

Choice Based Credit System (CBCS)

M.Sc. ZOOLOGY CURRICULUM 2020-2021



**Department of Zoology,
Tripura University (A Central University),
Suryamaninagar – 799022**

Details of Syllabus Revision

3rd August, 2016

26th March, 2018

5th October, 2020

Programme Specific Outcomes

The programme will enable the students to

- Develop problem solving abilities in the areas of zoology and allied fields.
- Apply zoological knowledge in nurturing animal resources for human welfare.
- Encourage field-based studies in relation to conservation and sustainable use of animal resources of aquatic and terrestrial ecosystem.
- Promote advanced knowledge and deeper skills to foster successful researchers in zoology/biological sciences.

CBCS Curriculum Structure M.Sc. in Zoology

Core (C) Credit :62; Elective (E) Credit: 20; Total Credit: 82

M.Sc. First (1st) Semester – 500 Marks (Core credit: 16, Elective Credit: 4)							
Paper Code	Paper Name	Credit Distribution			Total Credit	Marks	Remarks
		L	T	P			
ZL701C	Animal Diversity (Chordates & Non-chordates)	4	0	0	4	100	Core Course
ZL702C	Developmental Biology and Endocrinology	4	0	0	4	100	
ZL703C	Biochemistry and Molecular Biology	4	0	0	4	100	
ZL704C	Laboratory Exercise	0	0	4	4	100	
CSK II	Computer Skill - II	4	0	0	4	100	Compulsory Foundation Elective
Sub Total		16	0	4	20	500	
M.Sc. Second (2nd) Semester – 500 Marks (Core credit: 14, Elective Credit: 8)							
Paper Code	Paper Name	Credit Distribution			Total Credit	Marks	Remarks
		L	T	P			
ZL801C	Histology and Histochemistry	2	0	0	2	50	Core Course
ZL802C	Cell Biology and Genetics	4	0	0	4	100	
ZL803C	Environmental Biology and Animal Behaviour	4	0	0	4	100	
ZL804C	Laboratory Exercise	0	0	4	4	100	
ZL805E	Tools and Techniques in Biology	2	0	0	2	50	Elective Course
ZL806E	Neuroendocrinology	2	0	0	2	50	
ZL807E	Project	0	0	4	4	100	
Sub Total		14	0	8	22	550	

M.Sc. Third (3rd) Semester – 500 Marks (Core credit: 10, Elective Credit: 10)							
Paper Code	Paper Name	Credit Distribution			Total Credit	Marks	Remarks
		L	T	P			
ZL901C	Animal Physiology	2	0	0	2	50	Core Course
ZL902C	Parasitology and Immunology	4	0	0	4	100	
ZL903C	Project	0	0	4	4	100	
ZL904E	Aquatic Environmental Science	2	0	0	2	50	Elective Course from Department
ZL905E2	Fisheries	4	0	0	4	100	
ZL905E3	Comparative Endocrinology						
ST704E	Basic Statistics	4	0	0	4	100	Elective from other Department
Sub Total		16	0	4	20	500	
M.Sc. Fourth (4th) Semester – 500 Marks (Core credit: 08, Elective Credit: 12)							
Paper Code	Paper Name	Credit Distribution			Total Credit	Marks	Remarks
		L	T	P			
ZL1001C	Biosystematics and Evolution	2	0	0	2	50	Core Course
ZL1002C	Economic Zoology	2	0	0	2	50	
ZL1003C	Project	0	0	4	4	100	
ZL1004E	Aquaculture	2	0	0	2	50	Elective Course from Department
ZL1006E	Soil Zoology	2	0	0	2	50	
ZL1007E2	Fish Technology	4	0	0	4	100	
ZL1007E4	Mammalian Reproductive Biology						
	Elective Course from Other Department	4	0	0	4	100	Elective Course from

							other Department
Sub Total		16	0	4	20	500	
AGGREGATE (Entire Duration of M.Sc.)		62	0	20	82	2050	

L – Lecture hrs/week, T – Tutorial hrs/week, P – Project/Practical/Lab all other non- classroom activities etc. hrs/week, C – Core course credit point, E – Elective course credit point.

*Minimum credits to be earned – 80.

The candidate shall have to choose anyone of the elective papers (s). There shall be provision for change of special papers (Elective Course – 04 Credit), if required.

M.Sc. 1ST SEMESTER

ZL701C	Animal Diversity (Non-chordates and Chordates)	Credit: 4
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Course Outcomes

- Understanding of diversity in life forms from unicellular, colonial to multicellular organisms.
- Knowledge of evolutionary aspects in body organization of animals.
- Get idea about anatomical and functional aspects of invertebrates and vertebrates.
- Know about evolutionary consequences and adaptive changes in structural organization of animals.

Course Content

Group - A : Non-Chordates

1. Diversity in forms: unicellular, colonial and multicellular; opportunities and consequences of multicellularity
2. Diversity in body axis: oral – aboral axis, anterior – posterior axis, dorsal – ventral surfaces, body cavity, pattern of cleavage
 1. Diversity of characters in major and minor phyla
 2. Structural specialities of acoelomates (sponges, coelenterates, flat worms), pseudocoelomates (round worms, rotifers), coelomates (annelids, echinoderms), haemocoelomates (arthropods, molluscs)
3. Functional anatomy of body wall, muscles, locomotion, secretory organs, nervous system and reproduction in major phyla with examples
4. Larval forms in some aquatic and terrestrial animals

Group – B: Chordates

1. Outline classification of chordates; an evolutionary approach
2. Origin of vertebrates
3. Exoskeletal and endoskeleton structures in birds and mammals
4. Integument, its derivatives and functional significance in mammals
5. Structural evolution of alimentary canal in chordates (Amphioxus, fishes, birds and mammals) in relation to their food habit
6. Structural modification of lungs in birds and mammals in relation to their energy demand
7. Structural modification of nephrons in vertebrates in relation to different habitats
8. Adaptive radiation with reference to locomotory appendages and teeth in mammals
9. Buoyancy in pelagic fishes – role of swim bladder

Books Recommended

1. K. V. Kardong: Vertebrate: Comparative, Anatomy, Function, Evolution, 4th Edition
2. J. A. Pechenic: Biology of Invertebrate, 7th Edition.
3. R. B. Barnes: Invertebrate Zoology: A functional evolutionary approach
4. R. L. Kotpal: Modern Text Book of Zoology: Invertebrates.
5. R. L. Kotpal: Modern Text Book of Zoology: Vertebrates.
6. E.L. Jordan, P.S, Verma: Invertebrate Zoology, S. Chand Publication
7. E.L. Jordan, P.S, Verma: Vertebrate Zoology, S. Chand Publication

Course Outcomes

- Know about basics of development: cleavage pattern, blastula and gastrula formation.
- Knowledge about morphogenesis, organogenesis in animal embryo and sex determination.
- Understanding the basic concept of hormones, structure and function of endocrine glands in human.
- Knowledge about the endocrine disorders and related pathophysiology in human beings.

Course Content**Group A : Developmental Biology**

1. Gametogenesis and fertilization: production of gametes, acrosomal reaction and gamete interaction (sea urchin and mammals), prevention of polyspermy and egg activation
2. Basic concept of development: potency, specification, determination and differentiation, morphogens and morphogenetic gradients
3. Early development: cleavage, blastula, formation, fate maps, gastrulation, formation of germ layers (frog and chick)
4. Morphogenesis: cell aggregation and differentiation in Dictyostelium, axes and pattern formation in *Drosophila* (involvement of maternal, segmentation and homeotic genes), Hox genes and patterning in vertebrates, Axis formation in frog and chick
5. Organogenesis: vulva formation in *C. elegans*, eye-lens induction, limb development and formation of neural tube in vertebrates
6. Sex determination mechanisms in *Drosophila* and mammals
7. Regeneration
8. Stem cells and application

Group B : Endocrinology

1. Hormones: endocrine, paracrine and autocrine hormones, neuroendocrine system invertebrates, nature of hormone receptors
2. Hormones and Homeostasis: glucose homeostasis, calcium homeostasis and sodium Homeostasis
3. Hypothalamic hormones: nature and function, regulation of secretion
4. Adenohypophyseal hormones: nature, function regulation of secretion
5. Neurohypophyseal hormones: structure and function, regulation of secretion
6. Thyroid hormones: biosynthesis, regulation and functions
7. Pancreatic hormones: structure and their role in glucose homeostasis
8. Adrenocortical hormones: biosynthesis, regulation and function
9. Adrenomedullary hormones: biosynthesis, regulation and function
10. Sex steroids: structure, biosynthesis, regulation and their roles in spermatogenesis, estrous cycle, ovulation and pregnancy
11. Mechanism of action of steroid and peptide hormones

Books Recommended

1. S. F. Gilbert: Developmental Biology, 9th Edition, Sinauer Associates, Inc. USA
2. N.J. Berill, G. Karp: Development, McGraw Hill Higher Education
3. B. I. Balinsky, B. C. Fabian: An Introduction to Embryology, 5th Edition, CBS College Publishing.
4. P.S. Verma, V.K. Agarwal: Chordate Embryology, S. Chand Publishing
5. N. Arumugam: A Text Book of Embryology, Saras Publication
6. Mac E. Hadley: Endocrinology, 6th Edition, Pearson India Education Service Pvt. Ltd.
7. H. Maurice Goodman: Basic Medical Endocrinology, 4th Edition, Academic Press, USA
8. S. Melmed, R. Koenig, C. Rosen, R. Auchus, A. Goldfine: Williams Textbook of Endocrinology, 14th Edition, Elsevier
9. C.S. Negi: Introduction to Endocrinology, PHI Learning Pvt. Ltd.

Course Outcomes

- Knowledge about biochemical foundation of life, bioenergetics, macromolecules.
- Idea of macromolecules (proteins, lipids and carbohydrates) structural organizations and functions. Molecular synthesis and metabolic regulatory pathways.
- Learning of DNA replication mechanisms, regulation and repair.
- Concepts of RNA synthesis, processing and translation.

Couse Content**Group A : Biochemistry**

1. Bioenergetics: Law of thermodynamics, free energy, entropy, high energy bonds and its relevance to biological systems
2. Proteins: Amino acids, peptides and polypeptides, Primary and higher orders of protein structure, protein folding
3. Enzymes: Introduction to enzyme, enzyme properties, enzyme classification, cofactors and coenzymes, effects of physicochemical factors on enzyme activity; Enzyme kinetics – Michaelis –Menten equation and its derivation, Lineweaver-Burk plot, significance of K_m , calculation of enzyme kinetics; Inhibitors of enzyme activity, allosteric enzyme, isozyme, ribozyme
4. Carbohydrates: classification of carbohydrates, glycolysis and Kreb's cycle: pathway and regulation, mitochondrial electron transport chain complexes, oxidative phosphorylation; gluconeogenesis, HMP shunt pathway
5. Lipids: Lipids of physiological significance, membrane lipids, cholesterol synthesis, oxidation of fatty acids, ketogenesis
6. General Topics: Purine and pyrimidine bases, structure and properties of DNA and RNA

Group B : Molecular Biology

1. Basics of Molecular Biology
2. DNA replication: semiconservative, structure and properties of DNA polymerases (pro- and eukaryotic), initiation and elongation of replication in prokaryotes and eukaryotes, enzyme and factors involve in DNA replication, DNA damage and repair mechanism
3. RNA synthesis: mechanism of transcription – initiation, elongation and termination, sense and antisense strand, structure and properties of RNA polymerases in prokaryotes and eukaryotes
4. RNA processing in eukaryotes: capping, poly-adenylation, splicing and RNA editing
5. Protein synthesis: activation, initiation, elongation and termination of protein synthesis in prokaryotes and eukaryotes, post translational modification

Recommended Books

1. D.L. Nelson, A.L. Lehninger, M.M. Cox: Lehninger Principles of Biochemistry, Freeman
2. D. Voet, C.W. Pratt, J.G. Voet: Principles of Biochemistry, Willey
3. V.W. Rodwell, D. Vender, K.M. Botham, P.J. Kennelly, P. Anthony Weil: Harper,s Illustrated Biochemistry, 31st Edition, McGraw Hill
4. J.M. Berg, L. Stryer, J. Tymoczko, G. Gatto Jr.: Biochemistry, 8th Edition, W.H. Freeman & Co.
5. P. Naik: Biochemistry, 5th Edition, Jaypee Brothers Medical Publishers
6. E.S. Goldstein, J.E. Crebbs, S.T. Kilpatrick: Lewin's Genes XII
7. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira: Molecular Cell Biology, 6th Edition, W.H. Freeman and Company, USA
8. G.M. Cooper, R.E. Hausman: The Cell: A Molecular Approach, 4th Edition, ASM Press, USA.
9. B. Albert, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: Molecular Biology of the Cell, 6th Edition, Garland Science, UK.

ZL704C	Laboratory Exercise	Credit: 4
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Course Outcomes

- Learning of structural organization of various life forms.
- Various developmental stages with help of slides of chick embryo.
- Histological staining and structural organizations of endocrine glands.
- Biochemical methods of proteins and carbohydrates determinations.
- Agarose and acrylamide gel electrophoresis.

Course Content

1. Slide preparation of mouth parts of different insects
2. Drawing of development of schizocoelic and enterocoelic body cavities
3. Drawing of cleavage pattern in protostomes and deuterostomes
4. Identification of bones in birds (Pigeon) and mammals (Cavia/Ratus)
5. Mounting, drawing & labelling of different types of scales, feathers in birds
6. Slide identification: T.S. of skin (amphibian and mammalian), T.S. of lung (bird and mammal), T.S. of kidney (fish, bird, mammal), T.S. of intestine (amphibian and mammal)
7. Development of Chick embryo at different incubation period – studies with permanent slides
8. Development of neural fold, notochord and somites in Chick embryo
9. Development of fore brain, mid brain and hind brain in chick embryo
10. Stages of development of heart in chick embryo
11. Study of endocrine gland with permanent slides
12. Double stain (H-E) preparation of permanent slides of endocrine glands
13. Estimation of protein by Folin's reagent
14. Estimation of glucose by Anthrone reagent
15. Enzyme assay: effect of time and temperature, effect of substrate
16. Protein isolation and polyacrylamide gel electrophoresis
17. DNA isolation and agarose gel electrophoresis
18. Determination of casein content in milk
19. Determination of ascorbic acid in lemon and tomato
20. Determination of glucose absorption by intestine of chick

M.Sc. 2nd SEMESTER

ZL801C	Histology and Histochemistry	Credit: 2
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Course Outcomes

- Students learn about tissue fixation, dehydration, sectioning and staining.
- Knowledge about histological basis of tissue classifications, origin, structure and functions.
- Understanding of origin, gross anatomy, blood supply, histology and function of endocrine glands in mammals.
- Knowledge about histochemical methods of localization and analysis.

Course Content

1. Methods of tissues preparation: fixation, dehydration, embedding & sectioning, staining; acid stains & basic stains; auxochrome & chromophore groups in stain
2. Classification of tissues- their origin, structure and functions
3. Histology of lymphoid organ (spleen & its function)
4. Origin, gross anatomy, blood supply, histology & functions of exocrine glands of mammals, viz., liver and pancreas
5. Origin, histology and functions of skin in the mammalian
6. Origin, gross anatomy, blood supply, histology and functions of endocrine glands in mammals, viz., pituitary, thyroid, adrenal, islets of Langerhans, testis & ovary
7. Principle and methods of histochemical localization of Carbohydrates, proteins, lipids and nucleic acids
8. Principle and methods of histochemical analysis of enzyme activity

Recommended Books

1. G.P. Pal: Textbook of Histology, Paras Publication
2. F. Geneser: Textbook of Histology, Munksgaard
3. M.R. Vijayaraghavan, A.K. Sukla: Histochemistry: Theory & Practical, Bishen Singh Mahendra Pal Singh Publication.
4. J.A. Kiernan: Histological and Histochemical Methods: Theory and Practice, Scion Publishing Ltd.
5. L.R. Patki, B.L. Bhalchandra, I.H. Jeevaji: Introduction to Microtechnique, S. Chand & Co. Ltd.
6. Anthony L. Mescher: Junqueira's Basic Histology: Text and Atlas, McGraw-Hill Education

ZL802C	Cell Biology and Genetics	Credit: 4
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Course Outcomes

- Understanding of Cell types and life forms, cellular complexity and structural organization, cytoskeleton, chromosome structure, cell signalling.
- Knowledge about cell cycle and its regulation; Cell communication and cellular transport.
- Knowledge of the basic principles of heredity, gene interaction, gene linkage and recombination and microbial genetics.
- Understanding of the human karyotype and chromosome banding, chromosome anomalies and diseases.

Course Content

Group A : Cell Biology

1. Cells: chemical complexity and organization, distinctive structure and molecular features of prokaryotic and eukaryotic cells
2. Cell cycle and its regulation; cell division – mitosis and meiosis
3. Plasma membrane: chemical constituents and function
4. Cytoskeleton: general features, microtubules, microfilaments and intermediate filaments- structural and functional dynamics
5. Endomembrane system: organization and function of endoplasmic reticulum, Golgi and lysosomes
6. Mitochondria, oxidative phosphorylation, peroxisomes
7. Chromosome Structure: organization of chromatin, nucleosome, structure and organization of telomere, centromere and kinetochore, unique and repetitive DNA, euchromatin and heterochromatin, constitutive and facultative heterochromatin, chromatin domains and boundary elements
8. Signal transduction: Intracellular and cell surface receptors, signal transduction pathways
9. Cell transformation and cell death, genes involved (viral oncogenes, cellular oncogenes and tumor suppressors), angiogenesis and metastasis, cell death pathways and their significance

Group B : Genetics

1. Mendel's laws and their chromosomal basis: extension of Mendelism: dominance relationship, epistasis, pleiotropy, expressivity, penetrance, alleles, multiple alleles, isoalleles
2. Microbial genetics: methods of genetic transfers: transformation, conjugation, transduction and sex-duction; genetics of bacteriophage: lytic and lysogenic cycle and regulatory mechanisms, genetic fine structure: rII locus

3. Human genetics: karyotype and nomenclature of metaphase chromosome bands: concept of G- banding, R-banding and Q-banding; chromosome anomalies and disease: common syndromes caused by aneuploidy, mosaicism, deletion and duplication, chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma, retinoblastoma and Wilm's tumor) fragile site and X-linked mental retardation.
4. Linkage and recombination, Gene mapping techniques: three-point test cross in *Drosophila*; gene mapping in human by linkage analysis in pedigrees; concept of LOD score; somatic cell fusion and gene mapping on chromosomes
5. Mutation: types, causes and deletion: autosomal and sex-linked, loss of function, gain of function; Molecular basis of mutation, germinal versus somatic mutants; Insertional mutagenesis
6. Regulation of gene expression: lac operon; trp operon; typical eukaryotic genes

Recommended Books:

1. H. Lodish, A. Berk, C.A. Kaiser, M. Krieger, M.P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira: Molecular Cell Biology, 6th Edition, W.H. Freeman and Company, USA
2. G.M. Cooper, R.E. Hausman: The Cell: A Molecular Approach, 4th Edition, ASM Press, USA.
3. B. Albert, A. Johnson, J. Lewis, D. Morgan, M. Raff, K. Roberts, P. Walter: Molecular Biology of the Cell, 6th Edition, Garland Science, UK.
4. SP Vyas, A Mehta: Cell and Molecular Biology, CBS Publication and Distributer, New Delhi.
5. C.B. Powar: Cell Biology, Himalaya Publishing House Pvt. Ltd. Mumbai, India.
6. EJ Gardner, MJ Simmons, PJ Snustad: Principles of Genetics, Wiley Student Edition
7. B. Pierce: Genetics- a conceptual approach, 6th Edition, WH Freeman
8. W.S. Clug, M.R. Cummings, C.A. Spenser, M.A. Palladino: Concept of Genetics, Pearson

ZL803C	Environmental Biology and Animal Behaviour	Credit: 4
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Course Outcomes

- Knowledge of life and physical environment, energy and heat relationship, physico-chemical and biological characteristics of ecosystem.
- Understanding of population structure, regulation of ecosystem function, resource and consumers and applied ecology.
- Concept of animal behaviour, innate and cognitive behaviour causes and mechanisms.
- Concept of behavioural ecology, methods of animal communications, territory building and relationships.

Course Content

Group A : Environmental Biology

1. Environmental zoology: scope, principle and definition
2. Physico-chemical and biological factors affecting terrestrial and aquatic environment; comparison of stressed and non-stressed environment
3. Spheres of earth: atmosphere, hydrosphere, lithosphere and biosphere; mass and energy transfer across different interfaces. Climate change and global warming- GHG, causes and effects; adaptations; management
4. Natural resources, conservation and sustainable development
5. Environmental pollution and their control methods- case studies (sugarcane, leather and paper mill)
6. Input and effects of organic loading on sedimentation-DO, BOD, COD and NOD
7. Soil: inputs of heavy metals on ecosystem (arsenic, lead, cadmium) and their Management
8. Bioindicator: concept and their uses in environment

Group B : Animal Behaviour

1. Basic component of animal behaviour: proximate cause, ultimate cause, adaptive values; innate behaviour – mechanism with examples; learning behaviour –mechanism with examples
2. Behavioural genetics: genetics basis of behaviour – examples; selection of behaviour with life history fitness attributes – examples
3. Cognitive behaviour: problem solving solution in non-human animals – examples
4. Migratory behaviour: orientation – taxis and kinesis; long range migration in birds and Fishes
5. Animal communication: kinds of communication signals – levels of specificity; importance of communication in reproduction and group living; dance language of honeybees Behavioural ecology: foraging behaviour – optimization theory; territorial behaviour
6. Altruism and group Living: kin selection – Hamilton's Rule, genetic relationship; evolution of social system – honey bees, leaf cutter ants, some vertebrates

Recommended Books:

1. P.D. Sharma: Environmental Biology, 2nd Edition, Deep and Deep Publication
2. P.S. Verma, V.K. Agarwal: Environmental Biology, S Chand & Co. Ltd.
3. M.R. Fisher: Environmental Biology, Open Oregon Educational Resources
4. M. Calver, A. Lyubery, J. McComb, M. Bamford: Environmental Biology, Cambridge University Press
5. V.K. Agarwal: Animal Behaviour (Ethology), S. Chand & Co. Limited
6. R. Mathur: Animal Behaviour, Rastogi Publication
7. J. Alcock: Animal behaviour-An evolutionary approach, 10th Edition, Oxford University Press
8. A. Manning, M.S. Dawkins: An Introduction to Animal Behaviour, Cambridge University Press

ZL804C	Laboratory Exercise	Credit: 4
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Course Outcomes

- Understanding of microtechniques: tissue preparations, staining and histological study of glandular and muscular tissues.
- Study of mitosis and meiosis divisions and chromosome preparation from metaphase.
- Knowledge of heredity of traits by pedigree analysis in human beings.
- Analysis of dissolve oxygen, carbon dioxide, carbonates and bicarbonates in aquatic system.

Course Content

1. Processing of mammalian glandular tissues and their double staining (Eosin & Haematoxylin)
2. Preparation and staining of skeletal muscle of mammals
3. Staining and identification of blood cells
4. Identification of histological slides based on syllabus
5. Metaphase chromosome preparation from rat bone marrow cells
6. Polytene chromosome preparation from *Drosophila/Chironomus* salivary glands
7. Staining of mitochondria
8. Nucleocytoplasmic index
9. Fluorescence staining
10. Study of meiosis from grasshopper testis
11. Immunofluorescent staining of actin fibres
12. Analysis of Human Pedigree and construction of Pedigree Chart
13. Determination of dissolve oxygen in water
14. Determination of free carbon dioxide in water
15. Analysis of Turbidity and Transparency of supplied sample
16. Analysis of Carbonates and Bicarbonates of supplied sample
17. Chromatographic separation of amino acids
18. Tissue preparation for analysis of proteins, enzymes, nucleic acids using tools like centrifuge and spectrophotometer

ZL805E	Tools and Techniques in Biology	Credit: 2
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Course Outcomes

- Understanding of the principles and application of microscopes, centrifuges and spectrophotometers.
- Knowledge of principles of electrophoresis and application of agarose and acrylamide gel electrophoresis.
- Understanding of the principles of chromatography and uses of different chromatographic techniques.
- Know about blotting techniques and recombinant DNA techniques.

Course Content

1. **Microscopy:** Basics of bright field, dark field, phase contrast, fluorescence, confocal microscopy; transmission and scanning electron microscopy
2. **Centrifugation:** Principle and uses of centrifuges (tissue processing and separation of various sub-cellular organelles)
3. **Spectrophotometry:** Types and function of spectrophotometers; Beer-Lambert Law, molar extinction coefficient, absorption spectrum
4. **Electrophoresis:** Principles, agarose and polyacrylamide gels, isoelectric focusing, two-dimensional electrophoresis
5. **Chromatography:** Principle and types, absorption, partition, gel filtration, ion-exchange, affinity, elementary concepts of HPLC
6. **Blotting techniques:** Southern, Northern and Western blotting, microarray, DNA foot printing, EMSA
7. **Recombinant DNA techniques:** Restriction endonucleases, cloning vectors, gene cloning, polymerase chain reaction, DNA sequencing
8. Production of transgenic animals and application

Recommended Books:

1. K. Wilson, J. Walker: Principles and Techniques in Biochemistry and Molecular Biology, Cambridge University Press
2. M.R. Green, J. Sambrook: Molecular Cloning-A laboratory manual, Cold Spring Harbor Laboratory Press.
3. D. Das: Biophysics and Biophysical Chemistry, Academic Publishers
4. P. K. Bajpai: Biological Instrumentation and Methodology, S. Chand & Company Ltd.
5. R.N. Roy: A Text Book of Biophysics, Central Book Agency

ZL806E	Neuroendocrinology	Credit: 2
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Course Outcomes

- Knowledge about the concept of neurosecretion and about neurosecretory cells.
- Knowledge about chemical nature of neurohormones, staining and secretory dynamics of neurosecretory cells.
- Understanding of structure, functions and distribution of neuroendocrine cells and neuroendocrine gland in invertebrates.
- Understanding about synthesis, transport and release of neurohormones and their importance in metamorphosis, maturation and regeneration in invertebrates.

Course Content

1. Concept of Neurosecretion:

- Neurosecretory cells, ultrastructural features and types.
 - Differences between neurosecretory cell and ordinary neuron; hormone, neurohormone and neurohumor.
 - Chemical nature of hormone, neurohormone and neurohumor.
 - Staining characteristics of neurosecretory cells.
 - Secretory dynamics in neurosecretory cells.
- Distribution of neurosecretory cells, neurosecretory system and non-neural endocrine glands in invertebrates (Cnidaria to Echinodermata).
 - Detailed structure and functions of neurosecretory system, non-neural endocrine glands and neurohemal organs in invertebrates (Annelida, Insecta, Crustacea and Gastropoda).
 - Mechanism of synthesis, transport and release of neurohormone
 - Neuroendocrine control of –
 - Growth and regeneration in Annelids
 - Growth and metamorphosis in Insects
 - Gonad maturation in Cephalopod molluscs
 - Neuroendocrine integration in invertebrates.

Recommended Books:

1. L. Luo: Principles of Neurobiology, Garland Science.
2. G.M. Shepherd: Neurobiology, Oxford University Press
3. C.U.M. Smith: Elements of Molecular Neurobiology, 3rd Edition, Willey
4. M. Wilkinson, R.E. Brown: An Introduction to neuroendocrinology, 2nd Edition, Cambridge University Press.
5. G. Fink, D.W. Pfaff, J Levine: Handbook of Neuroendocrinology, Academic Press
6. M.E. Hadley, J.E. Levine: Endocrinology, Pearson
7. Gary G. Mathews: Neurobiology: Molecules, cells and systems, Blackwell Science

ZL807E	Project	Credit: 4
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Course Outcomes

- Learn to do literature review and formulation of objectives of study.
- Learn to make study plan and setup of methodologies and execution research work.
- Learn to compilation of results, report preparation and power point presentation.

Course Content

Literature review and formulation of objectives

Laboratory/ Field work

Dissertation submission and power point presentation
Dissertation submission and power point presentation

M.Sc. 3rd SEMESTER

ZL901C	Animal Physiology	Credit: 2
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Course Outcomes

- Understanding of mechanisms of circulation in animal system, structure and functions of heart, blood and various aspects related to blood circulation.
- Knowledge of structural and functional aspects of nerves system and muscles, synaptic transmission and muscle contraction.
- Knowledge of respiratory system, respiratory organs, respiratory pigments and gaseous transport.
- Understanding of structure and function of excretory system and osmoregulatory mechanisms in aquatic and terrestrial organism.
- Understanding of digestive system and mechanism of digestion in mammals.

Course Content

1. **Circulation:** circulatory systems in invertebrates and vertebrates, physiological types of hearts, composition and functions of blood, haemopoiesis, blood pressure, blood groups, blood coagulation.
2. **Neurons:** Ultrastructure, types and function, resting and action potential, nerve impulse conduction through an axon, neurotransmitters and synaptic transmission.
3. **Musculature in vertebrates:** smooth, skeletal and cardiac muscles, ultrastructure and chemical composition of skeletal muscle, mechanism of skeletal muscle contraction, muscle fatigue, tetanus and rigor mortis.
4. **Respiration:** respiratory organs in vertebrates, mechanism of respiration through gills in fishes, mechanism of breathing and its regulation in mammals, respiratory pigments – brief chemistry and functions, transport of O₂ and CO₂, oxygen dissociation curve, Bohr effect and Root effect.
5. **Excretion & Osmoregulation:** nitrogen excretion in animals, structure of vertebrate kidney and nephron, formation of urine, counter-current mechanism in higher vertebrates, homeostasis, osmoregulation in aquatic and terrestrial animals – mechanism and regulation.
6. **Digestion:** digestive enzymes in vertebrates, secretion and regulation in mammals, mechanism of digestion of food materials in mammals.
7. **Chromatophores:** Structure, types, their role in colour change in animals, nervous and hormonal control of colour change.

Recommended Books:

1. D. Randall, W. Burggren, K. French: Ekart Animal Physiology, W.H. Freeman
2. C.D. Moyes, P.M. Shultz: Principles of Animal Physiology, 2nd Edition, Pearson
3. K. Schmidt-Nielsen: Animal Physiology-Adaptation and Environment, 5th Edition, Cambridge University Press
4. R.W. Hill, G.A. Wyse, M. Anderson: Animal Physiology, 4th Edition, Sinauer Associates Inc.
5. D. Pramanik: Principles of Physiology, Academic Publishers
6. R.C. Sobti: Animal Physiology, Narosa Publishers

Course Outcomes

- Knowledge about basics of parasitism, vectors, life history of some parasitic protozoans and pathophysiology.
- Know about Helminthes and Nematodes parasites, life cycle and pathophysiology.
- Understanding of immuno-parasitology, host parasite interactions, vaccination.
- Know about basics of immunity, immune cells, antigens, antibody types, structure and functions.
- Knowledge about generation of immune responses, antigen processing and presentation, cytokines, inflammations, hypersensitivity reactions etc.

Course Content**Group A : Parasitology**

1. Parasitism as a part of animal association and its features, niches of parasites, concept of vectors
2. Important parasitic protozoa belonging to sporozoa (*Plasmodium*) flagellate (*Leishmania*, *Trypanosoma*) with reference to their life cycle, disease caused, immunopathology, control and treatment
3. Helminth parasites belonging to Digenea and blood parasites (*Fasciola*, *Schistosoma*)
4. General account of parasitic cestode and nematoda (*Echinococcus*, *Wuchereria*) including general characters, life history, physiology, pathology, control and treatment
5. Immuno-parasitology: general host response, specific host parasite response, vaccination
6. General principles of *in vitro* culture of parasitic protozoa and endoparasitic helminths

Group B : Immunology

1. Basics of Immunity: introduction; Cells and organs involved in innate and acquired immunity; antigens, antigenicity and immunogenicity, B and T cells
2. Antibodies: structure and function of immunoglobulin molecules; generation of antibodies diversity; monoclonal antibodies, antigen-antibody interactions
3. Generation of immune responses: MHC molecules; antigen processing and presentation; activation and differentiation of B cells and T cells; B and T cells receptors; humoral and cell mediated immune responses; primary and secondary immune responses
4. Immune effector mechanism: cytokines; complement system; cell mediated effector functions, inflammations; hypersensitivity and autoimmunity

Recommended Books

1. J.D. Smyth: Animal Parasitology, Cambridge University Press
2. A.E.R. Taylor, J.R. Baker: In Vitro Methods for Parasite Cultivation, Academic Press
3. F.B. Mandal: Human Parasitology, PHI Learning
4. K.D. Chatterjee: Parasitology (Protozoology and Helminthology), CBS Publishers
5. G.D. Schmidt, L.S. Roberts: Foundations of Parasitology, McGraw-Hill Education
6. J. Heelan, F. Ingersoll: Essentials of Human Parasitology, S. Chand & Company Ltd.
7. T.J. Kindt, R.A. Goldsby, B.A. Osborne: Kuby Immunology, 6th Edition, W.H. Freeman & Company
8. P.J. Delves, S.J. Martin, D.R. Burton, I.M. Roitt: Roitt's Essential Immunology, 13th Edition, Willey
9. K. Murphy, C. Weaver: Janeway's Immunobiology, 9th Edition, Garland Science
10. AK Hati, S Roy, B. Saha, K Bharati: Basic Concept of Immunology, Allied Book Agency, Kolkata

ZL903C	Project	Credit: 4
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Course Outcomes

- Learn to do literature review and formulation of objectives of study.
- Learn to make study plan and setup of methodologies and execution research work.
- Learn to compilation of results, report preparation and power point presentation.

Course Content

Literature review and formulation of objectives

Laboratory/ Field work

Dissertation submission and power point presentation
Dissertation submission and power point presentation

ZL904E	Aquatic Environmental Science	Credit: 2
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Course Outcomes

- Knowledge about basics of aquatic systems and ecosystems, light penetration in aquatic bodies, thermal stratification, gaseous distribution etc.
- Understanding of gaseous and sedimentary biogeochemical cycles and meteorological data causes and effects on biota.
- Know about lentic and lotic aquatic system, marine and estuarine ecosystem and hydrological cycles.

Course Content

1. Definition and scope of aquatic environmental biology, structure and function of aquatic ecosystem, wetland, pond, lake, river etc.
2. Water and Light: scatter and diffusion, effects of UV radiation on aquatic fauna
3. Thermal stratification and thermocline formation in lake, flow of heat
4. Contribution of atmospheric gases to aquatic ecosystem; Importance of wetlands as carbon sequester
5. Gaseous biogeochemical cycle: Carbon and Oxygen cycle - diurnal and seasonal changes; Nitrogen cycle - forms of nitrogen, nitrogen fixation, dissolved organic nitrogen, eutrophication and control
6. Sedimentary biogeochemical cycle: Phosphorus cycle, recycling of phosphorus, eutrophication and control
7. Concept of meteorological data, climate change, causes and effects on biota, algae as carbon sequester, management
8. Lentic and lotic resources- their conservation and sustainable development, basic characteristics of lentic and lotic environment, role of inorganic carbon and organic carbon (CO₂, CO₃, HCO₃, H₂CO₃) and organic carbon
9. Pesticides in freshwater: Origin, fate and effects on biota
10. Marine ecosystem, its chemical characters and faunal distribution
11. Estuarine ecosystem, its chemical characters and impact on faunal distribution
12. Principles of analytical methods, Titrimetry, Gravimetry, Colorimetry and Spectrophotometry
13. Hydrologic cycle, global water balance, ice sheets and fluctuations of sea levels, origin and composition of seawater, factors influencing the surface water, resources of oceans, ocean pollution, human use of surface and groundwaters, groundwater pollution and control measures

Recommended Books:

1. W.T. Edmondson: Freshwater Biology, John Willey & Sons Inc.
2. R.G. Wetzel: Limnology, Elsevier
3. C.R. Goldman, A.J. Horne: Limnology, McGraw Hill
4. B.B. Hosstti, A. Kumar: Text Book of Applied Aquatic Biology, Daya Publishing House
5. L. Holt: Aquatic Biology, Callisto Reference

ZL905E2	Fisheries	Credit: 4
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Course Outcomes

- Understanding of fisheries-definition, types, fishes, classification.
- Know about diversity of freshwater and marine water fish fauna.
- Understanding of riverine environment, characters of stream, physico-chemical and biological characters.
- Know about dams and their effects on fish migration, Hatcheries, nature of fish pond ecosystem.

Course Content

Group - A

1. Fisheries-definition, types, fishes, classification
2. Diversity of freshwater and marine water fish fauna
3. Riverine environment, characters of stream, physico-chemical and biological characters
4. River pollution, Chemical characters of polluted river, biological indicators of India
5. Dams and their effects on fish migration
6. Fisheries of important reservoirs and lakes
7. Estuarine and coastal fisheries
8. Management of stocking ponds – Indian major carps (IMC), definition, characterization, wild resources, control of weeds, insects and predatory fishes, pond, fertilization, stocking, supplementary feeding, disease control
9. Responsible fisheries - laws and regulations for conservation
10. Endangered, near threatened, vulnerable and rare fish species and conservation strategies

Group - B

1. Hatcheries- types, characteristics, water quality
2. Nursery, rearing, pre-stocking and post-stocking systems management
3. Lay-out criteria of different nature of fish pond ecosystem
4. Monoculture, principles, basic steps of field studies - merit and demerit
5. Polyculture, principles, practices, merit of polyculture
6. Integrated fish farming- concept, types, Paddy cum fish culture, Duck cum fish culture, sewage fed fisheries, scope and limitations
7. Culture of herbivore fishes – role of *Ctenopharyngodon*, *Hypophthalmichthys* for biological control of weeds and microalgae, low carbon foot print fish
8. Sustainable fish culture
9. Monosex culture of Tilapia
10. Shrimp farming

Recommended Books:

1. W.T. Edmondson: Freshwater Biology, John Willey & Sons Inc.
2. V.G. Jhingran: Fish and Fisheries of India, Hindustan Publishing Corporation
3. B. Hopher: Nutrition of Pond Fish, Cambridge University Press
4. Hand Book of Fisheries and Aquaculture, Indian Council of Agricultural Research, New Delhi
5. A. Southern, W King: The Aquaponic Farmer-A Complete Guide to Building and Operating a Commercial Aquaponic System, New Society Publishers

ZL905E3	Comparative Endocrinology	Credit: 4
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Course Outcomes

- Knowledge about basic concepts of neurosecretion, neuroendocrine system and neurosecretory cells in invertebrates and vertebrates.
- Understanding of comparative aspects of hypophyseal structures and functions among vertebrates.
- Understanding of comparative aspects of peripheral endocrine glands structure and functions in vertebrates
- Know about evolutionary consequences in neurosecretory and endocrine glands in animal systems

Course Content

1st Half

1. An overview of endocrine system in vertebrates
2. Basic concept of neurosecretion: neurosecretory system in invertebrates with special reference to insects; anatomy and functions of hypothalamic neurosecretory centers in vertebrates; anatomy of neurohypophysis and its hormones in vertebrates; median eminence: structure and functions invertebrates
3. Structure and functions of adenohypophysis: general organization invertebrates; cell types and functions in teleost and mammals
4. Structure and functions of pars intermedia in non-mammalian vertebrates
5. Synthesis of steroid, peptides and glycoprotein hormones in vertebrates
6. Pineal organ: cellular organization and functions in vertebrates

2nd Half

7. Morphology and histology of pituitary gland
8. Morphology and histology of thyroid gland in vertebrates; the role of thyroid hormones in amphibian metamorphosis
9. Cellular organization and functions of parathyroid hormones
10. Cellular organization and functions of endocrine pancreas
11. Anatomy, histology and functions of adrenal gland (inter-renal/cortex and chromaffin tissue/medulla)
12. Gonad as endocrine organs: anatomical and histological organization of testis and ovary; functions of testicular and ovarian hormones; effect of castration on male reproductive system

Recommended Books:

1. D.O. Norris, J.A. Carr: Vertebrate Endocrinology, 5th Edition, Elsevier Science
2. I. Chester-Jones, P.M. Ingleton, J.G. Phillips: Fundamentals of Comparative Vertebrate Endocrinology, Plenum Press
3. C. D. Turner, J. Bagnara: General Endocrinology, W.B. Saunders Company
4. P.J. Bentley: Comparative Vertebrate Endocrinology, Cambridge University Press
5. Mac E. Hadley: Endocrinology, 6th Edition, Pearson India Education Service Pvt. Ltd.
6. A. Gorbman, H.A. Bern: A Text Book of Comparative Endocrinology, Wiley
7. K.P. Joy, A. Krishna, C. Haldar: Comparative Endocrinology and Reproduction, Narosa Publishing House

M.Sc. 4th SEMESTER

ZL1001C	Biosystematics and Evolution	Credit: 2
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Course Outcomes

- Understanding of the biological species concept, genetic basis of species and population.
- Know about taxonomic procedure- alpha, beta, and gamma taxonomy, micro and macro taxonomy.
- Learn about principles of zoological nomenclature and brief digest of rules, principles and methods of molecular taxonomy, DNA bar coding.
- Understanding of modern theories of evolution including synthetic theory and neutral theory of evolution; Hardy-Weinberg equilibrium, major evolutionary forces, types of selection etc.

Course Content

1. Biosystematics: special concerns, biological species concept, genetic basis of species and population
2. Taxonomy concept: taxonomic procedure – alpha, beta and gamma taxonomy; micro- and macro taxonomy
3. Taxonomic methods: taxonomic categories; principle of assigning animal grouping into categories
4. Taxonomic characters: selection and kinds of characters – morphological, biochemical, behavioural, cytological and ultra-structural
5. Variation in characters: meaning, methods of measuring variations, intraspecies, taxonomy – biotypes, ecotypes, races, demes; phenotypic plasticity – genetic basis
6. Principles of zoological nomenclature and brief digest of rules
7. Molecular taxonomy: principle and methods
8. Origin and history of life, evolutionary time scale
9. Organic evolution: concept and evidences, theories (Lamarckism, Darwinism and modern theories), types of selection
10. Population as unit of evolution, Hardy-Weinberg equilibrium, major evolutionary forces, modes of speciation
11. Isolating mechanism: different types, description with example, significance.
12. Evolution at molecular level: genomic and proteomic changes, molecular clock, molecular phylogeny

Recommended Books:

1. G.G. Simpson: Principles of Animal Taxonomy, Scientific Publishers
2. V.C. Kapoor: Principles and Practices of Animal Taxonomy, Oxford & IBH Publishing
3. A. Verma: Principles of Animal Taxonomy, Narosa Publishing House
4. T.H. Savory: Animal Taxonomy, Heineman Educational
5. E. Mayr: Principles of Systematic Zoology, 2nd Edition, McGraw Hill Inc
6. G. L. Stebbins: Processes of Organic Evolution, Prentice Hall India
7. D. J. Futuyma: Evolution, Sinauer Associates
8. B.K. Hall, B. Hallgrímsson: Strickberger's Evolution, Jones and Bartlett Publishers
9. V.B. Rastogi: Evolutionary Biology, Ramnath Kedarnath Publishers
10. M.P. Arora, C. Kanta: Organic Evolution, Himalaya Publishing House

ZL1002C	Economic Zoology	Credit: 2
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Course Outcomes

- Concept of pest, integrated pest management, pesticides and their mode of action.
- Learn about sericulture, types of silk, composition of silk, silk extraction, disease of silk worm.
- Know about Fish and Prawn culture, indigenous and exotic fishes.
- Concept of vermiculture, vermicomposting and their importance in agriculture.

Course Content

1. Concept of pest, Pest management, Integrated pest management. Insect pests of paddy and vegetables, pesticides and their modes of actions.
2. Sericulture: types of silk worm and silk, composition of silk, rearing of silk moth, extraction of silk, diseases of silk worm, scope of sericulture industry and recent approaches to improvement in quality of silk.
3. Fish culture: Economic importance, edible fresh water fishes, indigenous and exotic fishes, culture practices, conservation, by products of fish industry, management
4. Prawn fishery: Characterization of prawn and shrimp; fresh water prawn culture and its prospects in India
5. Vermiculture and vermicomposting: selection of earthworm, principle, method, in-situ and ex-situ earthworm technology. Importance of vermicomposting in agriculture.

Recommended Books:

1. G.S. Shukla, V.B. Upadhyay: Economic Zoology, Rastogi Publication
2. M.C. Dash: Tools for Vermitechnology, I.K. International Publishers
3. J. Ahsan, S.P. Sinha: A Handbook of Economic Zoology, S. Chand & Co.
4. L.S. Daugherty, M. Daugherty: Principles of Economic Zoology, Palala Press
5. V.L. Kellogg, R.W. Doane: Elementary Text Book of Economic Zoology and Entomology, Kessinger Publishing
6. S. Sarkar, G. Kundu, K.K. Chaki: Introduction to Economic Zoology, New Central Book Agency

ZL1003C	Project	Credit: 4
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Course Outcomes

- Learn to do literature review and formulation of objectives of study.
- Learn to make study plan and setup of methodologies and execution research work.
- Learn compilation of results, report preparation and power point presentation.

Course Content

Literature review and formulation of objectives

Laboratory/ Field work

Dissertation submission and power point presentation
Dissertation submission and power point presentation

ZL1004E	Aquaculture	Credit: 2
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Course Outcomes

- Knowledge of aquaculture definition, principle and scope, types, aquatic adaptation of fish.
- Knowledge about selection of sites for aquaculture, design and construction of aqua farms, and selection of aquaculture species
- Learning of nutrition and feeds, food and feeding habits of cultivable species
- Knowledge about management of fishpond and fish health

Course Content

1. Aquaculture definition, principle and scope, types, aquatic adaptation of fish, advantages of aquafarming, cultural diversity, biological pathway, socioeconomic importance
2. Selection of sites for aquaculture, land-based farm, open water farm etc, water quality and quantity management
3. Biological characteristics of aquaculture species, common species and their importance
4. Design and construction of aqua farms, fundamental concept, economic criteria
5. Nutrition and feeds, food and feeding habits of cultivable species, HUFA, PUFA, nutritional importance and human health
6. Economic viability, data requirements, cost-benefit analysis of aquaculture
7. Aquaculture practices, husbandry procedures, carp
8. Ornamental fish, diversity, culture and importance
9. Management of stocking pond - optimal conditions of water quality criteria, management
10. Culture of air breathing fishes-concept, principles and practices
11. Culture of endangered species- *Ompok*
12. Fin fish and shell fish- major cultivable species of shrimps, reproduction and larval rearing
13. Fish health and disease treatment, husbandry procedures-cleaning, feeding, effluent treatment and management

Recommended Books:

1. T.V.R. Pillay, M.N. Kutty: Aquaculture – Principles and Practices, Wiley India Pvt. Ltd.
2. T.V.R. Pillay: Aquaculture and Environment, Wiley India Pvt. Ltd.
3. T.V.R. Pillay: Aquaculture Development - Progress and Prospects, Halsted Press
4. Hand Book of Fisheries and Aquaculture, Indian Council of Agricultural Research, New Delhi
5. A. Southern, W King: The Aquaponic Farmer-A Complete Guide to Building and Operating a Commercial Aquaponic System, New Society Publishers

ZL1006E	Soil Zoology	Credit: 2
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Course Outcomes

- Understanding of soil components, importance of soil organisms, micro, meso, and macro fauna.
- Knowledge of soil inhabiting nematodes, their life cycle and control measures.
- Learning of earthworms, ecological categories, earthworm as ecological engineers, their biogenic structures, effects of vermicompost on soils.
- Knowledge of termite colonies, their feeding habits and digestive process and adaptation strategy in soil invertebrates.

Course Content

1. Soil components and types; soil profile; physical and chemical properties of soil; macro and micro nutrients in soil and their importance to the soil organisms; physico-chemical changes in soil following application of organic manure/ vermicompost
2. Soil micro, meso- and macro- fauna - their spatial and vertical distribution and importance in soil ecosystem
3. Soil inhabiting nematodes, their general characters; life cycle of a plant parasitic nematode (*Meloidogyne incognita*); beneficial and harmful role of soil inhabiting nematodes
4. Earthworm and termites as soil-ecosystem engineers; their ecological categories, soil turnover, formation of biogenic structures (casts, galleries)
5. Reproductive biology of Earthworms; hermaphroditism, conjugation, cocoon production and biology of cocoon
6. Termite colonies; feeding habits and digestive processes in termites
7. Adaptive strategies in soil invertebrates

Recommended Books

1. David C. Coleman, D. A. Crossley Jr., Paul F. Hendrix: Fundamentals of Soil Ecology, Elsevier
2. P. Lavelle, A.V. Spain: Soil Ecology, Springer
3. M. Gorny, L. Grum: Methods in Soil Zoology, Elsevier Science Inc.
4. L.K. Porter, J.B. Harsh, J.M. McCray: Advances in Soil Science, Springer Verlag
5. M.C. Dash: Tools for Vermitechnology, I.K. International Publishers
6. P.S. Chaudhuri, S.M. Singh: Biology and Ecology of Tropical Earthworms, Discovery Publishing House Pvt. Ltd., India

ZL1007E2	Fish Technology	Credit: 4
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Course Outcomes

- Understanding the concept of induced breeding, brood stock management, selection criteria, feeding.
- Concept of acclimatization and captive breeding, physical factors affecting captive breeding.
- Knowledge of cryopreservation techniques, sex reversal, triploid and transgenic fishes.
- Knowledge about fish pathology, fish harvesting and post harvesting management.

Course Content

1st Half

1. Brood stock management, selection criteria, feeding
2. Reproduction and genetic selection
3. Basic water quality characters of nursery and rearing ponds
4. Acclimatization, concept, basic importance, pathway for acclimatization technology
5. Concept of captive breeding, steps for captive breeding technology, factors stimulating and suppressing, gonadotropin, *ex-situ* conservation of endangered fish
6. Cryopreservation of gametes, significance, cryo-protectants, steps for cryopreservation, merit and limitations
7. Sex control, sex reversal, sterilization, Hybridization, interspecific, intergeneric, significance
8. Triploid fish, characterization of the species, artificial technology for development of triploid fish
9. Transgenic fishes, gynogenesis, androgenesis, scope and limitations

2nd Half

1. Fish pathology, fungus infection, bacterial diseases, protozoan diseases, control measure
2. Harvesting and post harvesting technologies, by products of fish industry and their economic importance
3. Transportation of live fish and seed, merits and limitations
4. Freshwater prawn culture technology, breeding characteristics, juvenile prawn migration, culture practices
5. Scope for Hilsa breeding and development
6. Low carbon foot print fish culture- silver carp, grass carp, common carp etc.
7. Induced spawning, brood stock, management, environmental control of spawning
8. Trout, Salmon, stripping, fertilization and hatching
9. Raceway culture technology, water quality characteristics, significance
10. Cage culture and Pen culture technology, species specification, steps of culture, scope

Recommended Books:

1. V.G. Jhingran: Fish and Fisheries of India, Hindustan Publishing Corporation
2. B. Hopher: Nutrition of Pond Fish, Cambridge University Press
3. Hand Book of Fisheries and Aquaculture, Indian Council of Agricultural Research, New Delhi
4. N.R. Chattopadhyay: Induced Fish Breeding-A Practical Guide for Hatcheries, Academic Press
5. T. Gjedrem, M. Baranski: Selective Breeding in Aquaculture – An Introduction, Springer
6. T.L.S. Samuel, S.F. Moses: Fish Genetics and Breeding, Daya Publishing House
7. D. Lambert: A Practical Guide to Breeding Your Freshwater Fish (Tankmasters Series), Barrons Educational Series Inc.

Course Outcomes

- Understanding of structural and functional aspects of male and female reproductive system.
- Knowledge about various pathophysiological consequences in spermatogenesis and oogenesis.
- Knowledge about endocrine regulation of spermatogenesis and ovulation, fertilization and pregnancy.
- Knowledge of hormonal regulation of parturition and lactation.

Course Content

Male Reproductive System

1. **Male reproductive system:** scrotum, testis, cryptorchidism, disorder of testicular functions, ducts of testis, accessory sex glands, sperm transport in male genital duct, motility of sperm in male genital ducts
2. **Spermatogenesis:** spermatozoa – ultrastructure, hormone control of spermatogenesis, maturation of sperm
3. **Semen:** constituents of semen, coagulation of semen, physiological significance of seminal plasma
4. **Prostaglandins:** eicosanoids, prostaglandins, mechanism of actions of prostaglandins and other eicosanoids, functions of prostaglandins
5. **Male hormones:** characteristics, receptors and target cells, mechanism of hormone action
6. **Sexual differentiation and behaviour:** gonadal differentiation, brain differentiation, hormones in sexual behaviour

Female Reproductive System

1. **Female reproductive system:** structure of ovary; female duct system, external genitalia, mammary gland
2. **Oogenesis:** process and hormonal control
3. **Reproductive cycles:** types and duration of reproductive cycles, estrous cycle and menstrual cycle
4. **Ovulation and fertilization:** process of ovulation, endocrine regulation of ovulation, fertilization – detailed process, prevention of polyspermy
5. **Implantation and pregnancy:** pre-implantation, implantation, placenta, physiology of pregnancy, pseudopregnancy
6. **Parturition and lactation:** onset of parturition, the stage of labour, Ferguson's reflex, hormonal control of parturition, process of lactation and hormonal control

Recommended Books:

1. K. Schillo: The Reproductive Physiology of Mammals – From Farm to Field and Beyond, Delmar Cengage Learning
2. T.M. Plant, A.J. Zeleznik: Knobil's and Neill's Physiology of Reproduction, Academic Press
3. M.H. Johnson: Essential Reproduction, 8th Edition, Wiley-Blackwell
4. M.P. Hardy, M. Griswold: Testicular Cell Dynamics and Endocrine Signalling, Wiley-Blackwell
5. F.H. Bronson: Mammalian Reproductive Biology, The University of Chicago Press
6. D.R.P. Tulsiani: Introduction to Mammalian Reproduction, Springer
7. V. Hayssen, T.J. Orr: Reproduction in Mammals-The Female Perspective, Johns Hopkins University Press
8. G. Prakash: Reproductive Biology, Narosa Publishing