and processes General concept of biodiversity; Types and levels of biodiversity; Patterns and process; Local and regional biodiversity-niche assembly theories; Unified Neutral theory, Island biogeographical model; Hotspots of biodiversity; Restricted range species and endemism; keystone species, flagship species, indicator species, surrogate Species; Biodiversity with reference to Eastern Himalayas	12	1
	UNIT II: Threats to biodiversity Threats to species diversity: Habitat loss, Habitat fragmentation; Endemism, Population bottleneck, Genetic drift, inbreeding depression; Risks to biodiversity extinction, Extinction vortex; Human-animal conflict: type and nature of conflict, causes of conflict, and measures of conflict mitigation	12	2
	UNIT III: Basic concept of wildlife biology Definition and importance of wildlife; Wildlife wealth of India; Threatened wildlife and IUCN status - Concept of Extinct, Critically Endangered, Endangered, Vulnerable and rare species; Red data book; Wildlife wealth of India; Management of rare and endangered species; Control and management of overabundant wildlife populations; Wildlife census technique: objectives, direct and indirect methods with reference to herpetofauna, birds and mammals;wildlife protection Act.	12	3
	UNIT IV: Basic concept of wildlife conservation Wildlife conservation Indian perspective: Aims & Objectives of wildlife conservation; in-situ and ex-situ conservation; Threats to wildlife conservation in India; Conservation status, habit & habitat, threats and conservation management of the following animals; Himalayan salamander/Sphenodon / Olive ridleyturtles / Great Indian bustard / Himalayan musk deer/Greater one-horned rhinoceros / Fishing cat / Ganges River dolphin/Bengal Tiger/Red Panda/Snow leopard; Wildlife sampling: random sampling, systematic sampling, stratified sampling, cluster sampling	12	4
	UNIT V: Protected areas concept and legal framework of biodiversity In-situ conservation- problems and prospects; Sanctuaries, National parks, Community and Conservation Reserves; Biosphere Reserve, laws and policies for biodiversity conservation; convention on biological diversity and important protocols; Aichi targets; Indian Biodiversity laws and rules, national biodiversity authority, state biodiversity boards, Biodiversity management committees and people's biodiversity register	12	5

Learning Resources	
Text Books	1. M. Kato. (2000) The Biology of Biodiversity. Springer. 2. Kothari, A.S. &Chapgar. (2005) Treasure of Indian Wildlife, BNHS, Mumbai.
Ref. Books	1. B. B. Hosetti. (2005) Concepts in Wildlife Management. 2nd Revised & Enlarged Ed, 2005. Daya Publishing House, Delhi. 2. Smith, R.L. and T.M. Smith (2002) Ecology and Field Biology. Addison – Wesley Educational Publishers Inc. 3. Hussain, M. (2013) Environment and Ecology: Biodiversity, Climate Change and Disaster Management. Access Publishing House. 4. Biodiversity: Convention on Biological Diversity, Abiotic Stress, International Treaty on Plant Genetic Resources for Food and Agriculture Books LLC, Wiki Series (2011). 5. Wilson, E. O. (1988) Biodiversity. National Academy Press. 6. Krihhnamurthy (2008) An Advanced Textbook On Biodiversity: Principles And Practice. Oxford &Ibh Pub. Co. Pvt. Ltd. 7. Anderson, A.B. (2006) Applying Nature's Design - Corridors as a Strategy for Biodiversity Conservation (Issues, Cases, and Methods in Biodiversity Conservation). Columbia University Press. 8. deBoef et al. ed (2013) Community Biodiversity Management: Promoting resilience and the conservation of plant genetic resources (Issues in Agricultural Biodiversity). Routledge. 9. Lanzerath, D. and Friele, M. (2014) Concepts and Values in Biodiversity (RoutledgeStudies in Biodiversity Politics and Management). Routledge.

Course Code	MZOLE03	Course Name	ENTOMOLOGY	Course Category	C		L	T	P	C
							4	0	0	4
Pre Requisite			Nil	Co-requisite		MZOLE08				

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Identify, classify and preserve insects	**1**	**H**						**M**	**M**			**H**
CLO-2	Describe insect morphology	**2**	**H**										
CLO-3	Relate the internal structures and functions of insects	**3**	**H**									**H**	
CLO-4	Analyze the medical and industrial role of insects	**4**	**H**				**H**					**H**	
CLO-5	Assess the agricultural aspects of entomology and pest management	**5**	**H**				**H**					**H**	
			H				**H**		**M**	**M**		**H**	**H**

Summary of Course Content			
S.	**Course Content**	**Hour**	**Alignment to CLO**
	UNIT I: Insect classification, collection and preservation techniques Classification of insects up to orders; General characters, Biology and habits of different orders of insects (special emphasis on economically important insects); Tools and Techniques of collection and preservation of insects- pitfall techniques, light traps, flight intercept trap, Bait trap;	12	1
	UNIT II- Insect Morphology Segmentation and division of the body: General morphology of head (Opisthognathus, Prognathus, Hypognathus); Head segmentation; Tentorium; Modifications in head capsule; Cephalic appendages; Antennae – Structure functions and types, Mouthparts – various modifications, feeding mechanisms; General morphology of thorax (thoracic segmentation, thoracic skeleton and thoracic appendages); Wings – Structure, Venation, Wing articulation, Wing coupling apparatus, Wing modifications; Legs-structure and adaptive radiation of legs, Locomotion; Morphology of abdomen and its appendages.	12	2
	UNIT III: Structure and function of internal organs Anatomy and histology of gut in insects; Modifications of gut (filter chamber); Circulatory system- Mechanism of circulation; Excretory system: Anatomy and histology of Malpighian tubules (Hemiptera, Coleoptera, Lepidoptera), Respiratory System: Anatomy and histology of trachea, tracheoles, spiracles and air-sacs, Reproductive system: External genitalia-structure and diversity of male and female genitalia; eg; Grasshopper, *Drosophila*, Light and Sound Producing Organs – Structure of light-producing organs, Production of light, Stridulatory organs in various insects-a general introduction.	12	3
	UNIT IV: Medical & industrial entomology Vectors of human diseases (Diptera, Anoplura and Siphonaptera); Epidemiology of Vector-Borne Diseases Malaria, Filariasis, Dengue Fever, Chickungunya and Encephalitis; Biology and rearing of lac insect and honey bee.	12	4
	UNIT V: Agricultural entomology and pest management Insect Pests of Crops: Life history, nature of damage and control measures of major pests of paddy, tea, large-cardamom, turmeric and ginger, Locusts –life history and migration, damage and methods of control; Pest management – concepts, definition, characteristics, pest management strategies and techniques; Biological control- History, ecological basis and agents of biological control – Parasites, Parasitoids, Predators.	12	5

Learning Resources	
Text Books	1. Rajendra Singh; Elements of Entomology Rastogi Publications 2007 2. Dhaliwal G.S.An Outline of Entomology Paperback –2017 Dhaliwal G.S.Kalyani Publishers. 3. Awasthy V.B. 1998. Introduction to General and Applied Entomology. ELBS, London
Ref. Books	1. Apple, J.L. and R.R. Smith .1976. Integrated Pest Management. Plenum Press, New York. 2. Awasthi, V.B. 2002. Introduction to General and Applied Entomology (2nd ed). Scientific Publishers (India), Jodhpur. 3. Byrd, J.H and J.L Castner (Eds).2000. Forensic Entomology: The utility of arthropods in legal investigations, CRC Press, London Dent, D.1991. Insect Pest Management. CAB International, UK Ghosh M.R. 1989. Concepts of Insect Control. Wiley Eastern Ltd. Bangalore and New Delhi Kettle, D.S.1995. Medical and Veterinary Entomology. CAB International. 4. Rolf G. Beutel, Frank Friedrich, Si-Qin Ge, Xing-Ke Yang; 2014; Insect Morphology and Phylogeny: A textbook for students of entomology 5. Mullen, G. and Durden, L. (Eds).2002. Medical and Veterinary Entomology. Academic Press 6. Lance A. Durden (editors) 2019; 7. Gary R. Mullen Medical and Veterinary Entomology 8. J. Gullan, P. S. Cranston The Insects: An Outline of Entomology 2014 Wiley-Blackwell 9. H. F. van Emden Handbook of Agricultural Entomology Wiley-Blackwell 2014 10. Cedric Gillott Entomology Springer 2005

Course Code	MZOLE2104	Course Name	PARASITOLOGY AND IMMUNOLOGY	**Course Category**	C		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre Requisite			Nil	**Co-requisite**		MZOLE09				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			O1 Disciplinary/ Professional Knowledge	**O2 Problem Analysis**	**O3 Design and Development of Solutions/ Policies**	**O4 Modern Usage tools**	**O5 Interdisciplinary Development**	**O6 Innovation and Entrepreneurship**	**O7 Ethics**	**O8 Individual or Team Work using effective communication**	**O9 Vocational and Industry Exposure**	**O10 Life-long learning**	**O11 Environment and sustainability**
CLO-1	Define the basic principles of Parasitology.	**1**	**H**									**H**	**M**
CLO-2	Explain the immunological implications and pathology of parasitic infections.	**2**		**H**			**H**						
CLO-3	Illustrate the biology, epidemiology, diagnosis and treatment of Protozoan Parasites	**3**	**H**	**H**		**H**							
CLO-4	Appraise the biology and control of helminthic diseases.	**4**	**H**	**H**		**H**							
CLO-5	Assess the impact of parasitic arthropods and vertebrates	**5**	**H**	**M**		**H**							
			H	**M**		**H**	**H**					**H**	**M**

Summary of Course Content			
S.	**Course Content**	**Hour**	**Alignment to CLO**
	UNIT I: Basic Principles and Concepts of Parasitology Animal associations and types of symbiosis; introduction to parasitism; Host-parasite interactions; Global scenario of parasitic diseases and the role of parasitology in human welfare; Infection Sites; Adaptations for Transmission; Behavioural Adaptations; Introduction to the basics of epidemiology; Parasite evolution-Evolutionary Associations between Parasites and Hosts; Parasitism and Sexual Selection; Evolution of Virulence.	12	1
	UNIT II: Immunology and Pathology of parasitic infections Susceptibility and resistance; Innate defence mechanisms; inflammation; Adaptive immune responses; Cellular and humoral immunity; Pathogenesis of parasitic infections; Immune reactions to protozoan, and helminth parasites; Virus as obligate parasites, and immunological implications of viral infections; Immunodiagnostic methods; Immunoevasion and immunomodulation; Mechanisms favouring immune Evasion in Parasites; Accommodation and tolerance in the host-parasite relationship; Parasites and pregnancy; Parasites and organ damage; Basics of Vaccine Immunology and Malaria vaccine.	12	2
	UNIT III: Protozoan Parasites Classification of protozoan parasites; Study of morphology, biology, epidemiology, pathology, mode of transmission, diagnosis and treatment of - parasitic Sarcomastigophorans, ***Trypanosoma, ***Leishmania, Giardia, ***Entamoeba, Trichomonads, Opalinida;* parasitic Apicomplexans- Malarial parasites and piroplasma: ***Plasmodium, Haemoproteus, Babesia*; parasitic Ciliates, Microsporidia and Myxozoa*: Nyctotherus, Balantidium Ichthyophthirius, Trichodina, Nosema, Myxobolus;* Immunological aspects of *Leishmania* infection.	12	3
	UNIT IV: Helminthic Parasites Classification of parasitic helminths; Study of morphology, biology, epidemiology, pathology, mode of transmission, diagnosis and treatment of - ****Fasciola, Schistosoma, Echinostoma, ***Taenia, Echinococcus; ***Ascaris, Trichuris, Trichinella, Strongyloides, Ancylostoma, Toxocara, Enterobius, ***Wuchereria, Loa loa, Dracunculus;* Immunomodulatory molecules in helminth infection and its possible application.	12	4
	UNIT V: Parasitic Arthropods and Vertebrates Classification of parasitic Arthropods; Study of morphology, biology, epidemiology, pathology, mode of transmission, diagnosis control and treatment of - *Argulus, Sacculina, ***Pediculus, Phthirus, Cimex* and other Cimicid Bedbugs, Flea; Flea as vectors of diseases; Role of dipteran flies and mosquitoes in diseases; Myiasis; Parasitic arachnids: Ticks and Mites; A brief account of parasitic vertebrates- Cookiecutter Shark, Candiru (*Vandellia cirrhosa*), Hood Mockingbird and Vampire bat; *(** Species marked with an asterisk to be studied in detail, in case of other species, general outline knowledge is only required.)*	12	5

Learning Resources	
Text Books	1. Parasitology Protozoology and Helminthology 13Ed (2019) KD Chatterjee CBS Publisher 2. Textbook of Human Parasitology Protozoology and Helminthology (PB 2020) Ramnik Sood CBS Publisher
Ref. Books	1. Foundations of Parasitology 9th International Edition (2013) Larry S Roberts McGraw-Hill Education – Europe 2. Eric S. Loker and Bruce V. Hofkin; Parasitology A Conceptual Approach(2015) Garland Science, Taylor & Francis 3. Alan Gunn Sarah J. Pitt Parasitology An Integrated Approach (2012) Wiley-Blackwell

COURSE CODE	COURSE TITLE	L	T	P	C
MZOLE05	ADVANCED FISH BIOLOGY	4	0	0	4
Co-requisite	MZOLE10				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Define various types of fish and its classification.	**1**	**H**								**M**	**H**	
CLO-2	Describe the morphology and physiology of fish.	**2**	**H**								**M**		
CLO-3	Apply the concept fish pathology and immunology.	**3**	**M**	**H**			**M**	**H**			**H**		**H**
CLO-4	Analyze the reproductive biology of fish and their culture.	**4**	**M**	**H**	**H**		**H**	**H**			**H**		**H**
CLO-5	Evaluate essential concepts of fishery and its management.	**5**	**H**	**M**		**H**		**H**			**H**		
			H	**H**		**H**	**H**	**H**			**H**		**H**

Summary of Course Content			
S.	**Course Content**	**Hour**	**Alignment to CLO**
	UNIT I: General introduction to fish biology General characteristic feature and classification of fish; biology and importance of Indian Major Carps, exotic carps, Study of economically important fish species- *Heteropneustes fossilis, Anabas testudineus*, *Neolissochilus hexagonolepis*; *Oncorhynchus mykiss*; introduction to ornamental fish culture; Small indigenous fish species- biology, importance, conservation; different types of fish adaptations.	12	1
	UNIT II: General morphology and physiology Food and feeding habits; Digestive system and physiology of digestion (one herbivorous and carnivorous); Aquatic and aerial respiration; accessory respiratory organs; circulatory system; Excretion and osmoregulation; Swim bladder and maintenance of buoyancy; electric organ; electroreceptors and electroreception; Bioluminescence in Fish.	12	2
	UNIT III: Fish pathology and immunology Development of immune system; cells and tissues of the fish immune system; modulators of fish immune responses; humoral and cell-mediated immune defence; Fish antibody molecules and their effector functions; Host-parasite interaction; common fish pathogens- viral/bacterial/protozoans fungal/arthropods; immune-evasion mechanisms of fish pathogens.	12	3
	UNIT IV: Sensory and reproductive physiology Olfactory and gustatory system and chemoreception; mechanoreception; Photoreception, Endocrine glands and neuroendocrine coordination; Reproductive strategies; Environmental factors regulating reproductive cycles; Hormonal control of oogenesis and spermatogenesis; Ovulation; vitellogenesis; spawning; and spermiation; Fertilization and development.	12	4
	UNIT V: Applied Fishery and Management Broodstock development and maintenance; Induced breeding of cultivable species; Hybridization; Composite fish culture, air-breathing fish culture; Sex manipulation, monosex culture; Hatchery management; and integrated fish farming; selective breeding; transgenic fish; Control of Fish diseases; production of sterile stock; Spoilage, processing and preservation of fish; Fish byproducts.	12	5

Learning Resources	
Text Books	1. Jhingran, V.G. Fish and Fisheries of India. Hindustan Publishing Corporation, New Delhi. 1985. 2. Khanna S. S. and H. R. Singh. A textbook of Fish Biology and Fisheries, Narendra Publishing House, 2003
Ref. Books	1. Bond, C.E., Biology of Fishes, Saunders College Publishing Philadelphia, 1979. 2. Brown, M.E., The Physiology of Fishes Vol. I, II. Academic Press, 1953 & 1957 3. Santhanam, R. Fisheries Science, Daya Publishing House, 1990. 4. Singh, B. R. Advances in Fish Research, Vol. I and II Narendra Publishing House, Delhi 1993 and 1997. 5. Srivastava, C.B.L. A Textbook of Fishery Science and Indian Fisheries, Kitab Mahal. 1985 6. The Wealth of India, Raw Materials Vol. IV, Fish and Fisheries, CSIR, 1962. 7. Bentley, P. J., Comparative Vertebrate Endocrinology, Cambridge University Press, 2000.

PRACTICAL: MAJOR ELECTIVE
(For Zoology students only, according to major elective theory)

Course Code	MZOLE06	Course Name	PRACTICAL: APPLIED ECONOMIC ZOOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOLE01	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Define various types of fish and its classification.	1	H								M	H	
CLO-2	Describe the morphology and physiology of fish.	2	H								M		
CLO-3	Apply the concept fish pathology and immunology.	3	M	H			M	H			H		H
CLO-4	Analyze the reproductive biology of fish and their culture.	4	M	H	H		H	H			H		H
CLO-5	Evaluate essential concepts of fishery and its management.	5	H	M		H		H			H		
			H	H		H	H	H			H		H

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	1. Identification of Earthworm types (Collection/specimens/photographs) a. *Megacolex mauritii* b. *Drawida modesta* c. *Pheretima posthuma* 2. Identification of Fish parasites (*Lernaea*, *Argulus*).	12	1
2.	3. Major-Identification and display of prawn appendages 4. Identification of *Poecilia reticulata* – Guppy, *Trichogaster lalius* - Dwarf gourami. 5. Identification and displaying of Catla/Rohu	12	2
3.	6. Demonstration of Different stage of Silkworm life stages 7. Demonstration of honey Bees mouth parts.	12	3
4.	8. Demonstration of different types of chicken.	12	4
5.	9. Field visit and submission of a report.	12	5

Course Code	MZOLE07	Course Name	PRACTICAL: BIODIVERSITY AND WILDLIFE CONSERVATION	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOLE02	Co-requisite						

ourse Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Demonstrate different types of census techniques.	**2**	**H**	**M**									
CLO-2	Survey the habitat of wildlife using Remote sensing and GIS technique.	**4**	**H**	**H**								**H**	
CLO-3	A design population study of wildlife using the camera trap method.	**6**	**H**	**H**						**H**		**H**	
CLO-4	Evaluate ecological indices using field data.	**5**	**H**	**M**		**H**							
CLO-5	Construct the quadrat sampling method for understanding the community of wildlife habitat.	**6**	**H**	**M**		**H**				**H**			
			H	**M**		**H**				**H**		**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	1. Census: Lines transact and point count. .	12	1
2.	2. Remote sensing and GIS in biodiversity and wildlife research.	12	2
3.	3. Camera traps	12	3
4.	4. Calculation of ecological indices.	12	4
5.	5. Quadrat study 6. Submission of a report from the field trip	12	5

Course Code	MZOLE08	Course Name	PRACTICAL: ENTOMOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOLE03	Co-requisite						

Course Learning Outcomes (CLO)	At the end of this course, learners will be able to:	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Identify specimens, bodyparts and and dissect systems	**2**	**H**	**M**									
CLO-2	Demonstrate Insects specimens of Economic importance	**2**	**H**	**H**								**H**	
CLO-3	Prepare reports on Lac culture practices in India	**4**	**H**	**H**						**H**		**H**	
CLO-4	Analyze the function of different organs	**4**	**H**	**M**		**H**							
CLO-5	Create a report on a field visit	**6**	**H**	**M**		**H**				**H**			
			H	**M**		**H**				**H**		**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	1. Demonstration and study of Insects specimens of Economic importance 2. Demonstration and study of the following insect specimens of medical importance- *Anopheles, Culex, Aedes, Pediculus* humans.	12	1
2.	3. Report on Lac culture practices in India 4. A Visit to an agricultural field to study, collect and observe insect pests and submission of a report.	12	2
3.	5. General identifications of the specimens of Insects up to families from the orders Thysanura, Collembola, and Odonata, Orthoptera, Hemiptera and Coleoptera. 6. Dissection (major) of the following insects to study the Digestive system of Cockroach or Grasshopper. 7. Demonstration of Air Sacs in Honey bee. (Only to be demonstrated.)	12	3
4.	8. Mountings from Cockroach (minor) - Mouthparts, Salivary glands, Spiracles. 9. Demonstration of different types of Antennae with reference to functional adaptations.	12	4
5.	10. Insect collection and preservation techniques through field and laboratory activities.	12	5

Course Code	MZOLE2109	Course Name	PRACTICAL: PARASITOLOGY AND IMMUNOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOLE04	Co-requisite						

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Identify Protozoan, Helminthic and arthropod parasites	**1**	**H**									**H**	
CLO-2	Compare different mosquito vectors	**2**		**H**	**M**	**M**							**H**
CLO-3	Demonstrate common ecto/endoparasites from commonly available specimens.	**3**	**H**								**H**		
CLO-4	Analyze different blood film/smear preparation and staining techniques	**4**				**H**					**H**		
CLO-5	Assess parasitic diseases and immunological parameters using modern molecular tools.	**5**		**H**	**H**		**H**				**H**		
			H	**H**	**H**	**H**	**H**				**H**	**H**	**H**

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	1. Identification with reasons/Study of adaptive features slides/preserved specimens/photographs: a) **Protozoa:** *Trypanosoma, Leishmania, Giardia, Entamoeba, Trichomonads, Opalinida, Plasmodium, Haemoproteus, Babesia, Nyctotherus, Balantidium, Ichthyophthirius, Trichodina, Nosema, Myxobolus* b) **Helminths:** *Fasciola, Schistosoma, Echinostoma,Taenia, Echinococcus, Ascaris, Trichuris, Trichinella, Strongyloides, Ancylostoma, Toxocara, Enterobius, Wuchereria, Loa loa, Dracunculus* c) **Arthropods:** *Argulus, Sacculina, Pediculus, Phthirus, Cimex,* Flea	12	1
2.	2. Identification of mosquito vectors: *Aedes, Anopheles, Culex,* adults, and larval forms 3. Study of ecto/endoparasites present in some commonly available specimens.	12	2
3.	4. Blood Film/Smear preparation and staining techniques.	12	3
4.	5. Demonstration of Qualitative ELISA/Antigen Detection Rapid Kits.	12	4
5.	6. Demonstration of PCR-based diagnostic tools.	12	5

Course Code	MZOLE10	Course Name	PRACTICAL: ADVANCED FISH BIOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOLE05	Co-requisite						

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			PLO1 Disciplinary/ Professional Knowledge	PLO2 Problem Analysis	PLO3 Design and Development of Solutions/ Policies	PLO4 Modern Usage tools	PLO5 Interdisciplinary Development	PLO6 Innovation and Entrepreneurship	PLO7 Ethics	PLO8 Individual or Team Work using effective communication	PLO9 Vocational and Industry Exposure	PLO10 Life-long learning	PLO11 Environment and sustainability
CLO-1	Identify different types of fishes with systemic positions.	**3**		**H**								**H**	
CLO-2	Identify plankton and methods of counting	**3**		**H**								**H**	
CLO-3	Identify scales, fins of different types of fish.	**3**		**M**		**H**							
CLO-4	Analyse different indexes and histological study.	**4**		**H**	**H**	**H**	**H**	**H**			**H**	**H**	**H**
CLO-5	Evaluate the different systems of fish	**4**		**H**	**H**			**H**			**H**		**M**
				H	**H**	**H**	**H**	**H**			**H**	**H**	**H**

Summary of Course Content

S. No	Course Content	Hour	Alignment to CLO
1.	Identification of selected fish specimens.		
2.	Plankton study: Volumetric estimation and counting; staining and identification of some common Zooplanktons and phytoplanktons.		
3.	Collection, fixation, staining and mounting of types of scales. Study of different types of fish fins (from local fish markets).		
4.	Report on feeding habit study: Study of buccopharynx and alimentary canal, and diet breadth analysis and diet overlap study. Study of fish gonads: Calculation of Gastro somatic index (GSI) and Fecundity. Histological studies of different organ tissues and their identification. Length-weight relationship and condition factor determination.		
5.	Dissection (Major): Digestive system, Urinogenital system of any bony fish, (Minor) Gills/Weberian ossicles of carp		

SEMESTER IV

Course Code	MZOL2141	**Course Name**	**ENDOCRINOLOGY**	**Course Category**	**C**		**L**	**T**	**P**	**C**
							4	0	0	4
Pre-Requisite			Nil	**Co-requisite**		MZOL2143				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			PLO1 Disciplinary/ Professional Knowledge	**PLO2 Problem Analysis**	**PLO3 Design and Development of Solutions/ Policies**	**PLO4 Modern Usage tools**	**PLO5 Interdisciplinary Development**	**PLO6 Innovation and Entrepreneurship**	**PLO7 Ethics**	**PLO8 Individual or Team Work using effective communication**	**PLO9 Vocational and Industry Exposure**	**PLO10 Life-long learning**	**PLO11 Environment and sustainability**
CLO-1	Define the Hormones and receptors	**1**	**H**									**H**	
CLO-2	Explain the function of the Hormones of Hypothalamus and Pituitary, Pineal gland	**3**	**H**										
CLO-3	Analyze the role of Thyroid, Parathyroid and Adrenal Hormones	**3**	**H**									**H**	
CLO-4	Interpret the role of Gastrointestinal Hormones, Pancreatic hormones and glucose homeostasis	**3**	**H**										
CLO-5	Evaluate Hormonal disorders in Reproductive Endocrinology	**4**	**H**	**M**					**M**			**M**	
			H	**M**					**M**			**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1	**Unit I: Hormones and receptors** Introduction to endocrinology; Hormones- Classification, Biosynthesis of peptide and protein hormones; Biosynthesis of steroid hormones; Hormone receptors-types, function and regulation; Hormonal signal transduction cascade-receptor mediated transmembrane signalling and steroid hormone regulation of gene transcription; Molecular mechanism of hormone action; Hormonal regulation of arthropod metamorphosis and ecdysis. .	12	1
2	**Unit II: Hormones of Hypothalamus and Pituitary, Pineal gland** Neuroendocrine regulation; Hypothalamo-hypophyseal axis, Posterior Pituitary hormones (Oxytocin, Vasopressin) and their biological functions; Hormones of anterior pituitary: Growth Hormone(GH), Prolactin, Thyroid Stimulating Hormone(TSH), Follicle Stimulating Hormone(FSH), Luteinizing Hormone(LH), Adrenocorticotropic Hormone(ACTH), Melanocyte Stimulating Hormone(MSH), Lipotropin(β-LPH); The Pineal gland, biosynthesis and function of melatonin.	12	2
3	**Unit III: Thyroid, Parathyroid and Adrenal Hormones** Thyroid-Biosynthesis and regulation of thyroid hormones; Metabolic effects of thyroid hormones; Histology and Hormones of Adrenal cortex and medulla; Corticosteroids: Types and function (Aldosterone, Cortisol, DHEA), Function of Catecholamines (Epinephrine and norepinephrine); Adrenal endocrine disorders; Calcium –regulation by Vit-D, Parathyroid Hormone and Calcitonin;	12	3
4	**Unit IV Gastrointestinal Hormones, Pancreatic hormones and glucose homeostasis** GI tract hormones and function including acid release, gall bladder contraction and relaxation, pancreatic enzyme secretion, and GI tract motility; Histology of pancreas, Biosynthesis and function of Insulin and Glucagon; Role in glucose homeostasis.	12	4
5	**Unit V: Reproductive Endocrinology and Hormonal disorders** Role of hormone in reproductive development; Hormonal regulation of gametogenesis, ovulation and reproductive cycles; Hormonal contraception and hormone replacement therapy; Hormones in pregnancy and lactation; Outline of common Hormonal disorders; Stress and hormones; Role of hormones in Cancer.	12	5

Learning Resources	
Text Books	1. Hadley; Endocrinology, 6e 2009; Pearson 2. B.N. Pandey; Endocrinology 2019; Atlantic Publishers & Distributors Pvt Ltd
Ref. Books	1. Shlomo Melmed, Kenneth S. Polonsky, P. Reed Larsen, Henry M. Kronenberg; Williams Textbook Of Endocrinology 2016 Elsevier 2. J. Larry Jameson, Harrison's Endocrinology, 2016 McGraw-Hill, 3. David G. Gardner, Dolores M. Shoback; Greenspan's Basic and Clinical Endocrinology;2017 4. McGraw-Hill Education 5. David O. Norris and James A. Carr; Vertebrate Endocrinology 2013 Academic Press 6. Patricia Molina; Endocrine Physiology, Fifth Edition (2018) McGraw-Hill Education Lange 7. Fox T, Brooks A, Baidya B. 2015. Endocrinology. JP Medical, London. 8. Norris DO. 2007. Vertebrate Endocrinology. 4th Edn. Elsevier Academic Press 9. Neal JM. 2000. Basic Endocrinology; an Interactive Approach. Blackwell Science. 10. Strauss JF, Barbieri RL. 2014. Yen & Jaffe's Reproductive Endocrinology. Elsevier Sounders 5.

Course Learning Outcomes:

Course Code	MZOL2142	Course Name	BIOPHYSICS; TOOLS AND TECHNIQUES IN BIOLOGY	**Course Category**	CP		**L**	**T**	**P**	**C**
							4	**0**	**0**	**4**
Pre Requisite			MZOL2144	**Co-requisite**		MZOL2143				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	**Bloom's Learning (BL) Level**	**Program Learning Outcomes (PLO)**										
			O1 Disciplinary/ Professional Knowledge	**O2 Problem Analysis**	**O3 Design and Development of Solutions/ Policies**	**O4 Modern Usage tools**	**O5 Interdisciplinary Development**	**O6 Innovation and Entrepreneurship**	**O7 Ethics**	**O8 Individual or Team Work using effective communication**	**O9 Vocational and Industry Exposure**	**O10 Life-long learning**	**O11 Environment and sustainability**
CLO-1	Describe the structure and function of different biomolecules	**2**	**H**									**H**	
CLO-2	Explain biophysical techniques and its applications	**2**	**H**			**H**							
CLO-3	Demonstrate basic laboratory principles, microscopy and histological techniques	**3**	**H**	**H**		**H**							
CLO-4	Analyze the working of different instruments in biological research.	**4**	**H**			**H**							
CLO-5	Apply cell culture and microbial techniques.	**5**	**H**	**H**		**H**			**H**				
			H	**H**		**H**			**H**			**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	**Unit I Understanding biomolecules: Structure and function** Biomolecules, Bonds, Theoretical foundations of molecular structure, folding and interactions; Biomolecular Structure and conformations, Molecular forces affecting Bimolecular Conformations; Bioenergetics and thermodynamics- Laws of thermodynamics, Entropy, Enthalpy, Gibbs free energy; Photobiology- Effect of light on living systems; source of energy, phototropism, phototaxis, photomorphogenesis; Radiation Biology and application of radioisotopes. .	12	1
2.	**Unit II Biophysical techniques and applications** Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy Molecular structure determination using X-ray diffraction; Molecular analysis using light scattering, different types of mass spectrometry, and surface plasma resonance methods.	12	2
3.	**UNIT III: Basic laboratory principles, Microscopy and Histological techniques** Lab safety and guidelines; Waste management and disposal; Microscopy-Principle and applications; Types (Light, Electron and AFM); Microtome-Types and applications; Collection & preservation of animal tissue – fixation, Embedding, Sectioning, Staining, dehydration, mounting and Identification; Tissue preparation for light and electron microscopy; Cryoultramicrotomy.	12	3
4.	**UNIT IV: Instrumentation in Biology** Working principle and applications-pH meter; Spectrophotometer; Centrifugation- Principle types and applications; Electrophoresis-principle, structural components, types and applications; Separation techniques- Chromatography Principle, types and applications Paper and thin-layer chromatography (TLC), Gas-Liquid Chromatography (GLC), Colum chromatography, Ion exchange chromatography, Gel-exclusion chromatography, High-Performance Liquid Chromatography (HPLC).	12	4
5.	**UNIT V: Cell Culture and Microbial techniques in Biology** Methods of sterilization and sterile techniques; History of cell culture; Types of cell culture and culture conditions, instruments used in microbiology and cell culture, Types of cell culture media; commonly used cell lines and their applications; Maintenance and preservation of cell lines Preparation and types of bacterial culture Media; Basic microbial lab techniques; Fermentation techniques and application in industry.	12	5

Learning Resources	
Text Books	1. Pranab Kumar; Introduction To Biophysics Paperback (2010) S Chand & Company 2. P. Narayanan; Essentials Of Biophysics Paperback (2007) ; New age publishers 3. Dubey. R. C., (2018). A Textbook of Biotechnology. S. Chand & Co. Ltd., New Delhi. 4. Lohar, P.S. (2014). Textbook of Biotechnology, MJP Publishers, Chennai, Tamil Nadu. 5. Glick, B.R. and C.L Patten. (2018). Molecular Biotechnology: Principles and Applications of Recombinant DNA, ASM Press, USA.
Ref. Books	1. Rodney Cotterill; Biophysics - An Introduction Paperback (2014) ; Wiley 2. William Bialek; Biophysics: Searching for Principles Hardcover (2012) Princeton University Press 3. Bisen & Mathew. Tools and Techniques in Life Sciences,- CBS Publishers & distributors. 4. Wilson & Walker Principles and Techniques in biochemistry and molecular biology -. 5. P.K.Bajpal: Biological instrumentation and methodology: (Tools and Techniques of Biology) 6. Robert Braun; Introduction to Instrumental analysis; McGraw Hill International Editions.

Course Code	MZOL2143	Course Name	PRACTICAL: ENDOCRINOLOGY, BIOPHYSICS, TOOLS AND TECHNIQUES IN BIOLOGY	Course Category	CP		L	T	P	C
							0	0	4	2
Pre Requisite			MZOL2141, MZOL2142	Co-requisite		MZOL2144				

Course Learning Outcomes (CLO)	*At the end of this course, learners will be able to:*	Bloom's Learning (BL) Level	Program Learning Outcomes (PLO)										
			O1 Disciplinary/ Professional Knowledge	O2 Problem Analysis	O3 Design and Development of Solutions/ Policies	O4 Modern Usage tools	O5 Interdisciplinary Development	O6 Innovation and Entrepreneurship	O7 Ethics	O8 Individual or Team Work using effective communication	O9 Vocational and Industry Exposure	O10 Life-long learning	O11 Environment and sustainability
CLO-1	Identify the anatomical/ histological study of glands and systems	**2**	**H**									**H**	
CLO-2	Explain Effect of insulin administration on blood sugar level in mice.	**2**	**H**			**H**							
CLO-3	Demonstrate basic lab practices	**3**	**H**	**H**		**H**			**H**	**H**			
CLO-4	Analyze the basic working of microscopy, spectroscopy, chromatography and agarose gel electrophoresis	**4**	**H**			**H**				**H**			
CLO-5	Apply sterile techniques in cell culture, histology and microbial techniques and demonstrate photobiology.	**5**	**H**	**H**		**H**			**H**	**H**			
			H	**H**		**H**			**H**	**H**		**H**	

Summary of Course Content			
S. No	**Course Content**	**Hour**	**Alignment to CLO**
1.	1. Anatomical study of glands and systems in endocrinology in suitable vertebrate species: Pituitary, Thyroid, Adrenal, Pancreas and Gonads. 2. Histological study and identification of endocrine organs from slides.	12	1
2.	3. Effect of insulin administration on blood sugar level in mice.	12	2
3.	1. Observation and identification of laboratory instruments and safety equipment. 2. Exposure to Biophysical techniques and applications through Demonstration/Lab visit/Audio-visual media. 3. Light microscope and its parts, Observation of unstained and stained cells.	12	3
4.	4. Preparation of buffer of the desired pH, using a pH meter 5. Determination of solution concentration using a spectrophotometer. 6. Thin Layer Chromatography 7. Agarose Gel Electrophoresis –Demonstration. 8. Experiment on the effect of light in biological systems.	12	4
5.	9. Methods of sterilization, and sterile techniques. 10. Gram staining of bacteria 11. Demonstration of microtome, fixation, sectioning, dehydration, staining of any animal tissue.	12	5

COURSE CODE	COURSE TITLE	Credits
MZOL2144	**LAB-INTERNSHIPS/PROJECTS/REVIEW OF PUBLISHED LITERATURE (INTERNAL ASSESSMENT, DISSERTATION AND SEMINAR) For a period of minimum 3 months**	**10**

In the final semester a student does 3 months, 10 credits, Lab-Internships/Projects/Review of Published Literature, MZOL2144 (Internal Assessment, Dissertation and Seminar) and MZOL41, MZOL42, MZOL2143 for a total of 20 credits.

COURSE CODE	COURSE TITLE	Credits
MZOL2145	**LAB-INTERNSHIPS/PROJECTS/REVIEW OF PUBLISHED LITERATURE (INTERNAL ASSESSMENT, DISSERTATION AND SEMINAR) For a period of minimum 5 months**	**20**

If the student gets a full-semester project for a period of minimum 5 months, MZOL41, MZOL42, MZOL2143 are not required, and MZOL2145 will be counted as a 20 credits subject.