DEPARTMENT OF ZOOLOGY
NAGALAND UNIVERSITY
HEADQUARTERS LUMAMI

M. SC. CBCS COURSE STRUCTURE

WITH

CREDIT SYSTEM

Latest Revision: 2024 (38th Academic Council dated 07th June, 2024)

Department of Zoology
Nagaland University
Headquarters: Lumami 798627
M.Sc. CBCS Course structure with Credit System in ZOOLOGY

Semester I

Course code	Course Name	Course type	Credit	Marks
ZOO-101	Biochemistry	Compulsory	03	75
ZOO:P-102	Biochemistry	Compulsory	02	50
ZOO-103	Cell Biology	Compulsory	03	75
ZOO:P-104	Cell Biology	Compulsory	02	50
ZOO-105	Biostatistics and Bioinformatics	Compulsory	03	75
ZOO:P-106	Biostatistics and Bioinformatics	Compulsory	02	50
ZOO-107*	Entomology	Elective	03	75
ZOO:P-108	Entomology	Elective	02	50
ZOO-109*	Aquatic Biology and Fishery	Elective	03	75
ZOO:P-110	Aquatic Biology and Fishery	Elective	02	50
ZOO-111*	Indian Traditional Knowledge	Elective	03	75
ZOO:P-112	Indian Traditional Knowledge	Elective	02	50

***** *Students may choose one course from elective section, either ZOO-107 + ZOO:P-108* ***OR*** *ZOO-109 + ZOO:P-110* ***OR*** *ZOO-111 + ZOO:P-112*

SYLLABUS FOR M.SC. ZOOLOGY

Semester II

Course code	Course Name	Course type	Credit	Marks
ZOO-201	Genetics and Cytogenetics	Compulsory	03	75
ZOO:P-202	Genetics and Cytogenetics	Compulsory	02	50
ZOO-203	Immunology	Compulsory	03	75
ZOO:P-204	Immunology	Compulsory	02	50
ZOO-205	Physiology	Compulsory	03	75
ZOO:P-206	Physiology	Compulsory	02	50
ZOO-207*	Medical Microbiology	Elective	03	75
ZOO:P-208	Medical Microbiology	Elective	02	50
ZOO-209*	Parasitology	Elective	03	75
ZOO:P-210	Parasitology	Elective	02	50

Students may choose one course from elective section, either ZOO-207 + ZOO:P-208* ***OR* *ZOO-209 + ZOO:P-210*

SYLLABUS FOR M.SC. ZOOLOGY

Semester III

Course code	Course Name	Course type	Credit	Marks
ZOO-301	Molecular Biology	Compulsory	03	75
ZOO:P-302	Molecular Biology	Compulsory	02	50
ZOO-303	Developmental Biology	Compulsory	03	75
ZOO:P-304	Developmental Biology	Compulsory	02	50
ZOO-305	Biosystematics and evolution	Compulsory	03	75
ZOO:P-306	Biosystematics and evolution	Compulsory	02	50
ZOO-307*	Fishery – I	Specialization	03	75
ZOO:P-308	Fishery – I	Specialization	02	50
ZOO-309*	Entomology – I	Specialization	03	75
ZOO:P-310	Entomology – I	Specialization	02	50
ZOO-311*	Cell & Molecular Biology – I	Specialization	03	75
ZOO:P-312	Cell & Molecular Biology – I	Specialization	02	50
ZOO-313*	Genetics – I	Specialization	03	75
ZOO:P-314	Genetics – I	Specialization	02	50

Students may choose one course from specialization section, either ZOO-307 + ZOO:P-308/ ZOO-309+ ZOO:P-310/ ZOO-311+ ZOO:P-312* ***OR* *ZOO-313 + ZOO:P-314*

SYLLABUS FOR M.SC. ZOOLOGY

Semester IV

Course code	Course Name	Course type	Credit	Marks
ZOO-401	Tools and Techniques	Compulsory	03	75
ZOO:P-402	Project Work	Compulsory	04	100
ZOO-403	Animal Behaviour	Compulsory	03	75
ZOO-404	Ecology	Compulsory	03	75
ZOO:P-405	Ecology & Animal Behaviour	Compulsory	02	50
ZOO-406*	Fishery – II	Specialization	03	75
ZOO:P-407	Fishery – II	Specialization	02	50
ZOO-408*	Entomology – II	Specialization	03	75
ZOO:P-409	Entomology – II	Specialization	02	50
ZOO-410*	Cell & Molecular Biology – II	Specialization	03	75
ZOO:P-411	Cell & Molecular Biology – II	Specialization	02	50
ZOO-412*	Genetics – II	Specialization	03	75
ZOO:P-413	Genetics – II	Specialization	02	50

Students may choose one course from specialization section, either ZOO-406 + ZOO:P-407/ ZOO-408+ ZOO:P-409/ ZOO-410+ ZOO:P-411* ***OR* *ZOO-412 + ZOO:P-413*

SYLLABUS FOR M.SC. ZOOLOGY

Programme Outcomes

1. The program has been designed to provide in-depth knowledge of applied subjects, ensuring employment skills in diverse fields. This will provide them with ample opportunities to explore different careers.
2. On completion of the program, the students will be well-versed in classical zoology and its applied aspects.
3. Besides knowledge of animals and their behaviors, the students will be abreast of the latest concepts in cell biology, immunology, molecular biology, genetics, biochemistry, developmental biology, and physiology.
4. Moreover, skills acquired in theoretical and practical aspects, as well as field studies and excursions, will imprint the concepts of teamwork for life outside of academia.

Programme Specific Outcomes

1. The program will enhance students' chances to progress to higher education, such as M.Sc., B.Ed., and Ph.D. The other dimension is that the program is versatile enough to ensure students succeed in competitive examinations.
2. They will have acquired complete knowledge of disciplinary and allied biological sciences, like practical skills in analytical biochemistry, biotechnology, biostatistics, bioinformatics, genetics, molecular biology, microscopy, enzymology, etc. As a result, they will have the expertise that will give them a competitive advantage in pursuing higher education in India or abroad and qualify them for jobs in academia, research, industry, and administration.
3. Some job avenues that would be particularly well suited for would-be scientists in the drug development industry, clinical and research laboratories, animal behaviorists, conservationists, wildlife biologists, zoo curators, wildlife educators, forensic experts, lab technicians, veterinarians, etc. This is apart from avenues like the Indian Forest Service and other allied services like Government Environmental Agencies.

4. Skill enhancement courses like aquaculture, sericulture, and apiculture will help them start their ventures and generate self-employment, making them successful entrepreneurs.

Semester	Course No	Course Name	Course outcome
I	ZOO-101	Biochemistry	• Students will understand the basic and fundamental biochemistry of carbohydrates, proteins, lipids, and nucleic acids. • Students will also learn about oxidative phosphorylation and redox reactions. • Students will understand the nature, mechanism, and kinetics of enzyme action, structure and properties of biomolecules, and metabolic and biochemical processes. • Students can correlate the changes in the level of the molecules with diseases in humans.
	ZOO-103	Cell Biology	• Students will understand the structures and functions of cell and cellular organelles and the nuclear organization of prokaryotic and eukaryotic organisms. • To impart Knowledge on the dynamism of biomembranes indicates the dynamism of life. Its working mechanism and precision are responsible for our performance in life. • Draw parallels between the physiological processes at the cellular and organismic levels.
	ZOO-105	Biostatistics and Bioinformatics	• Students will understand the various aspects of biostatistics, such as central tendency, t-test, chi-square, ANOVA, correlations, and regression.
	ZOO-107	Entomology	• Students will be able to explain the social organization of insects with examples and illustrate the role of household insects in relation to human health. • Students will learn details about the taxonomy and biology of insect pests, their interactions with crops, and their management policies in detail.
	ZOO-109	Aquatic Biology and Fishery	• Students will learn about the taxonomy and biology of fish and various aquaculture techniques.
	ZOO-111	Indian Traditional Knowledge	• Students will learn about our rich traditional practices and be enthused to conserve these.
II	ZOO-201	Genetics and Cytogenetics	• To impart knowledge of how organisms evolved, focusing on genetic variation and inheritance. • Have a deeper understanding of the branches of the biological sciences like microbiology, evolutionary biology, genomics, and metagenomics. • Gain knowledge of the basic principles of inheritance. • Analyse pedigree, leading to the development of analytical skills and critical thinking, enabling the

			students to present the conclusion of their findings in a scientific manner.
	ZOO-203	Immunology	• To develop knowledge about the structures and function of immune cells, immunoglobulins, antigens, and their interactions with antibodies. • Students will learn about MHC molecules, cytokines, hypersensitivity reactions, and the cellular mode of immunity development.
	ZOO-205	Physiology	• Students will be conceptualized about different physiological processes (digestive, respiratory, circulatory, reproductive excretory, nervous, musculature). • Learn about coordination amongst the different systems, neural control mechanisms, adaptations, etc.
	ZOO-207	Medical Microbiology	• Understand the methods of cultivation of microorganisms. • To understand and perform various biochemical tests to identify unknown microorganisms and practical exposure to fungus cultivation and staining. • To understand the use of differential, selective, and special media
	ZOO-209	Parasitology	• Students will be able to define the basic terms in parasitology, enlist common ectoparasites and endoparasites, and explain animal associations and their types. • Students can correlate the lifecycle and importance of major parasites. • Students will be able to illustrate transmission routes of animal and zoonotic parasites
III	ZOO-301	Molecular Biology	• Students will be able to understand the principles of molecular genetics. • Students will learn the replication, transcription, and protein synthesis mechanisms. • Students will understand the gene regulation in prokaryotes and eukaryotes.
	ZOO-303	Developmental Biology	• Students will also understand that development occurs through various levels, which underlies cell differentiation, and any alteration in the development process leads to devastating diseases. • Students learn best by doing and having the opportunity to put what they have learned into practice. Therefore, using various model organisms as a learning tool in developmental biology will help students learn how a cell behaves in response to an autonomous determinant or an external signal, i.e., on its developmental history.
	ZOO-305	Biosystematics and evolution	• Students will be learning how living forms diversified, how life originated on Earth, and the factors that led to evolution. • Students will be able to understand general taxonomic

			rules on animal classification and will apply them for species description. Students will know about population genetics, human evolution, various concepts about the origin of species, extinctions, and phylogenetic tree making.
	ZOO-307	Fishery - I	• Students can set up fish farms, including selecting suitable sites, designing aquaculture ponds, and operating hatcheries effectively. • Students will understand various fish culture methods, such as extensive, semi-intensive, and intensive culture, and learn about different forms of fish feeds. • Pond Management: Students will gain proficiency in pond management, including maintaining optimal physico-chemical properties of water and soil, fertilization techniques, and controlling predators, weeds, and aquatic vegetation. • Students will comprehend fish reproduction processes, including the anatomy of reproductive organs, maturation, spawning, fertilization, hatching, and larval development. • Students will learn to identify common fish diseases, understand their symptoms, and apply appropriate treatments and preventive measures to ensure fish health and well-being in aquaculture systems.
	ZOO-309	Entomology - I	• Students will attain a solid foundation in insect biology. • Students will be able to differentiate insects based on their morphological structures.
	ZOO-311	Cell & Molecular Biology - I	• Upon course completion, students can describe the basic structure and chemistry of nucleic acids, DNA, and RNA. • To compare and contrast DNA replication machinery and mechanisms in prokaryotes and eukaryotes. • To elucidate the molecular machinery and mechanism of information transfer processes– transcription and translation-in prokaryotes and eukaryotes
	ZOO-313	Genetics - I	• Students will attain a solid foundation on the fundamentals of genetics. • Students will understand the gene regulation in prokaryotes and eukaryotes. • Students will acquire knowledge of the core concepts of epigenetics.
IV	ZOO-401	Tools and Techniques	• To acquaint the students with various instruments and methodological techniques to enable them to pursue scientific research in the future. • To demonstrate proper and safe laboratory practice, proper use of equipment, and the ability to use basic techniques in several areas and advanced techniques.
	ZOO:P-402	Project Work	• Students will be trained and equipped with knowledge of different aspects of zoological sciences.

	ZOO-403	Animal Behaviour	• Students will be able to exhibit critical and integrative thinking skills. • Demonstrate ability to communicate scientific information in both oral and written formats. • Demonstrate knowledge of key concepts in animal behaviour. • Exhibit quantitative research skills (or demonstrate ability to perform all parts of the scientific method). • Demonstrate ability to think flexibly and apply knowledge to new problems.
	ZOO-404	Ecology	• Students will attain a solid foundation on principles of ecology. • Students will learn the biogeographic zones of the world. • Students will understand the role of abiotic factors in different ecosystems. • Students will develop an understanding of how species interaction is important in the development of communities. • Students will understand humans' impact on the entire ecosystem and the environment.
	ZOO-406	Fishery - II	• To produce students trained in fisheries who can work in government departments related to fisheries and aquaculture, research institutions, academia, etc. • To produce more fish and to increase the income of farmers and the Nation. • To provide the nation with a good nutrition and food security source. • To contribute to the growth of our nation's GDP.
	ZOO-408	Entomology - II	• Students will attain a solid foundation in insect physiology and morphology. • Students will understand the physiology of excretion processes in insects. • Students will understand the neuroendocrine system and the hormonal control on growth and differentiation.
	ZOO-410	Cell & Molecular Biology - II	• Students will have a deeper understanding of the branches of the biological sciences like microbiology, evolutionary biology, genomics, and metagenomics. • After successfully completing the course, the student should be able to design and comprehend experimental strategies for whole genome, transcriptome, and proteome analysis.
	ZOO-412	Genetics - II	• Students will acquire knowledge of genetic and molecular mechanisms that operate in development and reproduction. • Students will understand the genetic constitution of a population. • Students will learn the role of genetic variation in evolution.

SYLLABUS FOR M.SC. ZOOLOGY

COURSE NAME: BIOCHEMISTRY

Course Code: ZOO-101 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Structure of atoms, types of chemical bonds, acids, bases, pH, buffer, and their mechanisms of action. Carbohydrates – Monosaccharides, disaccharides, and polysaccharides. Proteins-Classification and structure, Amino acids classification, and general characters. Lipids-classification and functions of lipids and fatty acids.

Unit II: **11 hours**

Glycolysis and its regulation, oxidative decarboxylation.
Krebs cycle (TCA cycle) and its regulation.
Mitochondrial electron transport chain and mechanism of ATP synthesis.
Glycogenesis, Glycogenolysis, Gluconeogenesis, hexomonophosphate shunt.

Unit III: **12 hours**

Transamination and deamination, incorporation of amino acids into TCA cycle, integration between urea cycle.
Fatty acid oxidation and biosynthesis, ketone bodies.
First and second laws of thermodynamics.
Free energy, energy rich compound, Enthalpy and Entropy.

Unit IV: **12 hours**

Nomenclature and classification of enzymes, vitamins as co-enzymes.
Enzyme kinetics: Michales –Menten equation. Determination of Vmax and Km, Factors affecting the enzyme activity.
Enzyme inhibition: Competitive & non-competitive.
Mechanism of enzyme action: active sites, Chymotrypsin as a model, Regulation of enzyme activity, allosteric enzymes, PFK (Phosphofructokinase).

COURSE NAME: BIOCHEMISTRY

Course Code: ZOO:P-102 **Credit: 02**

Practical **60 hours**

1. Estimation of glucose using anthrone reagent.
2. Estimation of amino acid using ninhydrin reagent.
3. Estimation of protein using Biruret reagent.
4. Estimation of protein Folin's reagent.
5. Separation and identification of amino acids by paper chromatography.
6. Separation and identification of sugars by paper chromatography.
7. Qualitative test for amylase activity.
8. Quantitative estimation of amylase activity.
9. To study the effect of substrate concentrations on enzyme activity.
10. Estimation of muscle and liver glycogen.

Suggested books:

1. Lehningers Principles of Biochemistry, Nelson and Cox, Sixth Edition or recent edition, Macmillan Press.
2. Principles of Biochemistry, Voet, Voet and Pratt, 5th edition (2012) or recent edition, Wiley.
3. Harper's Illustrated Biochemistry, Murray, Granner and Rodwell, (27th Ed.), McGraw Hill, New York, USA.
4. Practical Biochemistry – Principles and Technique.

COURSE NAME: CELL BIOLOGY

Course Code: ZOO-103 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Structural organization and function of intracellular organelles: nucleus, mitochondria, endoplasmic reticulum, Golgi complex, lysosomes, and peroxisomes. Cell cycle: Features and phases – role of cyclin and Cdk in cell division.

Unit II: **9 hours**

Different models of membrane. Chemical composition of cell membrane. Structure and functions of membrane proteins: Integral protein, peripheral membrane proteins and lipid-anchored membrane proteins. An overview of membrane functions.

Unit III: **12 hours**

Structure and organization of microtubules, intermediate filaments and microfilaments and their role in cell motility. Types of spindle fibres. Polymerisation and depolymerisation of microtubules and its role in maintaining cellular architecture. Cellular changes associated with cancer.

Unit IV: **14 hours**

Different mechanism of cell signalling pathways, Movement of substances across cell membranes: Diffusion, active transport, uniport, symport and antiport. Replication, Transcription, translation, DNA damage, and repair.

COURSE NAME: CELL BIOLOGY

Course Code: ZOO:P-104 **Credit: 02**

Practical **60 hours**

1. Preparation of different fixative and stains.
2. Study of permanent histological slides of testis and ovaries of insects/ mice/rat.
3. Study of permanent histological slides of Liver and kidney of insects/ mice/rat.
4. Double staining techniques for histological study.

5. Study of Mitosis in Onion root tips.
6. Study of meiosis in grasshopper testes.
7. Study of sex chromatin in human buccal cavity cells.
8. Study of cancer cells- morphology, nuclei and chromosomes.
9. Isolation and Staining of Mitochondria from Goat/ Rat liver.
10. Study of different cells in blood smears from Mouse.

Suggested books:

1. Pollard T.D, Earnshaw W.C, (2002); Cell Biology; Saunders, an imprint of Elsevier Science, New York.
2. Gupta/Jangir (2002); Cell biology, Fundamentals and Applications, Published by Agrobios (India) Jodhpur.
3. Chhazillani V.K (2008); Cell Biology; mangala Publications, Delhi.
4. Alberts B., Bray D., Hopkin K., Johnson A., Lewis J., Raff M., Walter P., (2002); Essential Cell Biology; Garland science group, New York and London.
5. Power C.V. (2004); Cell Biology, Mangala Publication, Delhi.

COURSE NAME: BIOSTATISTICS & BIOINFORMATICS

Course Code: ZOO-105 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Definition and relevance of Biostatistics in biological research. Descriptive Statistics: Meaning, Objectives, Organization of data, Population, sample, variable, parameter, primary and secondary data, screening and representation of data, frequency distribution, tabulation, bar diagram, histograms, pie diagram, Measures of Central Tendency: Arithmetic Mean, median, mode, Measures of Dispersion: Range, variance, standard deviation, coefficient of variation; Skewness and Kurtosis.

Unit II: **12 hours**

Inferential Statistics: Hypothesis testing, Errors in Hypothesis Testing- Null Hypothesis, Alternative Hypothesis, Type I and Type II errors, Confidence Limits. Setting up of level of significance. One tailed and Two- tailed tests. Definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability.

Unit III: **10 hours**

Correlation and Regression: Correlation coefficient (r), properties, interpretation of r, partial and multiple correlations, linear regression: Fitting of lines of regression, regression coefficient, Bivariate and Multiple Regression. Parametric and Non-Parametric Statistics: Definition, Advantages, Disadvantages, Assumptions Parametric Tests: Student's t-test, One Way Analysis of Variance, Two Way Analysis of Variance Non-Parametric Tests: Chi square test.

Unit IV: **13 hours**

Definition and scope of Computational Biology and Bioinformatics, National Centre for Biotechnology Information (NCBI), Basic Local Alignment Search Tool (BLAST), Flavors of

BLAST (BlastP, BlastN, BlastX, BlastN), Different file formats, Bioinformatics in India- current status and future implications.

COURSE NAME: BIOSTATISTICS & BIOINFORMATICS

Course Code: ZOO:P-106 **Credit: 02**

Practical **60 hours**

1. Central tendencies.
2. Chi square test.
3. T-test analysis.
4. P value analysis.
5. Analysis of variance test.
6. Basic bioinformatics tools.
7. BLAST.
8. FASTA.

Suggested books:

1. Jensen, J.R. (2000). Remote sensing of the environment: An earth resource perspective. Prentice Hall, Upper Saddle River, NJ.
2. Joseph, George. (2003). Fundamentals of Remote Sensing. University Press (India) Pvt. Ltd, Orient Longman Pte. Ltd., Hyderabad, India.
3. Mount, D. (Second Edition). Bioinformatics: Sequence and Genome Analysis. Cold
4. Zar, J. H. (2008). Biostatistical analysis. 5th edition. Pearson Education Inc. and Dorling Kindersley Publishing Inc.

COURSE NAME: ENTOMOLOGY

Course Code: ZOO-107 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Origin and evolution of insects; phylogeny; pterygotes and apterygotes; theories on the evolution of wings; insect classification upto orders; insect life history patterns; metamorphosis types; voltinity.

Unit II: **12 hours**

Insect-plant interactions - phytophagy, entomophagy, entomophilly, symbiosis, dissemination of pathogens; insect pests of crops – cabbage (*Plutella xylostella* cabbage moth), rice (*Scirpophaga incertulas* yellow stem borer/rice yellow stem borer).

Unit III: **10 hours**

Insects as vectors of diseases – malaria, kala azar, typhus, dengue; IPM – history, principles and tenets, pesticide resistance and secondary pest outbreaks; tools/approaches.

Unit IV: **13 hours**

Social, beneficial and harmful insects with representative examples – ants, honey bees, lac insect, termites; nest architecture; introduction to aquatic insects; apiculture and sericulture techniques.

COURSE NAME: ENTOMOLOGY

Course Code: ZOO:P-108 **Credit: 02**

Practical **60 hours**

1. Morphological study of some representative insect orders.
2. Study of larva and pupa of some representative insect orders.
3. Morphology of various castes of some social insects.
4. Study of the nest architecture of some social insects.
5. Food preference of *Tribolium* species.
6. Study of permanent slides of some ectoparasites.
7. To determine the LC_{50} of any contact insecticide.
8. Collection, preservation and display of insect specimens.

Suggested books:

1. Blum M.S. (1985). Fundamental of Insect Physiology, John Wiley and Sons.
2. Gullan P.J. and Cranston P.S. (2010). The Insects: An Outline of Entomology. Wiley-Blackwell.
3. Kerkut G.A. and Gilbert L.I. (1985). Comprehensive Insect Physiology, Biochemistry and Pharmacology, Vols. 1-12. Edn. Pergamon Press, Oxford.
4. Ramakrisnan, T.V. (1984). Handbook of Economic Entomology of South India, International Books and Periodicals Service, India.

COURSE NAME: AQUATIC BIOLOGY AND FISHERY

Course Code: ZOO-109 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Water as a substance, molecular structure and properties of water, distribution of fresh water, hydrological cycle, global water balance.
Characteristics of hill stream, modification and adaptation of hill stream fishes.
Lake basins- different kinds of lake basins and their origin.
Planktons: classification and role in fisheries.

Unit II: **11 hours**

Ecology of reservoir and estuaries.
Characteristics feature of marine environment.
Measures of productivity: Estimation of primary and secondary production in aquatic eco-system.
Water pollution: Various types of pollutants and their effects on fisheries.

Unit III: **12 hours**

Basic concepts of aquaculture and fisheries; Inland aquatic resources of India.
Physico-chemical and biological characteristics of water for fish production.
Principal: cultivable cold water and warm water fishes.
Food and feeding habits of fishes.

Unit IV: **12 hours**

Fish culture versus capture fishery, cultivable fish, classification of fish culture practices.
Sewage- fed fisheries- characteristics of sewage, its treatment for fish culture and principle cultivated fishes.
Brackish water fish culture, fish culture in swamps and marshes.
Paddy cum fish culture, cage culture.

COURSE NAME: AQUATIC BIOLOGY AND FISHERY

Course Code: ZOO:P-110 **Credit: 02**

Practical **60 hours**

1. Estimation of light penetration and transparency in a water body (Sacchi disc method).
2. Collection and preservation of water sample.
3. Estimation of dissolved oxygen content in a water body.
4. Estimation of carbon dioxide in a water sample.
5. Estimation of total solids, total dissolved solids and suspended solids of water sample.
6. Estimation of total alkalinity and total Hardness of water.
7. Estimation of calcium and magnesium hardness in water samples.
8. Estimation of chloride in natural and domestic waste waters.
9. Estimation of sulphate content in water samples.
10. Estimation of nitrate content in water samples.
11. Estimation of phosphate content in water samples.
12. Qualitative and quantitative analysis of streams: phyto- and zooplankton communities.
13. Analysis of gut contents and food and feeding habits of common fish species.

Suggested books:

1. Gupta and Gupta: General and Applied Ichthyology (Fish and Fisheries) (2006, S. Chand).
2. Khanna and Singh: A Textbook of Fish Biology and Fisheries (2003, Narendra Publishing House).
3. Lagler, Bardach, Miller and May Passino: Ichthyology (2003, Wiley).
4. Pillay: Aquaculture: Principles and Practices (2005, First Indian reprint).

COURSE NAME: INDIAN TRADITIONAL KNOWLEDGE

Course Code: ZOO-111 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, Indigenous Knowledge (IK), and characteristics. Protection of traditional knowledge. Traditional Knowledge in Different Sectors (Overview)**.**

Unit II: **15 hours**

Specialization into eight branches, The tradition of surgery, medical genetics in Ayurveda, inoculation for smallpox, microbiology and parasitology, communicable diseases and epidemics.

Unit III: **12 hours**

Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Patents, and traditional knowledge, Strategies to increase protection of traditional knowledge.

Unit IV: **8 hours**

A Survey Harappan Technologies/ Later pottery/ Glass/Water Management/ Textile Technology.

COURSE NAME: INDIAN TRADITIONAL KNOWLEDGE

Course Code: ZOO:P-112 **Credit: 02**

Practical **60 hours**

1. Survey on traditional fishing techniques used in Nagaland.
2. Survey on traditional apiculture methods.
3. Survey on traditional use of medicinal plants for treatment by local tribes.
4. Visit to National park/sanctuary for understanding animal diversity and their habitat.

Suggested books:

1. Traditional Knowledge System in India, by Amit Jha, 2009.
2. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002.
3. "Knowledge Traditions and Practices of India" Kapil Kapoor and Michel Danino.
4. Traditional Knowledge System and Technology in India (English, Hardcover, Basanta Kumar Mohanta, Vipin Kumar Singh) Edition: 2012 Language English

COURSE NAME: GENETICS AND CYTOGENETICS

Course Code: ZOO-201 **Credit: 03**

Course Contents:

Unit I: **10 hours**

C-value and C- value paradox Unique and repetitive sequences in eukaryotic genome Transformation, transduction and conjugation Transposable elements in prokaryotes and eukaryotes DNA repair mechanisms Over lapping genes and pseudo genes.

Unit II: **11 hours**

Role of Y chromosome in sex determination Sex linked, sex limited and sex influenced inheritance Inborn errors of metabolism Polygenic and multifactorial inheritance Human genome project Functional genomics and Reverse genetics.

Unit III: **12 hours**

Chromatin structure, Histones, DNA, nucleosome morphology and higher-level organization. Functional states of chromatin. Metaphase chromosomes, centromere, and kinetochore. Telomere and its maintenance. Holocentric chromosomes, heterochromatin and euchromatin. Giant chromosomes like polytene and lampbrush chromosomes.

Unit IV: **12 hours**

Extra chromosomal inheritance. Inheritance of mitochondrial and chloroplast genes, mechanism of maternal inheritance, Role of Mitochondrial inheritance in evolution. Chromosomal anomalies. Structural and numerical alterations of chromosomes, Deletion, duplication, inversion, translocation, ploidy and their genetic implications.

COURSE NAME: GENETICS AND CYTOGENETICS

Course Code: ZOO:P-202 **Credit: 02**

Practical **60 hours**

1. Preparation of *Drosophila* culture medium.
2. Study of life cycle of *Drosophila*.
3. Study of sex comb in *Drosophila melanogaster*.
4. Study of genital plate in *Drosophila melanogaster*.
5. Study of polytene chromosomes in salivary gland cells of *Drosophila melanogaster* larvae.
6. Study of metaphase chromosomes in neuroblast cells of *Drosophila melanogaster* larvae.
7. Understanding inversion polymorphism in somatic chromosomes of *Drosophila ananassae* larvae.
8. Techniques in the study of chromosomes and their applications: short term (lymphocyte) and long term (fibroblast) cultures, chromosome preparations, karyotyping, chromosome labeling, in situ hybridization, chromosome painting.
9. Study banding pattern of chromosome.
10. Preparation of solutions for Molecular Biology experiments.

Suggested books:

1. Benjamin Lewin (2008) Genes IX.
2. Jones and Bartlett Publishers Griffiths AJF, Wessler SR, Carroll SB and Doebley J (2012) Introduction to Genetic Analysis. WH Freeman and Company.
3. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick (2012) Lewin's GENES XI.
4. Russell PJ (2010) iGenetics: A molecular approach (3 edition) Benjamin Cumming.

SYLLABUS FOR M.SC. ZOOLOGY

COURSE NAME: IMMUNOLOGY

Course Code: ZOO-203 **Credit: 03**

Course Contents:

Unit I: **8 hours**

Cells and organs of acquired immunity, Innate and acquired immunity, Humoral and cell mediated immune response, Antigen – Antigenecity and immunogenicity, factors affecting immunogenicity, Epitopes and Haptens.

Unit II: **12 hours**

Antibody- basic molecular structure, classes and functions, Major Histocompatibility complex (MHC)- in mouse and Human, MHC genes arrangement, MHC class I and II molecules-structure and functional significance, T-cell and B-cell generation, activation, differentiation and proliferation.

Unit III: **10 hours**

Cytokines and interferons- various types of cytokines and interferons, Cytokine receptors and signaling, Complement system- characteristic features, Classical pathway and alternative pathways of Complement system.

Unit IV: **15 hours**

Hypersensitivity-types and features of immediate and delayed hypersensitivity reactions.
Autoimmune- Mechanisms for induction of Autoimmunity; Treatment of Autoimmune diseases. Immunodeficiency. Vaccine types and vaccine development.

COURSE NAME: IMMUNOLOGY

Course Code: ZOO:P-204 **Credit: 02**

Practical **60 hours**

1. Agglutination Reaction:
2. Precipitation Reaction.
   a) Double Diffusion Reaction.
   b) Single Diffusion Reaction.
3. Separation of Lymphocytes.
4. Study of WBC in blood smears from mouse/Human.
5. Study of RBC in blood smears from mouse/Human.
6. Measurement of Phagocytosis by Phagocytes.
7. Demonstration of Immunoectrophoresis.
8. Neutralization and complement fixation.
9. Collection of macrophages and their characterization.
10. Identification of histological slides of lymphoid tissue - Spleen, thymus, lymphnode and bone marrow.

Suggested books:

1. Abul K. Abbas – Call and Molecular Immunulogy.
2. Kuby. Immunology, W.H Freeman, USA.

3. W. Pual, Fundamentals of immunology.
4. I.M. Roitt, Essential immunology, ELBS Edition.

COURSE NAME: PHYSIOLOGY

Course Code: ZOO-205 **Credit: 03**

Course Contents:

Unit I: **9 hours**

Types of neurons, ultrastructure and functions; generation of resting and action potentials; impulse conduction in non-myelinated and myelinated nerve fibres; generation of EPSPs and IPSPs; neurotransmitters and synaptic transmission.

Unit II: **12 hours**

Types of muscles, ultrastructure and composition; mechanism and energetics of muscle contraction; tetanus and Rigor mortis; digestion in vertebrates - digestive enzymes and regulation of their secretion; absorption of different types of food materials; GIT motility (peristalsis and segmentation); important GIT hormones and their role in digestion.

Unit III: **12 hours**

Respiratory organs in vertebrates; mechanism of respiration in terrestrial and aquatic animals; chemistry and function of respiratory pigments; transport of oxygen and carbon dioxide; oxygen equilibrium curve; Bohr and Root effect.

Unit IV: **12 hours**

Structure of vertebrate kidney; urine formation; acid-base balance and homeostasis; osmoregulation; composition and function of blood in mammals; haemopoesis; neural regulation of cardiac cycle.

COURSE NAME: PHYSIOLOGY

Course Code: ZOO:P-206 **Credit: 02**

Practical **60 hours**

1. Comparison of RBC number in different vertebrates.
2. Comparison of WBC number in different vertebrates.
3. Comparison of Hb content in different vertebrates.
4. Haemin crystals and their preparation.
5. Blood pressure measurement under different physiological conditions.
6. Estimation of casein in milk.
7. Estimation of ascorbic acid in tomato and lemon.
8. Estimation of glycogen content in any vertebrate.
9. Determination of oxygen consumption rates in an aquatic animal.

Suggested books:

1. Randall, Buggren and French Eckert (1997) Animal Physiology (4thed), W.H. Freeman and co.
2. Schmidt-Neilsen, K. (1984) Animal Physiology; Adaptations and Environment, Cambridge.
3. William S. Haor, General and Comparative physiology, Prentice Hall of India Pvt. Ltd.
4. Witherspoon J.D. (1978) Human Physiology, Harper and row, Publ New York.

COURSE NAME: MEDICAL MICROBIOLOGY

Course Code: ZOO-207 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Principles of classification of microbes. A brief introduction to major group of bacteria. Ultra structure of bacteria. Microbial Cultivation, Growth curve and factors influencing growth.

Unit II: **10 hours**

Disinfection and sterilization techniques. Staining characteristics and techniques. Serological characteristics. Bacterial respiration.

Unit III: **12 hours**

Antibiotics and their Mechanism of action. Molecular principles of drug targeting. Bacterial resistance to antibiotics. New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.

Unit IV: **13 hours**

Diseases caused by gram negative bacteria of family Enterobacteriaceae, Sexually transmitted diseases, Overview of medical parasitology.

Suggested books:

1. Mackie & McCartney Practical Medical Microbiology 14th edition: Eds: J.G.Colle, A.G. Fraser, B.P. Marmion, A.Simmons- Reprint 2008 Elsevier, New Delhi.
2. Koneman'sColorAltas and Text book of Diagnostic Microbiology 6th edn: Eds: Washington winn and others. 2006 Lippincott Williams and Wilkins, Baltimore, USA.
3. Ananthanarayan and Paniker'sText book of Microbiology 8th edn. 2009 Universities Press, Hyderabad.
4. Ananthanarayan&Paniker's Textbook of Microbiology, 8th Ed., Orient Longsman, India; 2009.

COURSE NAME: MEDICAL MICROBIOLOGY

Course Code: ZOO:P-208 **Credit: 02**

Practical **60 hours**

1. Preparation of culture media: Nutrient Agar.
2. Sterilization techniques.
3. Serial dilution techniques.

4. Streaking techniques.
5. Preparation of broth and culture plate for microbial growth.
6. Isolation of pure culture of bacteria.
7. Identification of microbes.
8. Gram staining techniques
9. Catalase and indole test.
10. Temperature and salt tolerance test.

Suggested books:

1. Apurba S, Bhat Sandhya (2023): Essentials of Medical Microbiology: Jaypee Brothers Medical Publishers (P) Ltd.
2. Patricia M (2021) Bailey & Scott's Diagnostic Microbiology, Elsevier
3. Joanne Willey et al (2019). PRESCOTT'S MICROBIOLOGY, 12TH EDI. Mcgraw and Hill.
4. Jawetz, Melnick &Adelberg's, Medical Microbiology 24th edition: Eds: Brooks and others, McGraw Hill, New York.

COURSE NAME: PARASITOLOGY

Course Code: ZOO-209 **Credit: 03**

Course Contents:

Unit I: **11 hours**

Basic principles and concepts of parasitism; Symbiotic associations.
Evolution of parasitism. Types of parasites and hosts. Parasitic transmission.
Host-parasite interactions. Molecular, cellular and physiological basis of host-parasite interactions.
Alteration of host behaviour by parasites. Zoonosis with reference to filariasis and schistosomiasis.

Unit II: **11 hours**

Distribution, habit and habitat, structure, life cycle and diseases caused by *Plasmodium* sp.
Problems and strategies in development of vaccination for malaria.
Morphology and life cycle of insect vectors involved in Leishmaniasis and Trypanosomiasis.
General morphology, life cycle and diseases caused by parasites (*Entamoeba histolytica, Giardia* sp., *Trichomonas* sp. *Toxoplasma gondii*).
Soil amoebae involved in newly emerging infections of humans (*Naegleria fowleri*, *Cryptosporidium parvum*, *Pneumocystis* spp.).

Unit III: **11 hours**

Monogenetic trematodes (*Polystoma integerrimum*); digenetic trematodes (*Fasciola* spp, *Schistosoma* spp, *Paragonimus* spp, *Clonorchis* spp).
Cestodes (*Diphyllobothrium latum, Taenia* spp, *Hymenolepis nana*, *Echinococcus granulosus*).
Nematodes (*Trichuris* spp, *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Dracunculus* spp).
Filarial worms.

Unit IV: **12 hours**

Fish and poultry parasites and its impact on human society.
Vectors and its importance in transmission of parasites.
Antigen antibody reaction and its role in clinical parasitology.
Molecular techniques in parasitology: (Isolation of DNA and RNA, Hybridisation, ELISA. Blotting techniques, DNA sequencing, Amplification of DNA by polymerase chain reaction).

COURSE NAME: PARASITOLOGY

Course Code: ZOO:P-210 **Credit: 02**
Practical **60 hours**

1. Preparation of thin, and thick blood smears for detection of blood parasites.
2. Study of parasitic infections with special reference to locally available fish/amphibians/mammal hosts.
3. Study of enteric and paenteric protozoans in earthworms/fish/frogs.
4. Study of parasites of medico-veterinary importance from permanent preparations.
5. Submission of prepared slides.
6. Identification of permanent slides.

Suggested books:

1. Chandler, A.C. & Read, C.P. Introduction to Parasitology (10th ed.), John Wiley & Sons Inc.
2. Cheng, T.C. General Parasitology, Academic Press, Inc. (1986).
3. Faust, E.C., Beaver, P.C., & Jung, R.C. Animal Agents and Vectors of Human Diseases (4th ed.), Lea & Febiger.
4. Manual of Veterinary Parasitological Techniques (1997), Technical Bulletin No. 18, HMSO, London.

COURSE NAME: MOLECULAR BIOLOGY

Course Code: ZOO-301 **Credit: 03**

Course Contents:

Unit I: **9 hours**

Replication and Transcription: Mechanism of DNA replication in prokaryotes and eukaryotes Transcription and Reverse transcription. Mechanism of transcription: Initiation, elongation and termination.

Unit II: **12 hours**

RNA processing, Genetic code and Protein synthesis: Cap formation, splicing, polyadenylation of mRNA RNA editing Genetic code: Triplet codon concept; features of genetic code Translation: Intitiation, elongation and termination Protein splicing and folding Signal hypothesis.

Unit III: **12 hours**

Gene regulation: Inducible and repressible operons in prokaryotes Multiple levels of eukaryotic gene regulation and its differences with prokaryotes Genetic regulation of the development of the Drosophila body plan Roles of miRNAs in development.

Unit IV: **12 hours**

Restriction enzymes Molecular cloning: Strategy and vectors (plasmid, bacteriophages, cosmid, Yeast artificial chromosome (YAC) and Bacterial artificial chromosome (BAC)) Detection of recombinant molecules Transgenic organisms and application of genetic engineering Functional genomics and Reverse genetics.

COURSE NAME: MOLECULAR BIOLOGY

Course Code: ZOO:P-302 **Credit: 02**

Practical **60 hours**

1. Genomic DNA extraction from animal tissues (Rapid method) (Brain/Body).
2. Genomic DNA extraction from animal tissues (Brain/Body).
3. Estimation of genomic DNA.
4. Extraction of RNA from animal tissues (Brain).
5. Estimation of RNA.
6. Restriction digestion.
7. Ligation.
8. Polymerase chain reaction (gene specific).
9. Electrophoresis.
10. Extraction of mitochondrial component of animal tissues (Brain/body).
11. Extraction of cytosolic component of animal tissues (Brain/body).
12. Extraction of animal tissue homogenates (Brain/body).

Suggested books:

1. Benjamin Lewin (2008) Genes IX. Jones and Bartlett Publishers.
2. Griffiths AJF, Wessler SR, Carroll SB and Doebley J (2012) Introduction to Genetic Analysis. WH Freeman and Company.
3. Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick (2012) Lewin's GENES XI.
4. Russell PJ (2010) Genetics: A molecular approach (3 edition) Benjamin Cummings.

COURSE NAME: DEVELOPMENTAL BIOLOGY

Course Code: ZOO-303 **Credit: 03**

Course Contents:

Unit I: **11 hours**

History of developmental biology (Contributions of Spemann, Hilde Mangold, Holtfreter, Needham, Waddington, Spratt, Briggs and King, Patric Steptoe and Robert Edwards); Model

organisms in developmental biology (*Caenorhabditis elegans*, *Drosophila*, Zebrafish, amphibians, chick and mouse).

Unit II: **12 hours**

Stages of development and differentiation of gonads in mammals.
Spermatogenesis: Formation of spermatids and spermiogenesis.
Oogenesis: Oocyte growth, vitellogenesis and maturation.
Ovulation and ovum transport in mammals.
Fertilization: Pre and post-fertilization events, Recognition of egg and sperm, Activation of egg, gamete fusion, Prevention of polyspermy. *in vitro* fertilization (IVF).

Unit III: **12 hours**

Patterns of cleavage and mechanisms of cleavage.
Gastrulation in chick embryo.
Fate of germinal layers.
Development of Brain.
Development of heart.
Placentation and implantation in mammals.

Unit IV: **10 hours**

Growth: Growth at cellular and intracellular level, Growth at organismic level and Growth curves; Regeneration in invertebrates and vertebrates; Biochemical aspects of metamorphosis in insects and amphibians; Homeotic genes and homeotic transformation in anuran tadpoles.

COURSE NAME: DEVELOPMENTAL BIOLOGY

Course Code: ZOO:P-304 **Credit: 02**
Practical **60 hours**

1. Observation of living chick embryo.
2. Dissection and Morphology observation of the 4-14 somite chick embryo (24-34 hours).
3. Dissection and Morphology observation of the 24-38 somite chick embryo (24-34 hours).
4. Culture of Early chick embryo *in vitro.*
5. Mounting of 72 and 96 hours chick embryo.
6. Larval developmental stages of Drosophila.
7. Patterns of regeneration in the planarian
8. Regeneration in the tail of Frog tadpoles.
9. Regeneration of tail fin of Zebra fish.
10. Developmental stage of frog.

Suggested books:

1. Gilbert, S. F. Developmental biology, 10th Edition, Sinauer Associated Inc., Massachusetts.
2. Muthukaruppan and Pitchappan. Animal development- a laboratory guide. CoSIP-ULP publications, India. First Edition, 1979.
3. Subramanyan T: Developmental Biology (Narosa Publ. House).
4. Rao, K. V.: Developmental Biology: A modern synthesis (Oxford- IBH Publ).

COURSE NAME: BIOSYSTEMATICS AND EVOLUTION

Course Code: ZOO-305 **Credit: 03**

Course Contents:

Unit I: **11 hours**

Biosystematics: definition, concepts and approaches-morphotaxonomy, cytotaxonomy, chemotaxonomy, molecular taxonomy, numerical taxonomy, differential taxonomy; speciation-mode of speciation, factors responsible for speciation; Concept of species and heirachial taxa.

Unit II: **11 hours**

Biological classification: theories and criteria for classification; taxonomic characters- concepts and weighting of characters; Intra population variations-non genetic and genetic variations; International code of zoological nomenclature; Taxonomic procedures-collection, preservation, cataloguing, curetting, identification, and publication.

Unit III: **12 hours**

Origin of life and Evolutionary history: concept and theories of organic evolution; Chemical evolution; Prebiotic molecules (Amino acid and nucleic acid base); Evolution of Prokaryotes and Eukaryotes; Evolutionary time scale- major events and human evolution; Phylogenetic tree.

Unit IV: **11 hours**

Molecular evolution: neutral evolution; Evolution as seen in proteins; Molecular divergence and molecular clock; Molecular tools in phylogeny; gene duplication and divergence; Population genetics – populations, gene pool, gene frequency; Hardy-Weinberg Law; Factors responsible for evolution- mutation, genetic variation, and genetic drift; Isolating mechanisms; Convergent evolution.

COURSE NAME: BIOSYSTEMATICS AND EVOLUTION

Course Code: ZOO:P-306 **Credit: 02**

Practical **60 hours**

1. Identification and classification of soil micro-arthropods of a grassland/soil habitat.
2. Identification and classification of common freshwater fish species.
3. Identification and classification of common amphibian species.
4. Identification and classification of Zoometric communities.
5. Identification and classification of decapod crustaceans.
6. Comparison of taxonomic diversity of natural populations.
7. Preparation of permanent mounts of various taxa.
8. Preparation of taxonomic keys for the studied taxa.
9. Visit the Zoological Survey of India (ZSI) to study taxonomic collection.
10. Collection, identification, and submission of local/regional collections.

Suggested books:

1. Sokal, Robert R. (1963). Principles of numerical taxonomy. San Francisco: W. H. Freeman
2. Minelli, A. (1993). Biological Systematics, Chapman & Hall.
3. Mayr, E. (1980). Principles of Systematic Zoology, Tata McGraw Hill Publishing company Limited.
4. Kimura. M (1983). The natural History of Molecular Evolution, Cambridge Univ press.

COURSE NAME: FISHERY-I

Course Code: ZOO-307 **Credit: 03**

Course Contents:

Unit I: **12 hours**

Fish farm: Definition-Site selection, design and construction of aquaculture pond, Formulation and operation of different types of hatcheries, Hatchery management, Criteria for selecting the candidate species for aquaculture - Types and methods: Extensive, semi-intensive and intensive culture. Forms of feeds: wet feeds, dry feeds, pelleted feeds, floating and sinking pellets.

Unit II: **11 hours**

Pond management: Physico-chemical properties of pond water and soil and their maintenance, Manuring (organic and inorganic) and liming, Composite fish farming and polyculture, Predatory and weed fishes and their eradication, Aquatic vegetation and its control, Biological means of increasing production.

Unit III: **12 hours**

Reproduction and Development: Male and female reproductive organs, Histology of the testis, seasonal changes in the testes, Maturation and spawning, Maturity stages in the female fish, Length-weight relationship, Fecundity, Ovulation and fertilization, Hatching and larval development.

Unit IV: **10 hours**

Diseases and Health Management: Parasitic and non-parasitic diseases, Symptoms, Treatments and prophylactic measures.

COURSE NAME: FISHERY-I

Course Code: ZOO:P-308 **Credit: 02**

Practical **60 hours**

1. Collection and preservation of water sample & Estimation of dissolved oxygen content in a water body.
2. Estimation of carbon dioxide in a water sample.
3. Estimation of total solids, total dissolved solids and suspended solids of water sample.
4. Estimation of total alkalinity and total Hardness of water.
5. Determination of fecundity in major carp and catfish
6. Determination of fertilization rate of carp

7. Determination of final oocyte maturation by scoring germinal vesicle breakdown
8. Study of functional morphology of testes and ovary by preparing permanent stained slides belonging to different reproductive phases
9. Determination of gonosomatic index and hepatosomatic index and their relations with regard to gonadal and body growth
10. Study of length weight relationship of major carp and catfish
11. To study the different common diseases of fishes caused by virus, bacteria, protozoan and helminthes.
12. Field visit to local fish farm and submission of fieldwork reports.

Suggested books:

1. Gupta and Gupta: General and Applied Ichthyology (Fish and Fisheries) (2006, S. Chand).
2. Srivastava: Fishes of U.P. and Bihar (2002, Vishwavidyalaya Prakashan).
3. Parihar: Fish Biology and Indian Fisheries (1999, Central publishing House Allahabad).
4. Singh: Advances in Fish Research, Vol. I, II and III (Fisheries and Fish Biology: Ed Datta Munshi) (1993, 1997 and 2004, Narendra Publishing House Delhi).

COURSE NAME: ENTOMOLOGY -1

Course Code: ZOO-309 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Structure and physiology insect integument; chemistry of cuticle – chitin, protein, lipids and pigments; synthesis and degradation of chitin; biochemistry of sclerotization and tanning.

Unit II: **11 hours**

Types of insect mouthparts – mandibulate and haustellate; major types of insect mouthparts; degenerate type; antenna structure; polymorphism in insect antennae; types of antennae, sensilla and its types; mechanism of olfaction.

Unit III: **12 hours**

Structure of digestive organs; digestive secretions; digestion and assimilation of nutrients – carbohydrates, proteins, lipids, sterols, and minerals; open and closed types of respiratory system; mechanism of gaseous exchange (aquatic and endoparasitic insects).

Unit IV: **12 hours**

Structure and variation of insectan male and female genitalia; ovipositors -appendicular and substitutional types; ovarioles – polytrophic, telotrophic and panoistic; vitellogenesis and its hormonal control.

COURSE NAME: ENTOMOLOGY -1

Course Code: ZOO:P-310 **Credit: 02**
Practical **60 hours**

1. Permanent slide preparation of mouthparts of cockroach, housefly, honeybee, mosquitoes and honeybee.
2. Study of antennae of some representative insect orders.
3. Study and dissection of digestive system of grasshopper/cockroach.
4. Dissection of respiratory system of cockroach/grasshopper.
5. Study of external genitalia of some representative orders.
6. Study and study of male and female reproductive systems (cockroach).
7. Histological preparation of testis and ovary of some insects.

Suggested books:

1. Gullan P.J. and Cranston P.S. (2010). The Insects: An Outline of Entomology. Wiley-Blackwell.
2. Hill D.S. (1994). Agricultural Entomology, Oregon Timber Press.
3. Iatrou, K., Gill, S.S. and Gilbert L.I. (2005). Comprehensive Molecular Insect Science, Vol. 1-7, Pergamon Press.
4. J.L. Nalian (2001) Insects Physiology and Biochemistry, C.R.C., Boca Raton, London.

COURSE NAME: CELL AND MOLECULAR BIOLOGY - 1

Course Code: ZOO-311 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Regulation of Cell cycle progression: Maturation promoting factors (MPF), Cyclins and Cyclins dependent kinases, growth factors and growth inhibitory factors. Cell death and apoptosis.

Unit II: **11 hours**

DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).

Unit III: **12 hours**

RNA synthesis and processing (transcription factors and machinery, formation of initiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, structure and function of different types of RNA, RNA transport).

Unit IV: **12 hours**

Constitutive, Inducible and Repressible gene expression, Positive and Negative control of gene expression, Lac, Tryptophan, arabinose operons; lysogenic repression in lambda bacteriophage. Eukaroytic genome organization, Proteins involved in the control of transcription, Post-translational control, DNA methylation, Cell Signaling, Ligand binding to membrane receptors.

COURSE NAME: CELL AND MOLECULAR BIOLOGY - 1

Course Code: ZOO:P-312 **Credit: 02**

Practical **60 hours**

1. DNA Isolation Techniques for Eukaryote.
2. RNA Isolation Techniques for both Prokaryote and Eukaryote.
3. Chromosome Isolation Techniques.
4. FISH (Fluroscence In-situ Hybridization Technique).
5. DNA and RNA Staining Techniques.
6. Plasmid DNA Isolation and Genomic DNA Isolation.
7. PCR and its application.
8. Electrophoresis Techniques in Genetics.
9. Protein Isolation techniques.
10. Cell Culture Techniques.

Suggested books:

1. Lewin, B. 2000. Genes VIII Oxford University, Press, New York.
2. Alberts, B. Bray, D., Lewis, J. Raff, M., Roberts, K. and Watson, J.D. 1999, Molecular biology of the cell. Garland Publishing, Inc. New York.
3. Wolfe, S.L. 1993, Gruissem, W. and Jones, R.L. 2000, Biochemistry and molecular biology of plants, American society of plant physiologists, Maryland, USA.
4. Frifelder, D. Molecular Biology. John and Bartlett Publishers, inc., Boston, USA.

COURSE NAME: GENETICS - 1

Course Code: ZOO-313 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Fundamental of Genetics

Concepts of Mendelian inheritance; Pedigree analysis; Chromosome theory of Inheritance, Concept of gene, allelic and gene interactions, a test of allelic complementation; Introduction to the linkage, crossing over, and developing genetic maps; Cytoplasmic inheritance.

Unit II: **12 hours**

Gene regulation in prokaryote

Jacob and Monod's model; Analyzing gene regulation with examples from *lac*, *trp* and *ara* operons; Genetic switch for lysis and lysogeny in λ phage**;** Global control by sigma factors; *GAL1* in yeast.

Unit III: **12 hours**

Gene regulation in eukaryotes

Perceiving signals- overview of cell signaling pathways; analyzing transcriptional control using examples of constitutive, inducible, and tissue-specific promoters; post-transcriptional regulation with examples of alternative splicing, RNA editing, mRNA stability, and

degradation; translational regulation-initiation, codon usage; post-translational modifications; control small RNA.

Unit IV: **11 hours**

An introduction to epigenetics

Concept and overview of epigenetics; Chemical changes-DNA methylation and histone modification in determining the chromatin structure; DNA binding proteins; Techniques for studying epigenetic modifications; Polycomb and Trithorax group of proteins; Histone variants in chromosomal inheritance and in stress; Chromatin remodelers, their families and functions; Position Effect Variegation, Heterochromatin spreading and gene silencing in *Drosophila*.

COURSE NAME: GENETICS - 1

Course Code: ZOO:P-314 **Credit: 02**

Practical **60 hours**

1. Study of gene expression in bacteria using lac operon in E. coli as a model.
2. Biochemical characterization based on β-galactosidase assay.
3. Difference between wild type and mutants in *E. coli*.
4. Difference under uninduced and induced conditions in the wild type strain of E coli
5. Karyotype study to understand chromosome banding patterns.
6. Development of chromosome map for mammals.
7. Analysis of methylation status of a gene and its expression.
8. Quantifying protein expressions by ELISA.
9. Demonstration of Southern hybridization.
10. Determination of DNA sequencing methods.

Suggested books:

1. DNA Markers: Protocols, Applications and Overviews Anolles GC & Gresshoff PM Wiley-Liss.
2. Molecular Markers in Plant Genetics and Biotechnology, Vienne De D, Science Publishers.
3. Genetics of Population, Hedrick PW, Jones & Bartlett.
4. Principles of Population, Genetics, Hartl DL & Clark AG, Sinauer Associates.

COURSE NAME: TOOLS AND TECHNIQUES

Course Code: ZOO-401 **Credit: 03**

Course Contents:

Unit I: **11 hours**

Introduction, types, simple and compound microscope, bright field microscope, stereoscopic zoom microscope, fluorescence microscope and confocal microscope. Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM). Significance of microscopy in research.

Unit II: **12 hours**

Basic Lab. Instruments (laminar air flow, incubator, oven, autoclave, centrifuge). Colorimetry, spectrophotometry, atomic absorption spectrophotometry (AAS). Tissue processing and fixation. Cell staining techniques.

Unit III: **10 hours**

Introduction, definition and application of chromatography, Types of chromatography (paper chromatography, thin layer chromatography (TLC), high performance liquid chromatography (HPLC), Gas chromatography (GC), gas chromatography mass spectroscopy (GCMS).

Unit IV: **12 hours**

Electrophoresis and its types. Blotting techniques. Polymerase Chain Reactions (PCR) and its application. Enzyme-linked immunosorbent assay (ELISA), radioimmunoassay (RIA) and its application.

Suggested books:

1. Principles and Techniques in biochemistry and molecular biology Wilson &Walkes
2. Culture of animal cells Freshman.
3. Sharma V.K. (1991), Techniques in microscopy and cell Virology, Tata-Mc Craw Hill.
4. Principles of animal cell culture, Basant Kumar &Rinesh Kumar, Int. Bork 2008, XXII edn.

COURSE NAME: PROJECT WORK

Course Code: ZOO:P-402 **Credit: 04**

Based on the specialization of the project guide.

COURSE NAME: ANIMAL BEHAVIOUR

Course Code: ZOO-403 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Ethology as a branch of biology.
Classification of behavioral patterns.
Biological clock.
Circadian rhythm.
Classification of behavioral patterns.

Unit II: **12 hours**

The genetics of behavior: Genetic difference and human behavior
Experience and behavioral development: Early experience and recognition of relatives.
Learning and behavioral development.

Unit III: **11 hours**

Foraging behavior of animals with reference to cost and benefit analysis.
Aggression.
Territoriality.
Migration.

Unit IV: **12 hours**

Benefits and cost of social life.
Feeding and learning behaviour.
Schooling in fishes, Flocking in birds, Herding in mammals.
Social organization on insects and primates.

Suggested books:

1. Reena Mathur (1988) Animal behavior Rastogi Pub. Meerut. 22.
2. Lee Alan Dugatkin (2009) Principles of Animal behavior, W. W. Norton Co. New York. 23.
3. Harjindra Singh (2000) A text book of Animal behavior. Anmol Pub. Pvt. Ltd., New Delhi. 24.
4. John Alcock (Ed.) (2001) Animal behavior: An evolutionary approach, Seventh Edition, Sinauer Associates, Inc., Massachusetts.

COURSE NAME: ECOLOGY

Course Code: ZOO-404 **Credit: 03**

Course Contents:

Unit I: **12 hours**

Concept of ecology: introduction to ecology; Biosphere, Atmosphere, Lithosphere and Hydrosphere; Biogeography-major biomes of the world, biogeographical zones of India; Limiting factors-Shelford's law of tolerance and Leibig's law of minimum; Ecological niche, niche overlap, and separation; Concept of communities- population density, and indices of relative abundance, frequency, ecological dominance, carrying capacity, species composition, richness, and species diversity; Succession- types, and changes involved in succession, and concept of climax and stability

Unit II: **12 hours**

Ecosystem ecology and energy flow: concept, structure, and function of ecosystem; Types of ecosystem and their biotic communities, some terrestrial and aquatic ecosystems of India; Energy flow and Lindemann's trophic dynamic concept; trophic relationship and ecological efficiencies; Concept of productivity-primary and secondary productivity; biogeochemical cycles.

Unit III: **11 hours**

Population ecology and species interaction: Growth pattern; natality and mortality; life tables & Survivorship curve; density-dependent and density-independent factors; Life history strategies-k and r selection; Population age distribution and sex ratio; Population fluctuations and cyclic oscillations; Species interactions-positive and negative interactions.

Unit IV: **10 hours**

Applied ecology: Environmental pollution; Climate change-environmental stresses and their management; Greenhouse effect, global warming, Ozone depletion; Environmental monitoring and environmental impact assessment; Biodiversity: status, monitoring, and documentation; major drivers of biodiversity change; biodiversity management approaches.

COURSE NAME: ECOLOGY & ANIMAL BEHAVIOUR

Course Code: ZOO:P-405 **Credit: 02**

Practical **60 hours**

1. Analysis of pH and specific conductivity of soil and water samples.
2. Estimation of moisture and thermal profile of soil.
3. Estimation of organic content of soil samples.
4. Estimation of chemical parameters of soil and water samples.
5. Estimation and comparison of dissolved oxygen.
6. Estimation of biomass by harvest method in a grassland ecosystem.
7. Estimation of population by quadrate method in a natural ecosystem.
8. To study the geotaxis, phototaxis, chemotaxis and hydrotaxi of earthworm.
9. To study the response of woodlice to hygrostimuli.
10. Fixed action pattern in spider.
11. Habituation in snail.
12. Behaviour observations in a primitive eusocial wasp.

Suggested books:

1. Chapman, J. L. and Reiss M. J. (1998). Ecology: principles and applications. 2nd Edition.
2. Cambridge; New York, NY: Cambridge University PressMcGill T E (1973) Reading in Animal behavior, Holt Rwnchart and Winston Inc., New York
3. Jelte Van Andel and James Aronson (2006). restoration Ecology, Blackwell Science Ltd. 2006.
4. R.B. Baird , A.D. Eaton, E.W. Rice (2017). Standard Methods for the Examination of Water and Wastewater, 23rd Edition. American Water Works Association (AWWA, WEF and APHA).

COURSE NAME: FISHERY-II

Course Code: ZOO-406 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Fish Production: Definition, scope and importance of aquaculture. Monoculture, polyculture/composite fish farming and integrated fish farming, fish spoilage. Livestock Integrated fish culture: Duck cum fish culture, pig cum fish culture & Poultry cum fish culture.

Unit II: **11 hours**

Methods of Fishing and Fish Gear: Fishing craft, Fishing without gear, Wounding gear, Stupefying methods, Fish trap, Dip net, Cast net, Triangular net, Purse net, Drag net, Gill net, Fixed bag net, Electric fishing, Mechanisation of boats and gear, use of acoustic equipment.

Unit III: **12 hours**

Preservation and Processing: Causes of spoilage of fish, Rigor mortis, Preservation of fish, Chilling, Freezing, Freeze drying, Smoking, Drying, Salting, Canning, Processing, By-Products, Liver oil, Fish oil, Fish meal, Fish manure, Hydrolysed protein, Isinglass.

Unit IV: **12 hours**

Induced breeding and Biofloc technology: Factors responsible for induced breeding, Hypophysation, Use of different synthetic and natural hormones, their formulation and mechanism of action, Bundh breeding, Hapa breeding, Hatchery breeding; Fish seed collection, transport of brood fishes and fish seed. Biofloc technology: principle design and components of Biofloc technology system.

COURSE NAME: FISHERY-II

Course Code: ZOO:P-407 **Credit: 02**

Practical **60 hours**

1. Identification of locally available fishes of economic importance.
2. Study of efficacy of different methods (freezing, drying, salting, and salting and drying simultaneously) of fish preservation.
3. Determination of protein and lipid contents in fresh and preserved fishes (carp and catfish).
4. Periodic survey of fish market to collect gonads and data related to length weight relationship.
5. Visit to a fishing site to study the variety of fish catches at different seasons.
6. Study of fishing nets being used at different seasons.
7. Collection and preservation of fish pituitary gland.
8. Preparation of fish pituitary extract for injection.

Suggested books:

1. Gopakumar, Singh and Chitranshi: Fifty Years of Fisheries Research in India (2000, Fisheries Division Indian Council of Agricultural Research).
2. Hall: Ponds and Fish Culture (1994, Agro Botanical Publishers).
3. Talwar, P.K. and Jhingran, A.G.: Inland Fishes of India and Adjacent Countries (1991, Oxford-IBH Publishing Co. Pvt. Ltd.).
4. APHA, AWWA, & WEF (2005): Standard Methods for the Examination of Water and Waste Water (21st ed., New York, Washington, DC: Jointly prepared and published by the American Public Health Association, American Water Works Association, and Water Environment Federation).

SYLLABUS FOR M.SC. ZOOLOGY

COURSE NAME: ENTOMOLOGY-II

Course Code: ZOO-408 **Credit: 03**

Course Contents:

Unit I: **10 hours**

Types of insect muscles and their ultrastructure; neuromuscular control; physiology of flight muscles – direct and indirect flight muscles; mechanism of flight and its control/flight stability; click mechanism; structure of wings.

Unit II: **11 hours**

Structure of excretory organs – basic and cryptonephridial systems; types of maphigian tubule-rectal cycling systems; physiology of excretion; synthesis of uric acid; nervous system types – CNS and VNS.

Unit III: **12 hours**

Neuroendocrine system in insects; morphogenesis; role of hormones in growth, differntiation, metamorphosis, diapause and reproduction; biosynthesis and mode of action.

Unit IV: **12 hours**

Pheromone types – releaser and primer pheromones with examples; different classes of exocrine glands; allomones and their mode of action; avoidance of autointoxication; biochemistry of haemolymph; types and functions of haemocytes.

COURSE NAME: ENTOMOLOGY-II

Course Code: ZOO:P-409 **Credit: 02**

Practical **60 hours**

1. Structure of insect wing: types and venation.
2. Study of central nervous system of adult (grasshopper/coackroach) and larval stages of silkworm.
3. Study of neuroendocrine system of grasshopper/cockroach and larval stages of silkworm.
4. Chromatographic analysis of haemolymph composition (free amino acids and sugars etc.) of an insect.
5. Haemocyte counting of an insect.
6. Detection of uric acid in the malphigian tubules.
7. Uptake of dye in the malphigian tubules.

Suggested books:

1. Chapman R.F. (2012). The Insect Structure and Function, ELBS 5th Edn., The English Univ. Press, London.
2. Gilbert L.I. (2011). Insect Endocrinology, 1st Edn. Academic Press.
3. Gullan P.J. and Cranston P.S. (2010). The Insects: An Outline of Entomology. Wiley-Blackwell.
4. Nation J.L. (2008). Insect Physiology and Biochemistry, 2nd Edn. CRC Press.

COURSE NAME: CELL AND MOLECULAR BIOLOGY - II

Course Code: ZOO-410 **Credit: 03**

Course Contents:

Unit I: **10 hours**

The genetic material - Structure of nucleic acids - folding motifs, conformation flexibilities, super-coiling of DNA; Packaging of DNA in the nucleus- structure of chromatin, Function of the genetic material. Evolution of genetic material.

Unit II: **12 hours**

Stability and variation in the genetic material. Mechanism of DNA repair; Genome instability; Homologous and site-specific recombination. Mechanism of homologous recombination in prokaryotes and eukaryotes. Role of oncogenes and tumor suppressor genes in cancer.

Unit III: **12 hours**

Fate of RNAs exported from the nucleus- Stability of different types of RNA; Translational machinery and translational control- Energetics of amino acid polymerization, tRNAs and their modifications; Amino-acylt-RNA synthetases; Initiation of translation in prokaryotes and eukaryotes and its regulation; elongation and its control, Termination of translation.

Unit IV: **11 hours**

Post-transcriptional gene control mechanism and nuclear transport - Processing of the 5' and 3' ends of eukaryotic mRNA; Types of introns and their splicing, Micro RNA and other noncoding RNAs; Transport across the nuclear envelope- Structure of the nuclear membrane and the nuclear pore complexes.

COURSE NAME: CELL AND MOLECULAR BIOLOGY - II

Course Code: ZOO:P-411 **Credit: 02**

Practical **60 hours**

1. Preparation of loading dye, tracking dye and buffers for molecular biology.
2. Restriction digestion analysis and its role.
3. UV Spectrophotometry- best for quantifying oligos, single stranded RNA and DNA.
4. Representative DNA Size Markers for Agarose Gels.
5. Ethidium fluorescence- best if you have small quantities and no fluorometer.
6. Simplified preparation of DNA from blood.
7. Determination of cellular DNA and Protein concentrations.
8. HPLC methods for determination of amino acids.
9. Staining method to determine nucleic acid.
10. Role of Gel Doc in genetic study.

Suggested books:

1. Molecular Biology of the Gene, Watson et al. (7th Ed. 2017), Pearson Education, Delhi, INDIA
2. Lewin's Genes XI (2014), Jones and Bartlett Publishers, Boston, USA
3. Molecular Cell Biology, Lodish et al., W.H. Freeman and Company (8th Ed. 2016)

4. Accuracy in Molecular Processes: Its Control and Relevance to Living System, TBL Kirkwood, RF Rosenberger, and DJ Gala (1989), Chapman and Hall, NY, USA.

COURSE NAME: GENETICS - II

Course Code: ZOO-412 **Credit: 03**

Course Contents:

Unit I: **12 hours**

Genetic variation: Types and sources of variation; Mechanisms of mutation; Detection of polymorphism–DNA markers and their detection techniques.

Organization and measurer of genetic variation: Random mating population; Hardy-Weinberg principle; Complications of dominance; Special cases of random mating– multiple alleles, sex-linked genes.

Unit II: **12 hours**

Linkage and Linkage disequilibrium: Definition of linkage disequilibrium and the difference between linkage and linkage disequilibrium; Different parameters to estimate linkage disequilibrium.

Unit III: **10 hours**

Population sub-structure:

Hierarchical population; Isolate breaking; inbreeding, assortative and non-assortative mating.

Gene frequencies and evolution: Mutation, selection, migration, genetic drift.

Unit IV: **11 hours**

Quantitative genetics:

Johannsen pure line theory; Multiple factor hypothesis; Types of quantitative traits; Components of phenotypic variation and genetic models of quantitative traits; Concept of heritability.

COURSE NAME: GENETICS - II

Course Code: ZOO:P-413 **Credit: 02**

Practical **60 hours**

1. Handling micro volumes: use of micropipettes and determining their accuracy by gravimetric method
2. Preparation of dilution of a given DNA sample and measure the absorbance at 260 nm to check accuracy of dilutions.
3. Preparation of plasmid DNA by alkaline lysis (mini and midi preparation).
4. Calculating yield and purity of DNA by studying its absorbance and digestion with restriction enzyme.
5. Isolation and digestion of genomic DNA with different restriction enzymes.
6. Experiments with agarose gel electrophoresis to analyze relationship between mobility of DNA fragments of different sizes and the percentage of the gel.

7. Digestions and ligation of plasmid DNA. Studying ligations following single digest, double digest, and de-phosphorylation.
8. Real time quantification of nucleic acids.
9. Visit to facilities to introduce students to model organisms like *Arabidopsis*, zebrafish, *Caenorhabditis elegans*.

Suggested books:

1. DNA Markers: Protocols, Applications and Overviews Anolles GC & Gresshoff PM Wiley-Liss.
2. Molecular Markers in Plant Genetics and Biotechnology, Vienne De D, Science Publishers.
3. Genetics of Population, Hedrick PW, Jones & Bartlett.
4. Principles of Population, Genetics, Hartl DL & Clark AG, Sinauer Associates.