Syllabus
M.Sc. Zoology



DEPARTMENT OF ZOOLOGY
SCHOOL OF BIOLOGICAL SCIENCES
University of Science and Technology, Meghalaya

CONTENTS

Semester	Paper Code	Title of the Paper	Distribution of Credits			Distribution of Marks			
			T	P	Total	IA	T	P	Total
I	MSZ-101	Taxonomy, Biosystematics and Biostatics	4	-	4	30	70	-	100
	MSZ-102	Bio-instrumentation and Cell Biology	4	-	4	30	70	-	100
	MSZ-103	Animal Physiology and Endocrinology	4	-	4	30	70	-	100
	MSZ-104	Taxonomy, Biosystematics and Animal Physiology	-	4	4	30	-	70	100
	MSZ-105	Bio-instrumentation and Cell Biology	-	4	4	30	-	70	100
II	MSZ-201	Developmental and Reproductive Biology	4	-	4	30	70	-	100
	MSZ-202	Molecular Biology and Biochemistry	4	-	4	30	70	-	100
	MSZ-203	Ecology and Environmental Scie	4	-	4	30	70	-	100
	MSZ-204	Ecology & Environmental Science and Reproductive & Developmental Biology	-	4	4	30	-	70	100
	MSZ-205	Molecular Biology and Biochemistry	-	4	4	30	-	70	100
III	MSZ-301	Genetics and Evolution	4	-	4	30	70	-	100
	MSZ-302	Parasitology, Economic Entomology and Aquatic Biology	4	-	4	30	70	-	100
	MSZ-303	**MSZ-303A**: Cell and Molecular Biology-I **MSZ-303B**: Animal Ecology and Wildlife Biology-I **MSZ-303C**: Fish & Fishery Biology-I **MSZ-303D**: Entomology Insect Physiology & Economic Entomology-I	4	-	4	30	70	-	100
	MSZ-304	Genetics and Evolution, Parasitology, Economic Entomology and aquatic Biology	-	4	4	30	-	70	100
	MSZ-305	**MSZ-305A**: Cell and Molecular Biology-I **MSZ-305B**: Animal Ecology and Wildlife Biology-I	-	4	4	30	-	70	100

		MSZ-305C: Fish & Fishery Biology-I **MSZ-305D**: Entomology Insect Physiology & Economic Entomology-I							
	MSZ-306	Bioresource and Wildlife Management	4	-	4	30	70	-	100
IV	MSZ-401	Immunology, Bioinformatics and Research Methodology	4	-	4	30	70	-	100
	MSZ-402 Theory	**MSZ-402A**: Cell and Molecular Biology-II **MSZ-402B**: Animal Ecology and Wildlife Biology-II **MSZ-402C**: Fish & Fishery Biology-II **MSZ-402D**: Entomology Insect Physiology & Economic Entomology-II	4	-	4	30	70	-	100
	MSZ-403	Immunology, Bio-informatics and Research Methodology	-	4	4	30	-	70	100
	MSZ-404 Practical	**MSZ-404A**: Cell and Molecular Biology-II **MSZ-404B**: Animal Ecology and Wildlife Biology-II **MSZ-404C**: Fish & Fishery Biology-II **MSZ-404D**: Entomology Insect Physiology & Economic Entomology-II	-	4	4	30	-	70	100
	MSZ-405 Dissertation	**MSZ-405A**: Cell and Molecular Biology **MSZ-405B**: Animal Ecology and Wildlife Biology **MSZ-405C**: Fish & Fishery Biology **MSZ-405D**: Entomology	-	4	4	30	-	70	100
	MSZ-406	Economic Zoology	4	-	4	30	70	-	100

MSZ-101
Taxonomy, Biosystematics and Biostatistics
(4 Credits)

UNIT-I:

1. **Taxonomy and Systematics:** Definition, basic concept and importance of Systematics and Taxonomy; applications of systematics in biology, Natural and Cladistic classification, Stages in taxonomy, Relationship between taxonomy and systematic
2. **Newer Aspects of Taxonomy:** Cytotaxonomy, Chemotaxonomy, Numerical taxonomy, Molecular taxonomy.
3. **Species Concept:** Nominalistic Species Concept, Typological Species Concept, Phenetic Species Concept, Biological Species Concept, Evolutionary Species Concept, Ecological Species Concept, Recognition Species Concept, Aberrant Species Concept;
4. **Other Species definitions:** Monotypic and Polytypic Species, Allopatric and Sympatric Species, Peripatric and Parapatric Species, Cryptic Species and Sibling Species, Infraspecific Categories.

UNIT-II

1. **Taxonomic Collection, Preservation, Curation and Identification:** Importance of Museum Collections, Methods for collecting non-chordates, Methods for Collecting Chordates, Preservation of non-chordates, Preservation of Chordates, curation, Identification Method. Taxonomic keys- different types of Keys.
2. **Type concept:** definition and application
3. **Zoological Nomenclature:** Basic concept of ICZN, Process of Typification and Zoological Types, Binomial Nomenclature, Trinomial Nomenclature, Important rules.
4. **Evaluation of Biodiversity Indices:** Shannon Weiner Index, Dominance Index, Similarity and Dissimilarity Index, Association Index.

UNIT III

1. Arithmetic mean, mode and median- definition, calculation and Properties.
2. Range, Quartile deviation, Mean deviation and Standard deviation.
3. Elements of probability, Definition, relative frequency approach. Binomial and Poisson distribution
4. Correlation and Regression

UNIT IV

1. Concept of sampling, judgment sampling, Random sampling, stratified sampling, systematic sampling, subsampling.
2. Tests of significance: T-tests (One sample t-test, Two sample t-test, Paired t-test)
3. Chi-square test for goodness of fit, One way ANOVA
4. Mann-Whitney test, Kruskal- Wallis test

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Recommended Books

1. G. G. Simpson. Principle of animal taxonomy; Oxford IBH Publishing Company.
2. V.C Kapoor-Theory and practice of animal taxonomy, 6TH EDITION 1983 (Reprint 2011).
3. J.C. Avise. Molecular Markers, Natural History and Evolution, Chapman & Hall, New York.
4. E.O. Wilson, Biodiversity, Academic Press, Washington.
5. Ernst Mayer and Peter D. Ashlock: Principle Elements of Taxonomy.
6. E.O. Wilson. The Diversity of Life (The College Edition), W.W. Northern & Co. (International edition1991)
7. Dalela and Sharma- Animal taxonomy and Museology,
8. B.K. Tikadar. Threatened Animals of India, ZSI Publication, Calcutta.

MSZ-102
Bio-instrumentation and Cell Biology
(4 credits)

UNIT I

1. Microscopy: Phase contrast microscope, Fluorescence microscope, Electron microscope (TEM and SEM), Confocal microscope
2. General Principle and applications of Colorimeter and Spectrophotometer. Ultra centrifuge. Beer and Lambert's law.
3. Chromotagraphy-Principles and applications of GLC & HPLC; Electrophoresis- PAGE and Agarose Gel Electrophoresis; Flow cytometry, NMR
4. Cryopreservation of cells, tissues, organs and organisms. Cryosurgery, Freeze fracture and freeze drying; Autoradiography; Immunological techniques- Immunodiffusion, Immunoelectrophoresis, immunofluroscence, ELISA

UNIT II

1. Principles of tissue fixation& Staining, Histochemistry
2. Microbiological techniques- Types of media and sterilization, Innoculation and growth monitoring, microbial assays, microbial identification; Cell culture Techniques- Design and functioning of a tissue culture laboratory, Culture and media preparation, Cell toxicity and cell vialibility testing.
3. Insitu hybridization-FISH; Blotting Techniques- Western, Northern and Southern Blotting.
4. Polymerase Chain Reaction (PCR).

UNIT-III

1. Complexity and organisation of cell- Structural and Molecular feature of Prokaryotic and Eukaryotic cells.
2. Biomembranes- Molecular composition and functional feature of membrane lipid, protein and carbohydrate.
3. Cytoskeletons- Structure and Organisation of Microfilament, Microtubule and Intermediate filament.
4. Cell Motility- Muscle contractility, intercellular transport, kinesin-dynin, cilia and flagella.

UNIT-II

1. Cellular Reproduction- Various Stages and molecular events in mitosis and Meiosis.
2. Extracellular Matrix and Cell Interaction- Cell walls, Adhesion junctions, Tight junctions, Gap junctions, Plasmodesmata.
3. Cell –Cell Adhesion- Ca^{++} dependent and Ca^{++} independent Homophillic Cell-Cell Adhesion.
4. Cell-Cell Signalling- Cell Signalling, Cell surface receptors, G-Protein coupled receptors and Second messenger.

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Recommended Books

1. Alberts et al: Molecular Biology of the Cell (Garland, 2002)
2. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
3. Biochemistry (3rd Ed.), Tata-McGraw Hill, 1990
4. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd Ed.), Benjamin/Cumin, 1993
5. Brooker: Genetics : Analysis and Principles (Addison-Wesley, 1999)
6. DeRobertis&DeRobertis: Cell and Molecular Biology (Lee &Febiger, 1987)
7. Griffith et al: Modern Genetic Analysis (Freeman, 2002)
8. Hartl& Jones: Essential Genetics: A Genomic Perspective (Jones &Bartlet, 2002)
9. Karp: Cell and Molecular Biology (John Wiley & Sons, 2002)
10. Lewin, Genes VIII (Wiley, 2004)
11. Lodish et al: Molecular Cell Biology (5th Ed.), Freeman, 2004
12. Pollard &Earnshaw: Cell Biology (Saunders, 2002).
13. Russell: Genetics (Benjamin Cummings, 2002)
14. Snustad& Simmons: Principles of Genetics (John Wiley, 2003).
15. Switzer and Garrity: Experimental Biochemistry 92nd Ed.), Freeman, 1999
16. T.A.Brown, Genome 3rd, Ed
17. Wilson and Walker: Practical Biochemistry (3rd Ed.), Cambridge Univ. Press, 2000.

MSZ-103
Animal Physiology and Endocrinology
(4 credits)

UNIT I

1. Physiology of digestion: Glands and secretion of digestives enzymes, Mechanism of digestion, Gastrointestinal hormones, Absorption of Carbohydrates, lipids and proteins.
2. Physiology of Respiration: Alveolar ventilation, alveolar-capillary gas exchange, Transport of O_2 and CO_2 in blood, Oxygen dissociation curve and the factors influencing it, Regulation of respiration.
3. Circulatory system in mammals, blood chemistry, blood groups, blood clotting mechanism, cardiac cycle and its regulation in mammals.
4. Musculature in vertebrates: Types of muscles, Ultrastructure and chemical composition of skeletal muscles, molecular mechanism and regulation of muscle contraction, muscle fatigue and rigor mortis.

UNIT II

1. Physiology of Excretion: Ultrastructure of nephron, mechanism of urine formation, excretion of dilute solutes and mechanism of excretion of excess solutes. Osmoregulation in different animal groups (aquatic and terrestrial)
2. Thermoregulation: Heat balance in animals, Adaptations to temperature extremes, Aestivation and hibernation, acclimatization, avoidance and tolerance, stress and hormone,
3. Neuron: Ultrastructure, types and function, Resting membrane, membrane potential, action potential, Nerst Equation, Chronaxi, Rheobase, utilization time.
4. Neural impulse induction through an axon, neurotransmitters and synaptic transmission-mode of information transfer across electrical and chemical synapses

UNIT III

1. Basic concept of Endocrinology, Hormone and homeostasis.
2. Chemical nature of hormones: Amino-acid derived hormones, Peptide hormones, Glycoprotein hormones, Steroid hormones and Prostaglandin.
3. Hormone receptor and target organ concept, Feedback system and trophic hormones.
4. Biosynthesis and mechanism of action of peptide and steroid hormones.

UNIT IV

1. Structure of pituitary gland; pituitary hormones and their functions Hypothalamo – hypophysialaxis
2. Structure of thyroid glands, thyroidhormones – biosynthesisand metabolic functions. Role of thyroid hormone in amphibian metamorphosis
3. Structure of adrenal gland; Synthesis of adreno-cortical and medullary hormones and their functions.
4. Structure of endocrine pancreas and Hormones of Islets of Langerhans, testis& ovary – endocrine structure and their functions; Hormone therapy

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Books Recommended

1. Brooks and Marshall: Essentials of Endocrinology, Blackwell Science. 1995
2. Ganong: Review of Medical Physiology (21st Ed.), Lang Medical Publications, 2003
3. Guyton and Hall: Text Book of Medical Physiology (10th Ed.), W.B. Saunders, 2001
4. Hadley: Endocrinology, Prentice hall. International Edition. 2000
5. Keel et al: Samson Wright's Applied Physiology (13th Ed.), Oxford Press, 1989
6. Keel et al: Samson Wright's Applied Physiology (13th Ed.), Oxford Press, 1989
7. Larson: Williams Text Book of Endocrinology, 10th edition. W. B. Saunders Company, Philadelphia. 2002.
8. Murray et al: Harper's Illustrated Biochemistry (26th Ed.), Appleton & Lange, 2003
9. Murray et al: Harper's Illustrated Biochemistry (26th Ed.), Appleton & Lange, 2003
10. Norris: Vertebrate Endocrinology (2nd ed). Lea &Febriger. 1997
11. Turner and Bagnara: General Endocrinology, W. B. Saunders Company Philadelphia. 1984
12. West: Best and Taylor's Physiological Basis of Medical Practice (11th Ed.), Williams and Wilkins,1981.
13. West: Best and Taylor's Physiological Basis of Medical Practice (11th Ed.), Williams and Wilkins, 1981.

MSZ-104
PRACTICALS
Taxonomy, Biosystematics and Animal Physiology
(4 credits)

1. Collection, preservation, curation and identification of non-chordate and chordate species (only pest and cultured species)
2. Taxidermy of fish/rat/pigeon/fowl
3. Identification with only diagnostic features (specimen or model/diagnostic photograph)
    a. Spongilla, one coelenterate, Ascaris (male& Female), Fasciola, Taenia, Earthworm, Leech, Julus, King crab, spider, crab, prawn (fresh water), cricket, leaf insect, stick insect, beetle (one), butterfly (one), grasshopper, termite, Pila, sepia, Achitina, Slug, Echinodermata (any one)
    b. Puntius, Labeo, Cyprinus, Ctenopharyngodon, Hypopthalmichthys, Cirrihinus, Clarius, Anabas, Mystus, Mastocembalus, Macrognathus, Hoplobatrachus, Polypedates, Rhacophorus, Euphlictys, Fejervarya, Moina, sparrow, Parrot, rabbit, Duckbill platypus, Bat, monkey, whale/dolphin
4. Survey and application of biodiversity indices of animal species (any one group)
5. Calculation of Pearson correlation coefficient., T test (One sample t-test, Two sample t-test, Paired t-test); Chi square test, ANOVA, Mann-Whitney test from supplied data.
6. Detection of blood groups and Rh factor. Comparison of RBC and WBC in different groups of Vertebrate.
7. Dissection and mounting of pituitary gland from fish.
8. Determination of rate of Respiration.
9. Micronuclei assay from blood cells to study genotoxicity.
10. Preparation of practical record and submission
11. Viva-voce.

MSZ-105
PRACTICALS
Bio-instrumentation and Cell Biology and Endocrinology
(4 credits)

1. Study of structural arrangement of plasma membrane using model/chart.
2. Identification of various stages of mitosis and meiosis from prepared slides
3. Temporary squash preparation of onion root tip cells to study stages of mitosis and Grasshopper/ Gryllotalpa testis to study meiotic stage of cell division.
5. Preparation of temporary sex chromatin from buccal epithelial cell
6. Squash preparation and identification of salivary gland chromosomes in *Drosophila* / *Chironomus* larvae.
7. Preparation of agarose gel for gel electrophoresis; Demonstration of gel loading, gel runs for electrophoresis.
8. Estimation of total protein and glycogen using spectrophotometer/ colorimeter.
9. Separation and identification of amino acid by paper chromatography and TLC
10. Preparation of fixatives and stains
11. Preparation of culture media and sterilization.
12. Preparation of practical record and submission of materials related to above.
13. Viva-voce.

MSZ-201
Developmental and Reproductive Biology
(4 Credits)

UNIT-I

1. **Principle of Developmental Biology**: Embryogenesis and Blastogenesis, Ontogenic and Phylogenetic development, Potency, commitment, Specification, Induction, Competence.
2. **Fertilization**: Dual aspect of Fertilization, Mechanism of Fertilization, Change in the organization of egg cytoplasm after fertilization, Site of sperm entry, Chemistry of fertilization.
3. In Vitro Fertilization (IVF), Embryo transfer, Variations of Embryo transfer, Intracytoplasmic sperm injection (ICSI), Gamete intrafellopian transfer (GIFT).

UNIT-II

1. Morphogenesis: Axes, Compartment formation and pattern formation in Drosophilia, Wnt and Cadherin pathways.
2. Organogenesis: Vulva formation in caenorhapditselegans, Island induction.
3. Nucleocytoplsmic Interaction: Method of Nucleocytoplasmic interaction, Transfer of Nuclei, Cytoplasmic influence of nucleus.

UNIT-III

1. Sexual Cycle: Female Sexual Cycle, Menstrual cycle, Cause of Oestrus and Menstrual, Hormonal Regulation of Female cycle.
2. Ovarian Physiology: Folliculogenesis, Ovulation, Steroidogenesis and their regulation.
3. Testicular Physiology: Steroidogenesis, Semination.
4. Transport of Gametes in Reproductive tract.

UNIT-IV

1. Development of Endometrium and Implantation.
2. Physiology of placenta, Placental hormones and function.
3. Pregnancy, Parturition and Lactation in Mammal and their hormonal control.

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Recommended Books

1. Balinsky, B.I.1981 An Introduction to Embryology. W.B Saunders Co., Philadelphia.
2. Gilbert, S.F.2003.Developmental Biology. Sinamer Associates Inc. Saunderland, Massachusets, U.S.A.
3. John E. Hall: Text Book of Medical Physiology. Guyton & Hall
4. Kalthoff: Analysis of biological development. McGraw-Hill, 1996.
5. Karp,G. and Berrill,N.J.1981. Development. McGraw Hill, New York.
6. Nagabhushanam,R. and Sarojini,R.2002 Invertebrate Embryology. Oxford and IBA Publishing Co.
7. Oppenheimer, S.B.1980.Introduction to Embryonic Development. Allyn and Bacon, Inc.
8. Saunders, J.W.1982. Developmental Biology. MacMillan Co., London.
9. Tyagi and Shukla, 2002. Development of Fishes. Jaya Publishing House, New Delhi.
10. Wolpert: Principles of development. Oxford, 2002.

MSZ-202
Molecular Biology and Biochemistry
(4 Credits)

UNIT- I:

1. Nucleic acid- Molecular Structure and Properties of DNA and RNA.
2. DNA Replication- Replication in Prokaryotes and Eukaryotes, Semi conservative nature of DNA replication, Messelsons- Stahl experiment, Enzymes and proteins associated with replication, DNA polymerases, Regulation of eukaryotic genome replication.
3. DNA Damage and Repair Mechanism- Different type of DNA Damage, Direct repair system, Excision repair system, Mismatch repair system, DNA break repair.

UNIT- II:

1. Transcription- Basic concept of Prokaryotic and Eukaryotic transcription, Promoters (Pribnow box, TATA box, C*p* Gisland), Transcription factors, Initiation, elongation and termination of transcriptions in Eukaryotes.
2. Post Transcriptional Modification- Post transcriptional processing of RNA, Molecular events in Capping, Polyadenylation and Splicing mechanism
3. Translation- Genetic Code, Mechanism of Initiation, Elongation and Termination.

UNIT- III:

1. Carbohydrate metabolism- Glycolysis, Glycogenolysis, Gluconeogenesis, TCA cycle, Cori cycle, Phosphogluconate pathway.
2. Lipid metabolism- Oxidation of fatty acid, Cholesterol biosynthesis and metabolism, Prostaglandins.
3. Protein metabolism- Amino acid Classification, Amino acid degredation, Decarboxylation, Deamination, Ornithine Cycle.

UNIT- IV:

1. Bioenergetics- Energy producing and utilizing system, Electron transfer system and Oxidative Phosphorylation.
2. Enzymes- Classification of enzymes, General properties of enzymes, Mechanism of enzyme action, Enzyme kinetics, Michales-Menton equation, Enzyme inhibition.

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Recommended Books

1. Alberts et al: Molecular Biology of the Cell (Garland, 2002)
2. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
3. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd Ed.), Benjamin/Cumin, 1993
4. DeRobertis & DeRobertis: Cell and Molecular Biology (Lee & Febiger, 1987)
5. Freifelder: Physical Biochemistry (2nd Ed.), Freeman, 1982
6. Holme and Peck: Analytical Biochemistry (3rd Ed.), Tata McGraw Hill, 1998
7. Karp: Cell and Molecular Biology (John Wiley & Sons, 2002)
8. Lodish et al: Molecular Cell Biology (5th Ed.), Freeman, 2004
9. Pollard & Earnshaw: Cell Biology (Saunders, 2002).
10. Switzer and Garrity: Experimental Biochemistry 92nd Ed.), Freeman, 1999

MSZ-203
Ecology and Environmental Science
(4 Credits)

UNIT I

1. Definition and structure of ecosystems - abiotic and biotic components and their relationship.
2. Types of ecosystems – Salient features of aquatic and terrestrial ecosystems and their biotic communities.
3. Ecological energetics and energy flow- Food chains, food webs, trophic structure; concept of productivity, Measuring ecosystem productivity, Limits to primary production, patterns in primary production, Efficiency of primary and secondary production in aquatic system, Limits to secondary production.
4. Population Ecology - Population density, Growth rate, Natality, mortality, survivorship curves and life tables, Biotic potential: Generation time, net reproductive rate, reproductive values, Population and distribution, Population dispersion.

UNIT II

1. Community Ecology - Types of biotic communities, organization, population density, dominance, carrying capacity, r and K- selection, species richness, species diversity.
2. Community Development – Types of community changes, ecological succession-its causes and examples, climax community.
3. Positive and Negative interactions between two species**,** Competition theory, Niche, Habitat, Ecological Equivalents, Character displacement.
4. Liebig law of minimum, Shelford's law of tolerance, Significance of limiting factors, Ecotone and Edge effect.

UNIT III

1. Eutrophication in freshwater, coastal and marine ecosystem, Faunal interaction and changes, Remediation of eutrophication.
2. Acidification in aquatic and terrestrial environment, Consequences and control strategies.
3. Major environmental regimes of Earth, Environmental monitoring, Environmental impact assessment and environmental management plan.
4. Biogeochemical cycles –carbon, nitrogen, sulphur cycles, impact of human activity on nutrient cycles.

UNIT IV

1. Biodegradation and Bioremediation: concept, environmental limitation for bioremediation, bioremediation of ecosystem (Air/water/soil)
2. Wastes in Ecosystem and management: Agricultural wastes and Management, Biomedical wastes and Management, Domestic waste, effects and management for purification and recirculation.
3. Environmental toxicology: Diversity and classification of environmental toxins, Air pollutants, Water and soil pollutants, Food additives and contaminants, Pesticides, Metals and Solvents, Radioactive pollution.
4. National and International efforts for conservation: Indian Wildlife Protection Act, Indian Forest Act, Wildlife Trade and CITES, IUCN and criteria for Extinct (EX), Extinct in the wild (EW), critically endangered (CE), Low risk (LR), Data deficient (DD) and Not evaluated.

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Recommended Books

1. Asthana, D.K. and Asthana, M.2001. Environmental Problems and Solutions. S. Chand and Co., New Delhi.
2. Berwer. A.1988 .The Science of ecology. Saunder's college publishing.
3. Drickamer&Vessey: Animal Behaviour –Concepts, Processes and Methods (2nd ed.), Wadsworth, 1986.
4. Goodenough et al : Perspectives on Animal Behaviour, Wiley, 1993.
5. Grier : Biology of Animal Behaviour, Mosby, 1984.
6. Odum : Basic Ecology (Saunders, 1985)
7. Odum : Fundamentals of Ecology (Saunders, 1971)
8. Odum. E.P. 1996 Fundamentals of Ecology. Nataraj Publishers, Dehra Dun.
9. Raven, Berg, Johnson : Environment (Saunders College Publishing, 1993)
10. Sharma : Ecology and Environment (Rastogi Publication, 7th ed. 2000)
11. Smith, R.L.1986. Elements of Ecology. Harpet and Row Publishers, New York.
12. Trivedi, P.R.andGurdeepraj, K. 1992. Environmental Biology. Akashdeep Publishing House New Delhi
13. Turk and Turk : Environmntal Science (4rth ed. Saunders, 1993)

MSZ-204
PRACTICALS
Ecology & Environmental Science and Reproductive & Developmental Biology
(4 Credits)

1. Estimation of primary productivity in aquatic ecosystem.
2. Estimation of chloride of water sample.
3. Estimation of total alkalinity and hardness.
4. Study of zooplanktons and its role in a pond ecosystem.
5. Analysis of physical parameters of soil.
6. In vivo culture and study of chick embryo.
7. Observation of chick embryo using candling apparatus.
8. Isolation of chick embryo and preparation of whole mount.
9. Study of developmental stages of Chick/ Frog embryo from permanent slides.
10. Study of Chick/ Frog embryo using vital staining.
11. Study of different stages of estrous cycle in mice.
12. Dissection of male reproductive system of cockroach.
13. Dissection of female reproductive system of cockroach.
14. Submission of laboratory notebook.
15. Field Visit to a Protected area (Wildlife sanctuary/National Park).
16. Viva voice.

MSZ-205
PRACTICALS
Molecular Biology and Biochemistry
(4 Credits)

1. Isolation of genomic DNA from animal cell using agarose gel electrophoresis.
2. Isolation of protein from animal tissue using SDS PAGE.
3. Design of Tissue Culture Laboratory.
4. Flow chart of Hybridoma technology.
5. Quantitative estimation of DNA using diphenylamine reagent.
6. Quantitative estimation of RNA using Orcinol reagent.
7. Preparation of buffers of different pH using Henderson- Hasselbalch equation and its verification using pH meter.
8. Quantitative estimation of amino acid using ninhydrin reagent.
9. Quantitative estimation of total protein by Petsson – Lowry method.
10. Determination of glucose by Anthrone/ Benedict's reagent.
11. To study the enzymatic activity of salivary amylase on maltose.
12. Preparation of laboratory record book.
13. Viva voce

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MSZ-301
Genetics and Evolution
(4 Credits)

UNIT- I

1. Organisation of genetic material- Nucleosome, Molecular anatomy of eukaryotic chromosome.
2. Genome size and Complexity- C value paradox, Unique and repetitive DNA, Euchromatin and Heterochromatin.
3. Microbial Genetics- Bacterial Conjugation, Transformation, Transduction and Sexduction.
4. Genetic Imprinting- Imprinting of genes, Epigenetic, Epigenetic regulation by DNA methylation.
5. Somatic Cell Genetics- Cell fusion technology, Chromosome mapping, Application of Somatic Cell Genetics.

UNIT-II

1. Genetics of Cell Cycle- Cyclins and Cyclin Dependent Kinases (CDK), Regulation of CDK-Cyclin activity, Molecular basis of Cellular Check Points.
2. Sex Chromosomes- Sex determination, Role of Y chromosome, Dosage Compensation in Drosophila and Human Being, X- Chromosome inactivation, Sex chromosome anomalies.
3. Human Genetics- Normal Human Karyotyping, Autosomal chromosome abnormalities, Principle and Methods of Pedigree Analysis.
4. Genetic Counselling- Objectives, Ethics, Principle, Methods for counselling for Point mutation, Chromosomal Disorder.
5. Population Genetics- Population and gene pool, Hardy- Weinberg Law of genetic equilibrium, Calculation of gene frequencies.

UNIT-III

1. Evolution of Prokaryotes and Eukaryotes. Micro and Macro evolution.
2. Natural Selection- Concept of stabilizing selection, Frequency dependent selection, Balancing selection, Disruption selection.
3. Destabilizing factors- Mutation, Genetic drift, Migration, Meiotic drive.
4. Neural Theory- Emergence of Non Darwinian theory of evolution, Neutral theory of evolution (Kimura).

UNIT-IV

1. Isolation Mechanisms- Isolation Mechanisms and their role in speciation, Models of speciation (Allopatric, sympatric, parapatric)
2. Gene frequencies in population- The Hardy-Weinberg principle and analysis of gene frequencies in natural population. Major factors influencing gene frequencies (migration, inbreeding), effects of selection and mutation on gene frequencies. Gene flow between subpopulations.
3. Molecular basis of evolution- Constructing evolutionary trees, measures of genetic relationship among organisms, Molecular clock of evolution, Molecular phylogeny.
4. Origin and Evolution of Primates- Evolution of Anthropoid Primates, The first hominids and origin of modern man.

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Recommended Books

1. Brooker: Genetics : Analysis and Principles (Addison-Wesley, 1999)
2. DeRobertis&DeRobertis: Cell and Molecular Biology (Lee &Febiger, 1987)
3. Griffith et al: Modern Genetic Analysis (Freeman, 2002)
4. Hartl& Jones: Essential Genetics: A Genomic Perspective (Jones &Bartlet, 2002)
5. Lewin, Genes VIII (Wiley, 2004)
6. Russell: Genetics (Benjamin Cummings, 2002)
7. Snustad& Simmons: Principles of Genetics (John Wiley, 2003).
8. T.A.Brown, Genome 3rd, Ed
9. Colbert, E.H. 1969. Evolution of Vertebrates. John Wiley and Sons Inc, New York. Holstead. 1969 The Pattern of Vertebrate Evolution. Freeman and Co. San Francisco. U.S.A.
10. Hobart M. Smith, 1960 Evolution of Chordate Structure, Holt, Rinehart and Winston. Inc. New York.

MSZ-302

Parasitology, Economic Entomology and Aquatic Biology

(4 Credits)

UNIT-I:

1. **Introduction to Parasitology:** Type of parasites, Types of Host, Zoonosis, Sources of Parasitic Infection, Mode of Infection, Pathogenesis, Immunity in Parasitic Infection.
2. **Malaria:** Types of Malaria, Symptoms, Life history of *Plasmodium*, Prophylaxis and treatment of Malaria, Control of *Anopheles*.
3. **Dengue:**Symtoms, Life history of Aedes, Prophylaxis of Dengue and control of Aedes.
4. **Japanese Encephalities:** Symptoms, Life history of Japanese Encephalities virus, Pathogenecity, Prophylaxis and treatment.
5. **Leishmania:** General characterstic of Leishmania and different species; History and distribution, Morphology, Life cycle, Pathogenicity of *Leishmania donovani*; Clinical features of Kala-Azar, Post Kala-azar, dermal Leishmaniasis, Treatment and Prophylaxis.

UNIT-II:

1. Introduction to Insect Pest, Classification of Insect Pest.
2. **Pest of Major Crops:** Pest of Paddy, Wheat, Cotton, Sugarcane, Sorghum and Stored Grains.
3. **Forest Insect Pest:** Types of Pest; **Profile of some Major Forest Pest:** Sal Cockchafer, Sal Heartwood borer, Teak Defoliator, Teak Wood Borer, Casuarina and Palm (Coconut) seedling root feeder, The Chir Pine Borer, The Bamboo Borer.
4. **Sericulture:** Types of Silk Worm (Mulberry, Tasar, Muga and Eri), Diseases and Pest of Silk Worm.
5. **Lac Culture:** Biology of Lac Insects and Host Plants, Lac culture, potential of India in Lac Production.

UNIT-III:

1. **Aquatic resources:** Inland water resources, Global water balance, conservation and management of water resources. Classification and Diversity of water resources.
2. **Characteristic features:** freshwater, brackish water and marine water environment.
3. **Aquatic ecosystem:** Light and role of visible ray, thermal profile, dissolved oxygen, salinity, ionic concentration, carbondioxide and role of nutrients.
4. **Classification** of planktons, diurnal variations of planktons and their role in aquatic ecosystem. Attributes of nektons, sestons, neustons, benthos, macroinvertebrates and macrophytes.

UNIT-IV:

1. **Aquarium fish keeping:** Ornamental Fishes of India special reference to North East India, common aquarium fishes; Aquarium Maintenance.
2. **Fisheries management:** Composite fish culture, fish diseases, Fish preservation, Prawn and Pearl Culture, Exotic and Indigenous food Fishes of NE India.
3. **Concept** of Cryopreservation and Transgenic Species, Live Gene Bank of Fish Species and its importance in conservation.
4. **Method** of Genetic Selection and Hybridization of Cultured Fish Species.

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Recommended Books

1. Tembhare, D.B. 2012. Modern Entomology, 2nd Ed., Himalaya.
2. Mani, M.S., 1982. General Entomology, 3rd Ed., Oxford & IBH Publishing Co. Pvt. Ltd.
3. Mani, M.S., 1995. Insects. National Book Trust, India
4. P.G.Fenemore, Alkaprakash. 1992. Applied Entomology, Wiley Eastern Ltd., Delhi.
5. Nayar, K.K., Ananthakrishnan, T.N. and B.V. David. 1989. General and Applied Entomology. Tata McGraw Hill Publications, New Delhi.
6. Larry P.Pedigo. 1989. Entomology and Pest Mangement. Prentice Hall, New Jersey.
7. Metcalf, C.V. and Flint, W.P. 1979. Destructive and useful insects, their habitats and control. Tata McGraw Hill Publications, New Delhi.
8. Ramakrishna Ayyar T.V. 1989. Handbook of Economic Entomology for South India. Books and Periodicals Supply Service, New Delhi.
9. Brown, M.E. Physiology of fishes, Vols. 1 and 2, Academic press, 1957
10. Lagler, K. F., Bardach J.E., Miller R.R. and May Passino, D.R. Ichthyology, John Wiley, 2003.

MSZ-303A (Special Paper)
Cell and Molecular Biology-I
(4 Credits)

UNIT- I:

1. Cellular membranes- Nature of Plasma membrane, Molecular composition and arrangement of cell membranes, Functional consequences of proteins, lipids and carbohydrates in the cell membrane.
2. Membrane transport- Recapitulation of Plasma membrane, diffusion, osmosis, fascilitated diffusion, active transport and pumps, uniports, symports and antiports.
3. Lipid peroxidation- mechanism of Lipid peroxidation and role of cytomembrane in health and diseases.

UNIT-II:

1. Membrane targeting of Protein- Processing through endomembrane system, Targeting of cytosolic protein, Protein trafficking mechanism.
2. The Nucleus- Molecular structure of Nucleus, Structure of Nucleolus, Biogenesis of ribosomes, Nuclear receptors, Protein imports into cell nucleus.

UNIT-III:

1. Genomics- Genomes, Transcriptomes, Proteomes, their molecular features and functions.
2. Mitochondrial genome- Mitochondrial DNA, Structure of mitochondrial DNA, Expression and Variability.
3. Genome Mapping- Molecular Markers for genome mappings (SNP, VNTR, RAPD, RFLP, SSR), Genetic mapping of Genome, Physical mapping of Genome.

UNIT-IV:

1. Sequencing Genome- Maxam and Gilberts chemical degradation method, Sanger and Coulson method, Automated DNA sequencers, Contiguous DNA sequencing, Directed shotgun approach.
2. Analysing Genome Sequences- DNA sequence analysis using Bioinformatics softwares.

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Recommended Books

18. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
19. Biochemistry (3rd Ed.), Tata-McGraw Hill, 1990
20. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd Ed.), Benjamin/Cumin, 1993
21. DeRobertis&DeRobertis: Cell and Molecular Biology (Lee &Febiger, 1987)
22. Hartl& Jones: Essential Genetics: A Genomic Perspective (Jones &Bartlet, 2002)
23. Karp: Cell and Molecular Biology (John Wiley & Sons, 2002)
24. Lodish et al: Molecular Cell Biology (5th Ed.), Freeman, 2004
25. Pollard &Earnshaw: Cell Biology (Saunders, 2002).
26. Snustad& Simmons: Principles of Genetics (John Wiley, 2003).
27. T.A.Brown, Genome 3rd, Ed

MSZ -303B (Special Paper)
Animal Ecology and Wildlife Biology-I
(4 Credits)

UNIT:I

1. Ecology and Environment: Biotic and abiotic interactions, Habitat, Niche, Niche Width and Overlap, Fundamental and Realized niche, Resource partitioning, Competitive displacement, Ecological equivalents.
2. Population and Community Ecology: Species richness, Global patterns in species richness, Biotic and abiotic theories of species richness, Species diversity, Ecotone, Edge effect.
3. Competition and co-existence: Types of species interaction, Gause's principle, Effect of exotic competitors on local fauna-case study.

UNIT:II

1. Ecosystem Cybernetics: Meaning of stability and stability concept, Types of Stability, Resistance and resilience stability, Gaia hypothesis, Relationship of species diversity and stability, Stability of isolated populations.
2. Energy in the environment- Energy flow in the ecosystem, energy flow models, techno-ecosystems, ecological footprint.

UNIT:III

1. Management of rare and endangered species, Control of weed species, Distribution, status, threats to survival of Elephant, Greater Adjutant stork, Rhino (with special reference to NE India)
2. Captive Breeding of Wild Animals: Management, problems and prospects, Case studies with special reference to NE India.
3. Special Management Program of Wild Animals in India: Project Tiger, Operation Rhino, Project Elephant.

UNIT:IV

1. Wildlife Habitat: Forest types in NE India, Wetland habitat, Ramsar convention, Wetlands and their role in biodiversity conservation, National parks, Sanctuaries, Biosphere Reserve, Community Reserves.
2. Conservation and management of wildlife: Past and present strategies in conservation, Implications of succession in management of wildlife -Case studies: Manas NP, Kaziranga NP, Orang NP, Habitat destruction, Impact of forest fragmentation on wildlife.
3. Wildlife Legislation: Wildlife Protection Act, 1972, National Forest Policy, 1988, National Wildlife Action Plan, 2002, National and State Biodiversity Action Plans, Relevant Forest and Environmental Acts and amendments.

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Recommended Books

1. Bahuguna&JMallick. Handbook of the Mammals of South Asia, Nataraj Publication.
2. Odum : Basic Ecology (Saunders, 1985)
3. Odum : Fundamentals of Ecology (Saunders, 1971)
4. Primark : A Primer of Conservation Biology (2nd ed. Sinauer Associates)
5. Rajesh Gopal. Fundamentals of Wildlife Management, Nataraj Publication.
6. Raven, Berg, Johnson : Environment (Saunders College Publishing, 1993)
7. Sharma : Ecology and Environment (Rastogi Publication, 7th ed. 2000)
8. SurenderMehraStudy and Practise of Wildlife Laws in India, Nataraj Publication
9. Turk and Turk : Environmental Science (4rth ed. Saunders, 1993)
10. C.P. Prakasan& R.B. Bhagat Population & Environmental Linkages –
11. RanuGadi Environmental Studies
12. P.D. Sharma Ecology & Environment

MSZ–303C (Special Paper)
Fish & Fishery Biology-I
(4 Credits)

Unit–I : Anatomy and Physiology

1. Skeletal system of teleost – cranium, visceral arches, vertebral column and caudal vertebrae. Integument, types of scales. Pigmentation and colouration.
2. Swim bladder: General structure, composition of gas, hydrostatic control and function. Respiration: aquatic respiration, gills, respiratory pump, gas exchange. Air breathing: condition of air breathing, accessory respiratory organs.
3. Excretion and Osmoregulation. Kidney glomerular and aglomerular, excretion of nitrogenous wastes, water and ion balance. Stenohaline and euryhalineteleosts. Osmoregulation in migratory teleosts.
4. Digestion. Alimentary canal and its modification in relation to food and feeding habits. Physiology of digestion.

Unit–II: Applied Fish & Fishery

1. Fish diversity, classification and systematic. Classification of fishes of Northeast India. Identification of commercial, endemic and ornamental fishes Northeast India.
2. Endangered fishes of Northeast India.
3. Fishes indices: Length weight relationship, hepatosomatic index, ponderal index, index of fullness, index of preponderance, index of brightness. Maturity, fecundity and gonadosomatic index.

Unit–III: Inland capture Fisheries

1. Inland capture fisheries of India (with special reference to River Brahmaputra and its fisheries). Dams and their effect on fish migration, remedies.
2. Coldwater fisheries: Definition, characteristics of coldwater fisheries, adaptation of coldwater fishes. Game fishery.
3. Non-piscian fisheries, hill stream fishery, wetland fishery (Beel).

Unit–IV: Fish nutrition, Fish food, Haematology and Biochemistry

1. Fish nutrition —supplementary feeding, different kinds of process of feeds, feed ingredients, and fish feed formulations.
2. Fish food organisms: zooplankton, phytoplankton and their role in fisheries.
3. Biochemical composition of fish.

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Recommended Books

1. Brown, M.E. 1957. The Physiology of Fishes. Academic Press, New York Vol. 1 & 2.
2. Brown, M.E. Physiology of fishes, Vols. 1 and 2, Academic press, 1957
3. Evans, D.H. Physiology of Fishes, II Edn.
4. Hoar, W. & Randall, Fish Physiology, Vol I-XV., Acad. Press.
5. Hoar, W.S. & Randall, O.J. Fish Physiology, Vols I-X, Academic Press,1969- onwards
6. Jayaram, K.C. 2008. Fishes of the Indian Region. Narendra Pub., New Delhi
7. KitabMahal ,1985
8. Lagler, K. F., Bardach J.E., Miller R.R. and May Passino, D.R. Ichthyology, John Wiley, 2003.
9. Lagler, K.F., J.E. Bardach, R.R. Miller & D.R.M. Passino. 1977. Ichthyology. John Willey & Sons, New York.
10. Nelson, J. 2006. Fishes of the World., 4thEdn., Willey Eastern Bk. Ltd.
11. Norman and Greenwood: A History of Fishes, Third Ed., Ernest Bvenn Limited, 1975.
12. S.S. Khanna and H. R. Singh. A textbook of Fish Biology and Fisheries, Narendra Publishing House, 2003
13. Srivastava, C.B.L. A Textbook of Fishery Science and Indian Fisheries,
14. Vishwanath, W., P. C. Mahanta, S. Debajit& N. Anganthoibi. 2011. *Coldwater fishes of India—an atlas.* Directorate of Coldwater Fisheries Research (Indian Council of Agricultural Research), Bhimtal.
15. Vishwanth, W., W. S. Lakra & U. K. Sarkar. 2007. *Fishes of north east India*. National Bureau of fish genetic resources, Lucknow, ICAR, India.

MSZ-303D (Special Paper)
Entomology: Insect Structure and Function-I
(4 Credits)

UNIT: I

1. **Segmentation and Body Regions of Insects:** The Head- Head segmentation, Head Skeleton, Tentorium, Modification in Head Capsule, Cephalic Appendages, Cervix or Neck; The Thorax- Thoracic Segmentation, Thoracic Skeleton, Endothorax, Thoracic Appendages, Locomotion; The Abdomen- Segmentation, Skeletal Composition, Pre genital, Genital and Post Genital Segments.
2. **The Mouthparts of Insects:** Different types of Mouthparts, Evolution of Mouthparts, Control of Feeding. **The Wings of Insects:** Origin of Wings, Morphological variation, Structure and Insect flight.
3. **Insect Integument:** Structure of Insect Integument, Chemical composition of cuticle-chitin, Cuticular proteins, Reselins, Protective functions of cuticular proteins, cuticular lipids, Cuticular modification, Moulting, Sclerotization and functions of Integument.

UNIT: II

1. **Musculature:** Basic Structure and Function of Muscles, Arrangement of muscle, Musculature of Head, The Thoracic Musculature, The Abdominal muscles, muscles attachment to exoskeleton, Skeletal muscle, Synchronous and Asynchronous muscle, Muscles involved in locomotion, Adaptation for running, jumping and walking, Morphology and Physiology of Nonskeletal muscle- visceral muscles, heart muscle and alaray muscle.
2. **The Visual Organs:** The dorsal Ocelli, The Stemmata, The Compound eyes- Structure and functions. **The Sense Organs:** The General Classification of Sensory receptors, The Mechanoreceptors, The Chemoreceptors and Thermohygroreceptors. **The Effector Organs:** The sound producing organs and light producing organs.
3. **Development:** The Insect Egg, Early Embryonic Development, Embryonic Dynamics, Post embryonic development and metamorphosis.

UNIT: III

1. **Endocrine System and Functions:** Anatomical Organization, Structure, Hormones, Endocrine Control of Metamorphosis, Endocrine Control of Reproduction, Endocrine Control of Diapause, Endocrine Control of Intermediary metabolism, Endocrine Control of Osmoregulation, Hormones in Pest Control.
2. **Glands:** Secretion and Functions, Exocrine gland, Silk gland, Wax glands, Cephalic glands, Attractant glands and Poison glands.
3. **Ectohormones:** Pheromones and Allomones.

UNIT: IV

1. **Classification of Insects:** Modern Scheme of Insect Classification, Extinct Insect orders, Apterygote Orders, Palaeopteran Orders, Polyneopteran orders, Order Isoptera, Paraneopteran Orders, Oligoneopteran Orders.
2. **Mantophasmatodea, A new Insect Taxon:** Characters, Classification and Phylogeny.

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Recommended Books

1. Chapman, R.F., 1998. The Insect Structure and Function, Cambridge University Press.
2. Mani, M.S., 1882. General Entomology, 3rd Edition, Oxford & IBH Publishing Co. Pvt. Ltd.
3. Mani, M.S., 1995. Insects, National Book Trust, India.
4. Publishing House.
5. Saxena, S.C., 1992. Biology of Insects, Oxford & IBH Publishing Co. Pvt. Ltd.
6. Tembhare, D.B., 2012. Modern Entomology, 2nd Revised Edition, Himalaya
7. Wigglesworth, V. B., 1950. Principle of Insect Physiology, Methuen Publishers.
8. Wigglesworth, V. B., 1968. Insect and Physiology, American Elsevier Pub. Co.

MSZ-304
PRACTICAL
Genetics and Evolution; Parasitology, Economic Entomology and Aquatic Biology
(4 Credits)

1. Identification of some mammalian parasites, Insect Pest and Ornamental fishes of North East India.
2. Study of Insect diversity.
3. Study of the morphological adaptations in hill stream fishes of North east India.
4. Extraction of pituitary gland from carps.
5. Visit to pond fisheries for demonstration of fishery management.
6. Estimation of Transparency of near by fish pond using Sacchi Disc.
7. Estimation of free Co_2 and dissolved O_2 from the water samples collected from near by ponds.
8. Preparation of culture medium of Drosophila. Method of maintainance and Sex Determination.
9. Identification of mutant variety of Drosophila.
10. Karyotyping using human metaphase Chromosomes plate.
11. Submission of Practical Records Book.
12. Viva voce.

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MSZ—305A
PRACTICALS (Special)
Cell and Molecular Biology-I
(4 Credits)

1. Preparation of culture media for protozoan culture.
2. Identification of different variety of freshwater protozoa.
3. Study of mutants in *Drosophila*.
4. Squash preparation of onion root tip to study different stages of mitosis.
5. Effect of drugs on cell division (Colchicines or any other inhibitor).
6. Isolation of genomic DNA by salt precipitation method.
7. Isolation of genomic DNA by using phenol method.
8. Separation of genomic DNA using Agarose gel electrophoresis.
9. Isolation of protein from animal liver.
10. Separation of protein using SDS- PAGE.
11. Practical record book
12. Viva voce

MSZ—305B
PRACTICALS (Special)
Animal Ecology and Wildlife Biology-I
(4 Credits)

1. Identification of Invertebrate and Vertebrate fauna.
2. Identification of important food plants of Wild animals.
3. Study of Morphological characters of birds, lizards, frogs and turtles.
4. Collection and preservation techniques of Herpetofauna.
5. Shannon-Weiner diversity index.
6. Community dominant index.
7. Similarity and Dissimilarity index.
8. Activity budgeting in mammals.
9. Line transects and point transects methods.
10. Foliage height diversity index.
11. Use of GPS for Wildlife study.
12. Radio Collar technique.
13. Viva voce.
14. Practical Notebook.

MSZ—305C
PRACTICALS (Special)
Fish & Fishery Biology-I
(4 Credits)

Collection of common local freshwater fishes — identification classification and use of key characters, description, study of different adaptations of hill stream mode of life.

2. Dissection of accessory respiratory organs in *Notopterus/* catfishes/ *Anabas/* Carps.

3. Dissect and display Weberian ossicle of a teleost, e.g. *Labeo*.

4. 9^{th} and 10^{th} cranial nerves of *Notopterus/ Wallago*.

5. Slide preparation, haematology, body parts, and viscera microtomy.

6. Identification of haematological and histological slides, bones, and fishing gears.

7. Examination of gut contents, qualitative and quantitative.

8. Study of food and feeding habits of fishes: Bucco-pharynx of economically important fishes, pharyngeal teeth.

9. Submission:

    i) Slide (at least 5)

    ii) Skeleton submission

    iii) Specimen submission

    iv) Fishing gears.

10. Practical record book.

11. Viva-voce.

MSZ-305D
PRACTICALS (Special Paper)
Entomology: Insect Structure & Function-I
(4 Credits)

1. Mounting of mouthparts of mosquito, cockroach, butterfly and honeybee.
2. Mounting of legs, antennae and wings (at least of two types).
3. Mounting of Stored grain pest.
4. Preparation of arolium, empodium and pollen basket.
5. Mounting of Sting Apparatus of Honey bee.
6. Preparation and Identification of Haemocytes.
7. Detection of Uriase.
8. Detection of Chitin.
9. Study of insect collecting devices.
10. Study of methods of insect collection and preservation.
11. Study of insects of economic importance.
12. Collection and Identification of Stored grain pest, Paddy pest, pest of vegetables, Pest of pulses and Tea pest.
13. Practical Record Book.
14. Viva Voce

MSZ-306
MDC: Bio-resource and Wildlife Management
(Credit 4)

Unit-I

1. Bioresource: Definition and its type.

1.1 Natural resource- Definition, Renewable and Non-renewable source.

1.2 Mineral resource- Types and its importance.

1.3 Wildlife resources.

1.4 Water resources- Types of water resource, utilisation of water resources.

1.5 Animal resource- Sericulture resource, Aquaculture resource.

1.6 Land resources.

Unit-II

2. Wildlife: Definition and Objectives

2.1 Wildlife – Importance of wildlife.

2.2 Wildlife Conservation – Policies and methods.

2.3 Depletion of Wildlife and its causes.

2.4 In-situ conservation and Ex-situ conservation

2.5 Laws of Wildlife protection – Wildlife Protection Act, 1972.

Unit-III

3. Management of Wildlife

3.1 Principles of Wildlife management

3.2 Management of Wildlife habitat

3.3 Management of Zoo, Wildlife Sanctuary, National Parks.

3.4 Wildlife Census techniques, Documentation of Wildlife.

3.5 Problems of Wildlife management- Wildlife Trafficking, Poaching, Poisoning, Habitat destruction and Encroachment.

Unit-IV

4. Forest Management.

4.1 Introduction to forest

4.2 Forest types in Northeast India

4.3 Forest as a resource

4.4 Conservation of forest

4.5 Silviculture: Definition and objectives.

MSZ-401
Immunology, Bioinformatics and Research Methodology
(4 Credits)

UNIT-I

1. Immune System- Concept of immunity and development of the immune system, Innate and Acquired immune system.
2. Cells of Immune system- WBC, macrophages, Dendritic cells, B Cells, T Cells, NK Cells.
3. Organs of Immune system- Primary and secondary lymphoid organs, their structure and functions.
4. Antigens- Immunological property of antigens, factors influencing antigenicity.
5. Antigen Presentation- Antigen Presenting Cells (APC), Dendritic Cells, Major Histocompatibility Complex (MHC).

UNIT -II

1. Immunoglobulin- Immunoglobulin classes, Structure and domain of immunoglobulin molecules, Ig superfamily. Antibody affinity and avidity.
2. Antigen Recognition- T and B Cell receptor, Antigen receptor diversity.
3. Antigen-antibody reaction- Cross reactivity, Agglutination reaction, Diffusion in agar gel, Radioimmunoassay, ELISA.
4. Monoclonal and Polyclonal Antibody and its application
5. Immunological memory and Vaccination.

UNIT-III:

1. **Introduction to bioinformatics**- Definitions of bioinformatics, applications of bioinformatics and scope of bioinformatics.
2. **Biological Databases**- Primary databases - **Nucleotide sequence databases**: GenBank, EMBL, DDBJ; **Protein sequence databases**: SWISSPROT, PIR; **Structure databases**: PDB, NDB; **Secondary databases**: PROSITE, Pfam, CATH; **Literature database**: PubMed; **Database searching** – Entrez; **Database sequence submission** – BankIt.
3. **Database Searching-** Homology searching, Sequence similarity search tool- BLAST and FASTA.
4. **Sequence alignment and analysis**- Types of sequence alignment, Methods of sequence alignment, Scoring schemes, Data retrieval, Construction of phylogenetic trees.
5. **Systems Biology**-Introduction, metabolomics, gene network, synthetic biology.

UNIT-IV

1. **Basic concept of research:** Meaning of research, Objectives of research, Motivation in research, Significance in research, Research versus Research methodology. **Types of research:** Description/ Analytical, Applied/ Fundamental, Quantitative /Qualitative, Conceptual/ Empirical.
2. **Research formulation and Designs:** Observation and Facts, Prediction and Explanation, Induction, Basic principle of Research design; Meaning, Need and features of good design, Types of Research design.
3. **Literature Review:** Importance of literature review, Critical Literature review, Identifying gap areas from literature review.
4. **Intellectual Property Rights (IPR):** Copy right, Designs, Patents, Trademarks, Geographical Indication.
5. **Bioethics:** Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

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Recommended Books

1. Zubay et al: Principles in Biochemistry (2nd Ed.), WCB, 1995
2. Rawn: Biochemistry, Neil Patterson, 1989
3. Mahler &Cordes: Textbook of Biological Chemistry, Harper, 1966.
4. Nelson et al: .Lehninger Principles of Biochemistry (3rd Ed.), MacMillan Worth, 2000
5. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
6. Mathews et al.: Biochemistry (3rd Ed.), Pearson, 2004
7. Ivan Roitt: Essential Immunology (6th Ed.) Oxford, Backwill, Science Publication London.
8. Elgert: Immunology understanding the immune system, John Willy & Sons, Inc. Publication, New York, 1996.
9. Abbas et al. cellular and Molecular Immunology (3rd Ed.) W.B. Saunders Company, 2000

MSZ-402A
Special Paper
Cell and Molecular Biology-II
(4 Credits)

UNIT-I:

1. Receptors: G- Protein coupled receptors, Receptor tyrosine kinases (RTK), Ion channel receptors, Cytokine receptors (Tyrosine kinase linked receptors)
2. Second messengers: Inositol 1,4,5-trisphosphate (IP3), Di-acyl glycerol (DAG) Signaling pathways.
3. Cytoskeleton and Cell motility- Structure and dynamics of microtubules, microfilament and intermediate filament. Microtubule motors and their movement.

UNIT-II:

1. Apoptosis- Programme Cell Death, The extrinsic and intrinsic pathway for apoptosis.
2. Biology of Cancer- Difference between normal and Cancer cells, Oncogene and role in Cancer, Tumour suppressor gene.
3. Biology of Ageing- Cellular basis of ageing, Causes of ageing, Oxidative damage, Genetic instability, mitochondrial genome damage.

UNIT-III

1. Vectors- Plasmds, Cosmids, Bacteriophage, BAC and YAC vectors.
2. Molecular Cytogenetic Techniques- FISH, Chromosome painting, Flow Cytometry, Polymerase Chain Reaction (PCR), Microarray.
3. Restriction enzymes and DNA modifying enzymes.

UNIT-IV:

1. **Cloning Methodologies** -Gene isolation: Shot gun method, Genome libraries, cDNA libraries, Chemical synthesis.
2. Splicing and integration of isolated gene- cohesive end ligation, homopolymer tailing, extending linkers.
3. Methods of rDNA transfer to host cells- CaCl2 treatment, Virus delivery. Selection and screening of the transformed cells, Blue-white screening, Colony hybridization methods, Reporter genes, Fusion proteins.
4. Application of rDNA technology- Cord blood banking and recent advances in stem cell research (with examples). Cancer vaccines, Human Genome Project.

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Recommended Books

28. Pollard &Earnshaw: Cell Biology (Saunders, 2002).
29. Alberts et al: Molecular Biology of the Cell (Garland, 2002)
30. Berg et al.: Biochemistry (5th Ed.), Freeman, 2002
31. Biochemistry (3rd Ed.), Tata-McGraw Hill, 1990
32. Boyer: Modern Experimental Biochemistry and Molecular biology (2nd Ed.), Benjamin/Cumin, 1993
33. Brooker: Genetics : Analysis and Principles (Addison-Wesley, 1999)
34. DeRobertis&DeRobertis: Cell and Molecular Biology (Lee &Febiger, 1987)
35. Snustad& Simmons: Principles of Genetics (John Wiley, 2003).
36. Hartl& Jones: Essential Genetics: A Genomic Perspective (Jones &Bartlet, 2002)
37. Karp: Cell and Molecular Biology (John Wiley & Sons, 2002)
38. Lewin, Genes VIII (Wiley, 2004)
39. Lodish et al: Molecular Cell Biology (5th Ed.), Freeman, 2004
40. Russell: Genetics (Benjamin Cummings, 2002)
41. Griffith et al: Modern Genetic Analysis (Freeman, 2002)
42. Switzer and Garrity: Experimental Biochemistry 92nd Ed.), Freeman, 1999

MSZ -402B
Special Paper
Ecology and Wildlife Biology-II
(4 Credits)

UNIT:I

1. Biogeography and conservation: Theory of Island biogeography, Relation of Island factor with present day conservation networks, Gap Formation, Gap dynamics, Forest fragmentation.
2. Environmental monitoring and management: Ecological principles of Management, Role of ecologists in the management of natural ecosystem, Management techniques, Planning of ecosystem management, Ecological risk assessment, Environmental monitoring, Environment impact assessment.

UNIT:II

1. Restoration ecology: Restoration and its strategies, Restoration of terrestrial and aquatic ecosystems, Relevance of restoration ecology to present day scenario.
2. Behavioural Ecology: Habitat selection in animals, Factors restricting habitat use, Optimal foraging theory, Food selection, Predator Prey Interactions - Functional Strategies, Living in groups, Kin selection, Altruism, Reciprocal altruism, Social systems of mammals - Primates.

UNIT:III

1. Man and Wildlife: Issues of eco-development, Community participation in wildlife management, Sacred grooves, Man animal conflict- Case studies.
2. Wildlife Health: Importance of wildlife health management, Major diseases of wild animals in captivity and in the wild, Global health and zoonotic diseases.
3. Wildlife Trade: Assessment and documentation, Preventive measures and trans-boundary problems, Laws governing wildlife trade, ethics.

UNIT:IV

1. Importance of monitoring animal population and their habitats, Habitat assessment by indices- Community dominance index, Canopy coverage, Foliage Height diversity, Similarity and dissimilarity index, Association index
2. Wildlife Behaviour: Migration and its causes, communications and signaling, territoriality, home range, scent marking, courtship behavior, mating systems.
3. Wildlife Tools, Techniques and Practices, Wildlife census techniques- direct and indirect methods, Modern census techniques used for rhino, tiger, migratory birds, GPS, GIS, Telemetry.

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Recommended Books

1. Rajesh Gopal. Fundamentals of Wildlife Management, Nataraj Publication.
2. Sharma : Ecology and Environment (Rastogi Publication, 7th ed. 2000)
3. Bahuguna&JMallick. Handbook of the Mammals of South Asia, Nataraj Publication.
4. Odum : Basic Ecology (Saunders, 1985)
5. Odum : Fundamentals of Ecology (Saunders, 1971)
6. Primark : A Primer of Conservation Biology (2nd ed. Sinauer Associates)
7. Raven, Berg, Johnson : Environment (Saunders College Publishing, 1993)
8. SurenderMehraStudy and Practise of Wildlife Laws in India, Nataraj Publication
9. Turk and Turk : Environmental Science (4rth ed. Saunders, 1993)

MSZ–402C
Special Paper
Fish & Fishery Biology-II
(4 Credits)

Unit–I. Freshwater aquaculture

1. Aquaculture: definition, scope and importance, concepts of different system of freshwater aquaculture–monoculture, composite pisciculture, sewage fed fish culture, raft, raceway, pen and cage culture, and paddy cum fish culture; extensive, intensive, semi-intensive and traditional system of fish farmings.
2. Fish related aquatic microphytes of Northeast India. Macrophytes and their roles in aquaculture.
3. Management aspect of fish ponds (Nursery, rearing and stocking ponds). Pre and post stocking management of nursery pond.
4. Air breathing fish and its importance in fishery.

Unit–II. Fishery Technology.

1. Fishing gears: nets and crafts of Northeast India, selection of fishing gears, types of fishing gear used in different freshwater bodies.
2. Economic importance of fish and fishery in relation to human health.
3. Exotic fish culture: selection of species, invasive species and its impact on natural fisheries.

Unit–III. Fishery management

1. Fish health management: Diseases in aquaculture, parasitic and non-parasitic: bacterial, viral and fungal pathogens of fish. Fish pathology: prophylaxis and therapy.
2. Fish environment: relationship between environment and fisheries, pollution of water pollution and impact on fisheries. Physical and chemical characteristics of water and soil.
3. Fish processing and preservation: Principles and method of processing and preservation of fish by refrigeration and freezing, drying, salting, canning, smoking and pickling. Fish by products of their economic importance.

Unit–IV. Fish endocrinology, reproduction, genetics and biotechnology

1. Endocrine glands: Pituitary gland, thyroid gland and parathyroid gland, islet of Langerhans, Epiphysial gland etc., structure and functions.
   Reproduction: Functional morphology of gonads, types and modes of reproduction. Induced breeding: hypophysation, natural and synthetic hormones, bundh breeding.
2. Heredity and variation in fishes, chromosomes in fishes, sex determination in fishes. Fish biotechnology: Gynogenesis, androgenesis and polyploidy. Hybridization and monosex culture or sex reversal: procedure and advantages. Transgenic fishes: merits and demerits.

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Recommended Books

16. Brown, M.E. Physiology of fishes, Vols. 1 and 2, Academic press, 1957
17. Evans, D.H. Physiology of Fishes, II Edn.
18. Hoar, W. & Randall, Fish Physiology, Vol I-XV., Acad. Press.
19. Vishwanath, W., P. C. Mahanta, S. Debajit& N. Anganthoibi. 2011. *Coldwater fishes of India—an atlas.* Directorate of Coldwater Fisheries Research (Indian Council of Agricultural Research), Bhimtal.
20. Jayaram, K.C. 2008. Fishes of the Indian Region. Narendra Pub., New Delhi
21. KitabMahal ,1985
22. Lagler, K. F., Bardach J.E., Miller R.R. and May Passino, D.R. Ichthyology, John Wiley.
23. Lagler, K.F., J.E. Bardach, R.R. Miller & D.R.M. Passino. 1977. Ichthyology. John Willey & Sons, New York.
24. Nelson, J. 2006. Fishes of the World., 4thEdn., Willey Eastern Bk. Ltd.
25. Norman and Greenwood: A History of Fishes, Third Ed., Ernest Bvenn Limited, 1975.

MSZ-402D
Special Paper
Entomology: Insect Physiology and Economic Entomology-II
(4 Credits)

UNIT: I

1. **Digestive System:** The Alimentary Canal, The Salivary Gland, Insect Nutrition, Intestinal Micro-organism, Physiology of Digestion and Absorption.
2. **Respiratory System:** The Organs of Respiration, Mechanism of Gaseous Exchange, Respiration in Aquatic Insects, Physiology of Gill and Plastron Respiration, Respiration in Terrestrial insects- different types of spiracles and their structure, opening and closing mechanism of spiracles, trachea and tracheoles, Respiration in EntomophagusEndoparasites.
3. **Circulatory System:** Components- The haemocoel, The dorsal vessel, Accessory Pulsatile Organs, Phagocytic organs, The haemolymph, Chemical composition of haemolymph, different types of haemocytes and their functions; Mechanism of Blood circulation.

UNIT: **II**

1. **Excretory System:** Types of Excretory system, The organs of Excretion, The accessory organs of Excretion, Physiology of excretion, Malpighian tubules- Anatomy and Histology.
2. **Nervous System:** Different types of Neurons, The Central Nervous system, Gross anatomy and Microanatomy of Brain, The Sympathetic Nervous System and nerve impulse transmission.
3. **Reproductive Reproductive System:** The male reproductive system, The female reproductive system, Egg Maturation, Specialized Reproductive Mechanism, Hormonal control of reproduction.
4. **Types of Reproduction:** Ovoviviparity, Viviparity, Parthenogenesis, Paedogenesis, Polyembryony, Alternation of generation.

UNIT:III

1. **Insects Pests:** Classification of Pest, Pests of major crops- Pests of paddy, Pests of Wheat, Pests of Sugarcane, Pests of Cotton and Pests of Stored grains.
2. **Pests of Medical Importance:** Mode of Transmission, Common Vectors Insects- The Mosquitoes, The Sand flies, The Black flies, The tsetse flies.
3. **Forest Insect Pest:** Types of Pest, Profile of some forest insect pest of Teak, Sal and Bamboo trees.
4. **Pest Control:Primary Control Measures**- Mechanical measures, Physical measures, Cultural measures, Legislative measures, Quarantine measures; **Chemical Control**- Insecticidal formulation, Classification of Insecticides, Insecticidal Pharmacodynamics, Mode of action of Insecticides, Drawbacks of Chemical control; **Modern Trends in Pest Control**- Biological Control, Autocidal control, Integrated Pest Management

UNIT-IV:

1. **Immunity in Insects:** Mechanism of Innate Immunity in Insects; Antibacterial Immunity: Signalling pathways, Insect antibacterial protiens; Antiviral immunity: Antiviral RNAi Response, Regulation of antimicrobial peptide gene expression by JAK-STAT pathways; Bacterial resistance to Insect immunity; The Biological significance of Immunity.
2. **Forensic Entomology:** Principle and Scope, Forensic Insects and Factors and Forensic Entomological Investigation Methodology.

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Recommended Books

1. Alford: A textbook of Agricultural Entomology, Blackwell Science Ltd. 1999
2. Atwal: Agricultural pests of India and south-east Asia, Kalyani Publishers, New Delhi, 1986.
3. Busvine: Insects and Hygiene, Chapman and Hall, (3rd ed.) 1980
4. Chandler & Read: Introduction to Parasitology, Willey International, 1970
5. Chapman, R.F., 1998. The Insect Structure and Function, Cambridge University Press.
6. Dhaliwal and Arora: Principlals of Insect pest management, National Agricultural Technology Information Centre, Ludhiana, 1996.
7. Dhaliwal and Arora: Trends in Agricultural Insect pest Management, Commonwealth Publ., New Delhi, 1994
8. Gillot: Entomology (2nd ed.) Plenum Press, New York, 1995
9. Gullan& Cranston: The Insects: An Outline of Entomology (2nd ed.) Blackwell Science, 2000.
10. Harborne: Introduction to Ecological Biochemistry (4th ed.) 1993
11. Imms: A General Text Book of Entomology 2 Vols. Asia Publishing House, 1977
12. Klowden: Physiological Systems in Insects, Academic Press, 2002
13. Mani, M.S., 1882. General Entomology, 3rd Edition, Oxford & IBH Publishing Co. Pvt. Ltd.
14. Mani, M.S., 1995. Insects, National Book Trust, India.
15. Norris et al. Concepts in Integrated Pest management Prentice-Hall, New Delhi, 2002
16. Saxena, S.C., 1992. Biology of Insects, Oxford & IBH Publishing Co. Pvt. Ltd.
17. Srivastava: A testbook of Applied Entomology Vol. I & II (2nd ed.) Kalyani Publ., 1988, 1993
18. Tembhare, D.B., 2012. Modern Entomology, 2nd Revised Edition, Himalaya
19. Wigglesworth, V. B., 1950. Principle of Insect Physiology, Methuen Publishers.
20. Wigglesworth, V. B., 1968. Insect and Physiology, American Elsevier Pub. Co.

MSZ-403
PRACTICALS
Immunology, Bio-Informatics and Research Methodology
(4 Credits)

1. Study of Histological Slides: T.S. of Spleen, Thymus, Lymph nodes, etc.
2. Separation of Lymphocytes from whole blood.
3. Blood film preparation and identification of WBC.
4. Anitgen-antibody reaction-haemagluttination.
5. Collection of Plasma and serum from blood.
6. Photographs of hypersensitive reactions in human.
7. Demonstration of ELISA.
8. Database search and data retrieval using NCBI.
9. Method of sequence alignment- BLAST & Clustal W.
10. Construction of Phylogenetic tree by using Phylip.
11. Visualization of Protien structure by using RASMOL.
12. Protein structure stability using Ramachandran Plot.
13. Preparation of index and reference cards.
14. Preparation of practical record and submission of materials related to above.
15. Viva voce

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MSZ-404 A
PRACTICALS (Special Paper)
Cell and Molecular Biology-II
(4 Credits)

1. Identification of different types of cancer cells.
2. Cytological staining for mitochondria by Altman aniline fuchsin technique/ Novelli's acid fuchsin technique
3. Cytological staining for Golgi body by Ludford's Osmium tetraoxide technique/ Elfman's direct silver technique.
4. Supra vital staining of cells by Neutral Red – Janus Green B.
5. Histochemical staining of DNA by Feulgen reagent technique.
6. Histochemical staining of Protein by Chapman's mercury bromophenol blue technique.
7. Extraction of Genomic DNA by phenol-chloroform / salt precipitation method.
8. Separation of genomic DNA by agarose gel electrophoresis.
9. Demonstration of PCR.
10. Practical Note Book
11. Viva -voce

MSZ-404B
PRACTICALS (Special Paper)
Animal Ecology and Wildlife Biology-II
(4 Credits)

1. Study of the stages of ecological succession
2. Energy in ecosystem
3. The role of decomposers in the nitrogen cycle
4. Study of the component of an ecosystem
5. Quadrat method
6. Drift-fence pitfall method
7. Visual encounter survey method
8. Pellet group counting method
9. Pugmark census
10. Measurement of niche breadth
11. Measurement of niche separation
12. Cluster analysis
13. Regression analysis
14. Viva voce
15. Practical record

MSZ-404C
PRACTICALS (Special Paper)
Fish & Fishery Biology-II
(4 Credits)

1. Collection of water sample for a pond for physicochemical parameters viz. free CO_2, DO_2, hardness, turbidity and alkalinity.
2. Age determination of fishes from skeleton, spines, scales, otolith preparation and examination.
3. Fish blood for DLC, Hb, TLC, and TEC.
4. Fecundity & indirect estimation of fish population.
5. Quantitative estimation of lipid from the viscera of a fish.
6. Histology: skin, gills, liver, stomach, intestine, testis, ovary and pituitary.
7. Water sampling, plankton collection, study of primary productivity in a fish farm.
8. Study tour to various fish farms and institutions.
9. Planktons: Identification of common zoo- and phyto-planktons of the freshwater ponds.
10. Practical record book.
11. Viva-voce.

MSZ—404 D
PRACTICALS (Special Paper)
Entomology: Insect Physiology & Economic Entomology-II
(4 Credits)

1. Male Reproductive system of Cockroach.
2. Female Reproductive system Cockroach.
3. Nervous system of Cockroach/ Grasshopper.
4. Salivary gland of Cockroach.
5. Pharyngeal, labial and thoracic salivary gland of Honey bee.
6. Alimentary canal of House fly.
7. Bacterial Chamber of termites.
8. Mounting of hepatic caeca and malpigian tubules.
9. Sting Apparatus of Honey bee.
10. To determine the trehalase activity in haemolymph of any insect.
11. Determination of Amino acid in haemolymph of any insect by chromatographic technique.
12. Study of different types of insect Eggs.
13. Histological studies-cleavage, blastula, gastrula, Testes, spermatogenesis, Ovariole, oviduct.
14. Field observation, identification and collection of insect pest of paddy, cotton, pulses, vegetables and forest trees.
15. Estimation of LD 50 values for some insect pests.
16. Field observation, identification and collection of insect damages to crops.
17. Practical Record Book
18. Viva Voce

MSZ—405
DISSERTATION

MSZ—405A
DISSERTATION: Cell and Molecular Biology
(4 Credits)

MSZ—405B
DISSERTATION: Animal Ecology and Wildlife Biology
(4 Credits)

MSZ—405C
DISSERTATION: Fish & Fishery Biology
(4 Credits)

MSZ—405D
DISSERTATION: Entomology
(4 Credits)

MDC
MSZ-406
Economic Zoology
(4 credits)

Unit I: Sericulture, apiculture and lac culture **1 credit**

1.1 Different commercial species of silkworm and their Host plants, silkworm rearing and management practices (Muga & Eri); Enemies of silkworms.

1.2 Commercially important species of bees in India, bee products and their economic importance, Bee keeping and management.

1.3 Life cycle of the lac insects; Lac culture, properties and uses of lac.

Unit II: Fisheries and aquaculture **1 credit**

2.1 Types of fishery: Marine, Inland. Prawn and pearl culture;

2.2 Composite fish culture, Induced breeding and Hybridization.

2.3 Ornamental fish of NE India, prospects of ornamental fish culture and trade

2.4 Integrated fish farming

Unit III: Pests and pest management **1 credit**

3.1 Insect pests of Agricultural importance, Definition and categories.

3.2Major pests of paddy, tea and stored grain.

3.3 Forest insect pests

3.4 Pesticides and their hazards.

Unit IV: Parasitilogy **1 credit**

4.1 An introduction to Parasitology

4.2 Vectors of Insects Born Diseases: Vectors of Malaria, Japanese Encephalities and Dengue.

4.3 Medical Parasitology: *Ascaris* and *Taenia*

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