(Revised syllabus based on CBCS, NEP 2020 and on the inputs from the Board of Studies)

MJP RohilkhandUniversity, Bareilly

MASTERS IN ZOOLOGY

(Proposed to be implemented from 2022-2023)

M. J. P. Rohilkhand University, Bareilly

Syllabus

of

M.Sc. Zoology

Under National Education Policy- 2020

(To be effective from session 2022-23)

चरैवेति चरैवेति

महात्मा ज्योतिबा फुले
रुहेलखण्ड विश्वविद्यालय, बरेली

Designed & Approved by:

The Board of Studies in Zoology, M. J. P. Rohilkhand University, Bareilly

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Syllabus of B.Sc. with Research/M.Sc. Zoology Course according to NEP 2020

Course No.	Name of the Course	Credit	Remark
	Semester VII		
ZOOLCC-101	Non Chordata	**04**	**Core Course**
ZOOLCC-102	Animal Physiology	**04**	**Core Course**
ZOOLCC-103	Biochemistry and Cell Biology	**04**	**Core Course**
ZOOLCC-104	Biodiversity	**04**	**Core Course**
ZOOLCC-105	Lab based on ZOOLCC101,102,103,104	**06**	**Core Course**
ZOOLMN-101	Public health and Hygiene (Open minor)	**04**	**Minor paper**
	Semester Total	**22**	
	SemesterVIII		
ZOOLCC-201	Biosystematics, Evolutionary Biology and Conservation	**04**	**Core Course**
ZOOLCC-202	Developmental Biology and Immunology	**04**	**Core Course**
ZOOLCC-203	Quantitative biology and Bioinstrumentation	**04**	**Core Course**
ZOOLCC-204	Animal Behaviour	**04**	**Core Course**
ZOOLCC-205	Lab based on ZOOLCC 201,202,203,204	**06**	**Core Course**
ZOOLIN-201	Summer Internship/ Research Work/ Project	**08**	**Project**
	Semester Total	**22+8**	
	Semester IX		
ZOOLCC-301	Chordata	**04**	**Core Course**
ZOOLCC-302	Environmental Biology, Wildlife and Toxicology	**04**	**Core Course**
	Elective I		
ZOOLEL-301A	Principles of Endocrinology	**04**	**Elective**
ZOOLEL-301B	Insect Taxonomy, Morphology and Ecology		
ZOOLEL-301C	Fish Biology and Genetic Resources		
ZOOLEL-301D	General Parasitology		
	Elective II		
ZOOLEL-302A	Biology of Reproduction	**04**	**Elective**
ZOOLEL-302B	Insect Physiology		
ZOOLEL-302C	Fish Ecology, Aquaculture and Capture Fisheries		
ZOOLEL-302D	Biology of Parasites		
ZOOLCC-303	Lab based on ZOOLCC 301,302 and elective paper	**06**	
	Semester Total	**22**	
	Semester X		
ZOOLCC-401	Molecular Biology and Genetics	**04**	**Core Course**
ZOOLCC-402	Basic concepts of biotechnology	**04**	**Core Course**
	Elective		
ZOOLEL-401A	Endocrine disorders and their diagnostics	**04**	**Elective**
ZOOLEL-401B	Applied Entomology and Pest Management		
ZOOLEL-401C	Applied Fish and Fisheries		
ZOOLEL-401D	Immunoparasitology		
ZOOLEL-403	Lab based on ZOOCC 401,402 Elective paper 401A,B,C,D	**06**	
ZOOLCC-404	**Minor Paper (To be selected from other stream)**	**04**	
ZOOLMT-401	Master Thesis/ Dissertation	**08**	**Master Thesis**
	Semester Total	**22+8**	
	GRAND TOTAL	**88+16**	

ZOOL – Zoology; ZOOLCC – Core Course; ZOOLEL – Elective; ZOOLIN – Summer Internship/ Field Work/ Project; ZOOLMT – Master Thesis/ Dissertation; ZOOLMN -Minor course

A. Endocrinology and Reproductive Physiology

ZOOLEL-301A	Principles of Endocrinology
ZOOLEL-302A	Biology of Reproduction
ZOOLEL-401A	Endocrine disorders and their diagnostics

B. Entomology

ZOOLEL-301B	Insect Taxonomy, Morphology and Ecology
ZOOLEL-302B	Insect Physiology
ZOOLEL-401B	Applied Entomology and Pest Management

C. Fish and Fisheries

ZOOLEL-301C	Fish Biology and Genetic Resources
ZOOLEL-302C	Fish Ecology, Aquaculture and Capture Fisheries
ZOOLEL-401C	Applied Fish and Fisheries

D. Parasitology

ZOOLEL-301D	General Parasitology
ZOOLEL-302D	Biology of Parasites
ZOOLEL-401D	Immunoparasitology

I. Dissertation

Research Project in Postgraduation •

A student has to do a detailed research project in 4th and 5th year of higher education (first and second year of post-graduation)

This research project will be based on the main subject.

This research project can be interdisciplinary/multidisciplinary.

It can also be based on industrial training/internship/survey work.

This research project will be done under a supervisor from the institutional teaching faculty. A Cosupervisor from any industry/company/technical institute/Research Institute can also be chosen.

A postgraduate student has to do a research project of 4 credits (4 hours per week) per semester.

The final project report/dissertation of both semesters will be submitted at the end of the year by the student.

The final report will be evaluated by the supervisor and an external examiner appointed by the University for 100 marks.

Evaluation of the project work will be done considering the project report, presentation and vivavoce.

Students can be credited 25 extra marks if they get research papers based on projects published in UGC-CARE listed Journals during their postgraduation course. Nevertheless, the maximum marks will not exceed 100.

Grades will be mentioned on the basis of marks obtained in the research project and they will be included in the CGPA calculations.

In the IX and X semesters, a PG student has to choose one of the four electives.

1. **Endocrinology and Reproductive Physiology:** ZOOLEL- 301A, 302A, 401A, 402A;
2. **Entomology:** ZOOLEL- 301B, 302B, 401B, 402B;
3. **Fish and Fisheries:** ZOOLEL- 301C, 302C, 401C, 402C;
4. **Parasitology:** ZOOLEL- 301D, 302D, 401D, 402D).

Selection of Elective Courses:

Elective courses in Zoology:

The number of seats in each elective would be limited and will be announced before the commencement of the course in each year. The Selection of Elective papers in IX and X Semesters would be based on merit (performance in the First Semester Examination) and choice.

Selection of Minor Courses:

Minor Elective paper from other faculty

In the fifth year, a PG student will have to opt for one minor elective paper from any other faculty of 4 credits.

A. The break-up of marks for credit course examinations will be:

Assessment Type	**Theory course (Marks distribution) 4 credits**
Internal Assessment	
(a) Test	20
(b) Assignment/ Seminar/ Presentation	05
(c) Overall Performance	05
External Assessment	
(a) End semester Examination	70
Total Marks	**100**
Assessment Type	**Lab Course (Marks distribution) 6 credits**
Internal Assessment	
(a) Lab Performance/Demonstration	**15**
(b) Lab Record	**05**
© Viva	**05**
(d) field work / collection	**05**
External Assessment	
(a) Write up /Exercise	**20**
(b) Viva /Record/Field work	**20**
(c) Execution/Performance/Demonstration	**30**
Total Marks	**100**

Semester VII

ZOOLCC-101: Non–Chordata

Total Credits: 04

Unit I Protozoa

Ultrastructure, Osmoregulation, Locomotion, Nutrition, Reproduction

Porifera

Cell types, Skeleton, Reproduction

Cnidaria

Origin of metazoan, Polymorphism, Metagenesis, Corals

Unit II Platyhelminthes

Origin and evolution of bilateria, Parasitic adaptations, General organization of Larval stages of Trematoda and Cestoda

Aschelminths

General organization,Economic importance of nematodes in animals and plants

Unit III Annelida

Coelom & Metamerism, adaptive radiation in Polychaeta, Segmental organs, Filter feeding

Arthropoda

Organisation and affinities of Onychophora, Larval forms in Crustacea, Parasitism in Crustacea, Respiratory organs in Arthropods

Unit IV Mollusca

Foot and Radula, Respiration, Nervous system, Torsion in gastropods

Echinodermata

Origin of Deuterostomia, Water vascular system, Larval forms & affinities

Unit V Minor phyla

General Organization and affinities of Rotifera, Phoronida, Ectoprocta, Endoprocta, Ctenophora

Student learning outcomes

The student at the completion of the course will be able to:

- Demonstrate comprehensive identification abilities of non-chordate diversity
- Describe structural and functional diversity of non-chordate

- Explain evolutionary relationship amongst non-chordate groups

Suggested readings

1. Barnes et al (2009). The Invertebrates: A synthesis. Wiley Backwell
2. Hunter: Life of Invertebrates (1979, Collier Macmillan)
3. Marshall: Parker & Haswell Text Book of Zoology, Vol. I (7th ed 1972, Macmillan)
4. Moore: An Introduction to the Invertebrates (2001, Cambridge University Press)
5. Brusca and Brusca (2016) Invertebrates. Sinauer
6. Jan Pechenik (2014) Biology of the invertebrates. McGraw Hill
7. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

ZOOLCC-102: Animal Physiology

Total Credits: 04

Unit I

Physiology of Digestion

Digestion and absorption of proteins, carbohydrates, lipids, nucleic acids, Regulation of digestion and absorption

Physiology of Excretion

Homeostasis, Ion regulation, Physiology and Regulation of excretion

Physiology of Thermoregulation

Thermoregulation and animal categories, Acute and chronic metabolic responses to temperature change, Mechanism of thermoregulation

Unit II

Physiology of respiration

External respiration, Internal respiration, Gaseous exchange in terrestrial and aquatic animals, Respiratory pigments, Mechanism and regulation of respiration

Physiology of circulation

Pattern of circulation among different animal groups, Regulation of circulation, Cardiac cycle

Unit III

Physiology of muscular system

Types, function and properties of muscle tissue, Molecular organization of sarcomere, Molecular mechanism of striated muscle contraction, Molecular mechanism of smooth muscle contraction, Muscle metabolism, Regulation of muscle contraction

Neurophysiology

Neuronal tissue, Structural and Functional Organization of Nervous System, Ionic and Physical Basis of Membrane Potential, Electrotonic and Action Potential Conduction, Molecular mechanism of Synaptic transmission, vesicle fusion and recycling, Neurotransmitters and Neuro Modulators

Unit IV

Physiology of sense organs

Organization of Sensory System, Mechanoreception and Touch, Chemoreception and Taste, Olfaction,Vision

Physiology of endocrine system

Overview of endocrine glands, Mechanism of action of hormones

Unit V

Physiology of stress

Mechanism of stress, Stress disorders, Secondary effects

Physiology of Aging

Aging and Senescence, Physiological and Cellular Manifestations of Aging, Biological Theories of Aging: Programmed and Damage or error type of theory, Beyond Molecular Biology of Aging, Molecular Mechanisms of Aging

Student learning outcomes

The student at the completion of the course will be able to

- Understand various functional components of an organism body
- Analyse the complexities and interconnectedness of these functional components
- Identify the mechanism underlying maintenance of homeostasis of the body
- Infer the regulatory mechanisms for maintenance of function in the body

Suggested readings

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hercourt Asia PTE Ltd. /W.B. Saunders Company.

2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition John Wiley & sons

3. Christopher D. Moyes, Patricia M. Schulte 2016 Principles of Animal Physiology. 3rd Edition, Pearson Education

4. Hill, Richard W., et al. Animal physiology. Vol. 2. Sunderland, MA: Sinauer Associates, 2004.

5. Chatterjee C C (2016) Human Physiology Volume 1 & 2. 11th edition. CBS Publishers

ZOOLCC-103: Biochemistry and Cell Biology

Total Credits: 04

Unit I

Biomolecules

Introduction to biomolecules (carbohydrates, lipids, proteins, nucleic acids), Stablizing interactions (van der waals, electrostatic, hydrogen bonding, hydrophobic interaction *etc.*), Types and structure of amino acids, Secondary structure of Proteins (α-helix, β-sheet, motifs, folds, domains, Ramachandran plot) Tertiary and quaternary structure

Nucleic acids: DNA structure, DNA supercoiling, forms of DNA, chromatin organization Types of RNA

Unit II

Enzyme Kinetics

Introduction to enzymes: Apoenzyme, holoenzyme, prosthetic group, cofactors, coenzymes, abzymes, ribozymes.

Enzyme kinetics: Michaelis-Menten equation, LB Plots, enzyme inhibition,

Enzyme regulation: Allosteric regulation, covalent modification, zymogens, Proenzymes, isozymes

Unit III

Metabolism

Carbohydrates: glycolysis, citric acid cycle, gluconeogenesis, glycogenesis, glycogenolysis, phosphate pentose pathway, oxidative phosphorylation, and their regulation

Lipids --- Biosynthesis of saturated and unsaturated fatty acids, Catabolism of fatty acids and ketone bodies

Amino acids: Oxidation and production of urea

Nucleic acids: Biosynthesis and degradation of pyrimidines and purines

Unit IV

Cell Membrane

Lipid bi-layer, Membrane proteins & Fluid mosaic model

Transport: Diffusion,

Active transport: Mechanism

Targetting and sorting of proteins

Processing through endomembrane system

Mitochondria

Structure: Assemblies of respiratory chain & Fo-F1 ATPase Oxidative phosphorylation ATP and other high energy phosphate compounds

Unit V

Cytoskeleton

Organization of Microtubules, Microfilaments and Intermediary filaments

Nucleus

Structure, function, Nuclear membrane, Nucleolus, Chromatin Net, Barr Bodies, Hammerling Experiment

Ribosomes

Structure and biogenesis of ribosomes

Cell Signalling

Cell-cell interaction Chemical mediators Cell surface and intracellular receptors

Cell cycle and Cell division

Cell cycle overview and control
Checkpoints in cell-cycle regulation
Regulation of Mitosis and Mieosis
Cancer and apoptosis

Student learning outcomes

The course will lay down the foundation of biochemistry among students where they will develop a deep understanding of structure of biomolecules like proteins, lipids and carbohydrates and how simple molecules together form complex macromolecules. They will be able to understand the thermodynamics of enzyme catalyzed reactions and mechanisms of energy production at cellular and molecular levels.

Suggested readings

Lehninger's Principles of Biochemistry by Nelson & Cox (2000) McMillan
Principles of Biochemistry by Zubay *et al*1995 WCB Wiley
Biochemistry Vols 1 & 2 by Voet & Voet 2004
Harper's Illustrated Biochemistry Murray *et al* 2003 McGraw Hill
Practical Biochemistry – Principles and Techniques by Wilson and Walker Cambridge University Press
Biochemistry and Molecular Biology by Elliott and Elliott Oxford University press

ZOOLCC-104: Biodiversity

Total Credits: 04

Unit I

Biodiversity

What is Biodiversity?
Biodiversity Types: (a) Species, Ecosystem level, Genetic Level
(b) Alpha, Beta, Gamma level
Indian Biodiversity & Its Distribution
Importance/Significance
Biodiversity Hotspots/Parks
Keystone species, Indicator Species

Unit II

Classification and Diversity

General Classification & Diversity of Lepidopterans and Arachnids with common examples
General Classification & Diversity of Amphibians

Unit III

Tools/Techniques

Binoculars
Cameras- Digital & DSLR
GPS, Sound Recorder, Some Common Wildlife Softwares
Methods of Census & Biodiversity, Census Technique
Biodiversity indices

Unit 4

Threats

Major Threats to Biodiversity
Natural Threats: Climate Change, Natural Calamity, Desertification
Anthropogenic Threats: Pollution, Habitat Fragmentation Degradation, Hunting/Killing/Poaching, Agricultural Practices, Urbanization

Unit 5

Attributes

Biodiversity: concepts and hierarchical levels
Species diversity
Species richness and evenness
Genetic diversity
Ecosystem diversity and services
National laws of biodiversity

Student learning outcomes

The student at the end of the course will be able to

- Appreciate biodiversity, its threats.
- Identify common biodiversity in their courtyard.

- Comprehend and communicate details of various Government Bodies & Policies related to biodiversity.

Suggested readings

1. Biodiversity and Ecosystem functioning. edited by Michel Lorean, Shahid Naureen and Pablo Inchausti (Oxford University Press.)
2. Biodiversity and Conservation in Forests. By Diana. F. Tomback. Publication MDPI-Multidisciplinary Digital Publishing Institute.
3. Methods and Practice in Biodiversity Conservation by David Hawks-worber. (Springer Publication)
4. Recent Studies in Biodiversity and Traditional Knowledge in India. By Chandra Ghosh and A.P. Das (Publisher: Levant Books)
5. Biodiversity and Protected Areas by Beazley, Karen, Baldwin, Robert. (Publishers: MDPI)
6. An Advanced Text book on Biodiversity (Principle and Practice) by K.V. Krishnamurthy. (Publication-CBS)
7. Biodiversity Hotspots edited by Vittore Rescigrio and Savario Moletta. (Publishers: Nova Science Publishers)

ZOOLCC-105 Lab based on ZOOLCC101,102,103,104

General characters and classification of the non- chordates phyla (Protozoa to Echinodermata) with the help of museum specimens and slides.

Protozoa: Vital staining and staining preparation of *Paramecium ;* Permanent preparation of *Ceratium, Noctiluca,Paramecium, Vorticella,*

Study of prepared slides: *Balantidium,Nyctotherus,Opalina.Paramecium* conjugation / binary fission,*Entamoeba histolytica ,Giardia, Trypanosoma, Leishmania, Trichomona.*

Porifera: Permanent preparation of gemmules, sponging fibres and different kinds of spicules,

Study of museum specimens specimens/models; *Lecuosolania , Sycon , Grantia, Euplectella, Hyalonema, Oscarella, Chondrilla, Chliona, Chalina, Spongilla, Spongia, Hippospongia.*

Cnidaria and Ctenophora: Study of nematocycsts of *Hydra,* Permanent preparation of *Hydra; Obelia and* other hydrozoan colonies and *Obelia* Medusa ;

Study of museum specimens/ models : *Tubularia , Bougainvillia, Pennaria, Hydractinia, Sertularia, Campanularia, Millepora, Stylaster, Physalia, Porpita, Valella, Aurelia, Rhizostoma, Tubipora, Alcyonium, Gorgonia, Corallium, Pennatula, Zoanthus, Metridium, Adamsia, Cerianthus, Fungia, Madrepora, Cestum .*

Helminths: Permanent preparation of selected soil and plant nematodes , cestode and trematode and different larval stages of liver fluke,

Study of museum specimens/ whole mounts : *Convoluta, Dugesia, Bipalium, Fasciola , Paramphistomum, Schistosoma, Taenia, Moniezia , Echinococcus, Trichuris, Trichinella, Heterodera, Enterobius, Ascaris, Ancylostoma, Dracunculus,Wuchereria;study of prepared slides :Scolex of tape worm ,mature and gravid proglottid of tape worm;Study of cysticercus larva, hydatid cyst, larval stage of Fasciola .*

Annelida: Study of museum specimens*/models:Aphrodite, Tomopteris, Glycera, Chaetopterus, Arenicola ,Sabella, Amphitrite, Serpula, Tubifex, Branchiobdella, Eisenia, Metaphire, Placobdella,pontobdella Branchellion, Polygordius,:Study of prepared slides:T.S*. of body of leech passing through various places.

Arthropoda: Study of museum specimen: *Limulus, Palamnaeus, Lycosa, Apus, Argulus,Balanus, Sacculina, Mysis, Gmmarus, Squilla*, Prawn, Lobster, true crab, hermit crab, *Julus, Scolopendra, Scutigerella, Lepisma, Mantis,* stick insect, grass hopper, *termites ,Forficula,Pediculus, Ranatra, Dysdercus, Musca* ,Lady bird beetle, butterfly, wasp, *Xenopsylla,* life history of honey bee, lac insect and silk moth;

Study of prepared slides: Mouth parts of mosquitoes, house fly, honey bee, butterfly , *Sarcoptes, Ixodes, Cimex, Daphnia, Cypris, Cyclops, Pediculus, Pthirus.*

Mollusca : Study of museum specimen/models : *Chiton, Dentaliun, Pila, Aplysia, Baccinum, Doris, Lymnaea, Mytilus, Patella, Pecten, Limax,* pearl oyster*, Teredo, Nautilus, Loligo, Sepia, Octopus.*

Study of prepared slide: Radula, T.S of shell of *Unio*, T.S of gill lamina *of Unio,* T.S of body of *Unio* passing through middle region; Larvae of molluscs.

Echinodermata: Study of museums specimen/ models: *Astropecten, Asterias, Ophio*thrix, *Opiura, Echinus, Clypeaster, Echinocardium, Thyone, Holothuria, Antedom*;

Study of prepared slides: Larvae of echinoderms: Aristotle's lantern.

Hemichordata : Study of museum specimens: *Balanoglossus, Cephalodiscus: Tornaria* larva,

Minor phyla: Representative specimens of Onychophora (*Peripatus*), Sipunculida *(Sipunculus*), Echiurida (*Bonelia)*

ANIMAL PHYSIOLOGY

Estimation of blood glucose content.

Estimation of glycogen in liver

Determination of Blood cholesterol content.

Determination of Iodine number of fats to evaluate the biological value.
Total count of RBC and WBC.
Differential count of WBC.
Estimation of blood urea content.
Determination of serum acetylcholine esterase activity.
Estimation of RNA concentration by Diphenylamine method.
Estimation of serum LDH activity.

CYTOLOGY SLIDES

Different stages of Mitosis, Interphase, Prophase. Metaphase, Anaphase, Telophase, Different stages of Meiosis. 1st prophase Leptotene, Zygotene, Pachytene, Diplotene. Metaphase I, Anaphase *I,* Tetophase, Diakinesis, Chiasma formation, Metaphase II, Anaphase II. Telophase II. Golgi Apparatus, Mitochondria Preparation of temporary mounts to demonstrate stages of meiosis and mitosis

Biodiversity

Study of Hot spots with help of model/ chart

ZOOLMN-101: Public health and Hygiene

Unit I:

Maintenance of personal hygiene:
Introduction to public health and hygiene- determinants and factors.
Pollution and health hazards; water and air borne diseases.
Radiation hazards: Mobile Cell tower and electronic gadgets (recommended levels, effects and precaution).

Unit II:

Nutrient deficiency diseases: Classification of food into micro and macro nutrients.
Balanced diet, dietary plan for an infant, normal adult, pregnant woman and old person.
Importance of dietary fibres.
Significance of breast feeding.
Malnutrition anomalies – Anaemia (Iron and B12deficiency), Kwashiorkar, Marasmus, Rickets,

Unit III:

Non-communicable diseases and cure: Non-communicable diseases such as hypertension, stroke, coronary heart disease, myocardial infarction.
Diabetes- types and their effect on human health.
Gastrointestinal disorders- acidity, peptic ulcer, constipation (cause, symptoms, precaution and remedy) etc.
Obesity (Definition and consequences).

Unit IV:

Communicable and contagious diseases: Infectious agents responsible for diseases in humans.
Communicable viral diseasesmeasles, chicken pox, poliomyelitis, swine flu, dengue, chickunguniya, rabies, leprosy and hepatitis.
Communicable bacterial diseases- tuberculosis, typhoid, cholera, tetanus, plague, whooping cough, diphtheria, leprosy. sexually transmitted diseases- AIDS, syphilis and gonorrhoea.
Health education and preventive measures for communicable diseases

Suggested readings

1. Gibney, M.J. Public Health Nutrition.
2. Wong, K.V. Nutrition, Health and Disease.
3.Mary Jane Schneider. Introduction to Public Health.
4. Muthu, V.K. A Short Book of Public Health.
5. Detels, R. Oxford Textbook of Public Health

Semester VIII

ZOOLCC-201: Biosystematics, Evolutionary Biology and Conservation

Total Credit: 04

Unit I

Taxonomy and classification

Concepts, terminology and types of taxonomy and classification, Principles of classification, Artificial and natural classification

Unit II

Concept and preambles of ICZN, Law of priority, Proteins and nucleic acids in modern taxonomy

Unit III

Evolutionary Biology

Concept and type of species, Endemic species, Mechanisms of speciation, Origin of life: Life's beginnings, evolution of eukaryotes

Unit IV

Evolutionary Theories

Evolutionary theories, Natural selection, Molecular evolution, Adaptation (evolutionary analysis of form and function)
Phylogenetics: concept, phylogenetic gradualism and punctutated equilibrium

Unit V

Conservation Strategies

Wild Life Protection 1972, Biodiversity Act 2000, IUCN Categories, Red Data List, Biodiversity Conservation
Govt. Agencies- IWB, MoEF, WII etc., NGO'S – BNHS, ATREE etc.
Ex situ, In situ Conservation
Andolans :- Chipko Movement, Panipanchayat, etc.

Student leaning outcome

The student at the completion of the course will be able to understand:

- Basic concepts of biosystematics, evolutionary biology and biodiversity which will enable the students not only to understand the subjects but also to solve the biological problems related to the environment.
- Principles of taxonomy for identification, classification and naming the organisms scientifically.
- Origin and modification of various life forms during various time scales.

Suggested readings

1. Principles of Systematic Zoology by Ernst Mayr, McGraw Hill, New York
2. Principles of Animal Taxonomy by G.G.Simpson, Columbia University Press, Scientific Publisher.
3. Evolution: An Introduction by S.C.Stearns and R.F.Hoekstra, Oxford University Press, New York
4. Evolution by N. H. Barton, D.E.G. Briggs, J.A. Eisen, D. B. Goldstein and N.H. Patel, Cold Spring Harbor Laboratory Press, New York.

5. Ridley, M (2004) Evolution III Edition Blackwell publishing Hall, B.K. and Hallgrimson, B (2008). Evolution IV Edition. Jones and Barlett
6. What is biodiversity by James Maclaurin and Kim Sterelny, U.Chicago.Edu.
7. Schuh, R.T., and A.V.Z. Brower. 2009. Biological Systematics: Principles and Applications, 2nd Ed. Cornell University Press. 311+xi pp.
8. Wiley, E. O. and B. S. Lieberman. 2011. Phylogenetics: Theory and Practice of Phylogenetic Systematics, 2nd Ed. Wiley-Blackwell. 406+xvi pp.
9. Williams, D. M. and M. C. Ebach. 2010. Foundations of Systematics and Biodiversity. Springer. 309+xvii pp.
10. Biodiversity and Ecosystem Functioning by E.D. Shulze and H. A. Moonthy, Spriger Publication.
11. Methods and Practice in biodiversity Conservation by David Hawks worth, Springer publication
12. A Text Book of Biodiversity by K.V. Krishnamurthy, CBS Publication

ZOOLCC-202: Developmental Biology and Immunology

Total Credits: 04

Unit I

Gamete fertilization and early development

Structure and recognition of the gametes
Sperm capacitation and acrosomal reaction
Gamete binding and fusion, and the prevention of polyspermy
Cleavage patterns
Gastrulation
Neurulation

Unit II

Comparative account of underlying mechanisms in vertebrate development

Morphogenesis and cell adhesion
Evidence for genomic equivalence
Differential gene expression
Cell-cell communication in development
Primary organizers, induction and competence
Early development of fish, birds, and mammals

Unit III

Later developmental processes

The dynamics of organ development
Development of eye
Development of kidney
Development of limb
Metamorphosis: the hormonal reactivation of development
Amphibian metamorphosis

Unit IV

Immune system & responses

Types of Immunity (Innate, Adaptive, humoral, cell-mediated)
Cells of Immune system (B & T lymphocytes, Phagocytes, Granulocytic cells, Mast cells, NK Cells, Dendritic cells)
Organs of Immune system- (Primary and secondary lymphoid organs-Thymus, marrow, Bone lymph nodes, spleen, MAST)
Generation of B &T cell responses
Immunoglobulins (structure, Types/Classes & functions)
Epitopes
Monoclonal and polyclonal antibodies
Antibody diversity

Unit V

Immune mechanisms

Antigen antibody interactions (Agglutinaton Rn's, Precipitation Rns', cross reactivity, Antibody affinity and avidity, immune florescence, flow cytometry, western blotting,

immune electron microscopy, RIA, ELISA and it's types)
Antigen: types, processing & presentation
Major Histocompatibility complex: classes, structure, expression, immune responsiveness, and disease susceptibility (HLA)
Vaccine

Student learning outcomes

The student at the completion of the course will be able to understand:

- A variety of interacting processes, which generate an organism's heterogeneous shapes, size, and structural features,
- How a cell behaves in response to an autonomous determinant or an external signal, and
- The scientific reasoning exhibited in experimental life science.
- An in depth understanding about immune system & it's elaborate mechanisms.
- Recent trends in immune therapy in case of several diseases like cancer, hepatitis etc

Suggested readings

1. Developmental Biology: T. Subramaniam, (Reprint) 2013, Narosa Publishing House Pvt. Ltd., New Delhi
2. Essential Developmental Biology: Jonathan M. W. Slack, (3rd ed.) 2012, Wiley-Blackwell.
3. Developmental Biology: From a Cell to an Organism (Genetics & Evolution) eBook: Russ Hodge, 2009, Infobase Publishing.
4. Current Topics in Developmental Biology: Roger A. Pedersen, Gerald P. Schatten, 1998 Elsevier.
5. Developmental biology: Werner A. Müller, 2012, Springer Science & Business Media.
6. Human Embryology and Developmental Biology E-Book: Bruce M. Carlson, 2018, Elsevier Health Sciences.
7. Developmental Biology: Michael J. F. Barresi, Scott F. Gilbert, 2019, Oxford University Press.
8. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby (2007) Kuby Immunology. W H Freeman
9. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. (2017). Roitt's Essential Immunology, 13th Edition. Wiley Blackwell
10. Immunology by Ian. R. Tizard Saunders college Publishing Chicago, New York.
11. Nandini Shetty (2005) Immunology Introductory Textbook. New Age International.

ZOOLCC-203: Quantitative Biology and Bioinstrumentation

Total Credit: 04

Unit I

Biological data

Data on a ratio scale
Data on an interval scale
Data on an ordinal scale
Data on a nominal scale
Parametric and non-parametric tests (concepts and applications)

Unit II

Measures of central tendency (individual observations, discrete and continuous series)

Mean (simple and weighted)
Median
Mode (analysis using group table)

Measures of dispersion (individual observations, discrete and continuous series)

Range and mean deviation
Standard deviation

Unit III

Correlation and regression

Types and methods of studying correlation
Karl Pearson's coefficient of correlation and determination
Regression equation (X on Y and Y on X)
Regression lines

Tests of significance and their application

t-test
Chi-square test

Analysis of variance

One-way and two-way ANOVA

Unit IV

Bioinstruments

Basic principles of microscopy, Phase contrast microscope, Electron microscope, Fluorescence microscope ,Confocal microscopes
Centrifuge: principle, types of rotors, high speed and ultracentrifuge, pH Meter, Chromatography: Paper, Gel Filtration, Ion exchange, HPLC,ELISA

Unit V

Advanced instrumentation

Colorimetry and spectrophotometry: Beer-lambert law, absorption coefficient
Biochemical Analysers, Lyophilizer

Water purification system, Laminar flow, Autoclave
PCR machine, Gel Documentation System, Gel Apparatus
Flow cytometer, DNA sequencer, Microarray, Microplate reader

Student learning outcomes

The present course will enable the students to:

- Solve the biological problems during data analysis using various statistical methods such as uni-variate analysis, bi variate analysis, correlation, regression and various tests of significance.
- Learn the working of various equipments which will be useful in the final semester for their experimental work.

Suggested readings

Biostatistical Analysis (Fourth Edition) by Jerrold H. Zarr, Pearson Education Inc., Delhi.
Statistical Methods (Eighth Edition) by G. W. Snecdecor and W. G. Cochran, Willey Blackwell
Biostatistics (Tenth Edition) by W.W. Daniel and C. L. Cross, Wiley
Introductory Biological Statistics (Fourth Edition) by John E. Havel, Raymond E. Hampton and Scott J. Meiners

Suggested readings

Molecular Cloning vols I, II, III Sambrook*et al*2001 CSHL
Molecular Biotechnology Primrose 2001 Panima
Experimental Biochemistry Clark & Switzer 2000 Freeman
Bioinformatics: Instant Notes Westhead *et al* 2003 Viva Books

ZOOLCC-204: Animal Behaviour

Credits: 04

Unit I

Introduction –definition, historical out line, patterns of Behaviour, objectives of Behaviour, mechanism of Behaviour,
Reflexes; reflex action , types of reflexes, reflex arch ,characteristics of reflexes and complex Behaviour; orientation; primary and secondary orientation ;
kinesis- orthokinesis and klinokinesis , taxis – different kinds of taxis ; suncompass orientation

Unit II

Eusociality, social organization in honey bee, polyphenism and its neural control.
various type of communications , production of new qeen and hive , swarming, honey bee as super organism ; fixed actin pattern mechanism, FAP-characteristics and evolutionary features; learning and instincts, conditioning, habitatuation, sensitization .

Unit III

Parental investment, Origin and evolution of parental care, Patterns of parental care, Parent–offspring conflict, Sibling conflict, Brood parasitism

Aggression, dominance and territorial behavior, Habitat choice, Ideal free and despotic distribution Types of territories, Economic defendability, Territory size determinants and defense measure, Evolution of territoriality, Adaptive value of territoriality

Unit IV

Pattern of communication (chemical, visual, light, audio, species specificity of songs, evolution of language with respect to primates); social behhaviour with reference to insects and primates.

Unit V

Sexual Behaviour, courtship, sexual selection, mating patterns, migratory, Behaviour of fishes and birds.

Student learning outcomes

After successful completion of this course in animal behaviour the students should be capable of:

- Understanding and identify behaviors in a variety of taxa
- Discussing the proximate and ultimate causes of various behaviours
- Designing and implementing experiments to test hypotheses relating to animal behaviour
- Understanding about the molecules, cells, and systems of biological timing systems
- Conceptualizing how species profitably inhabit in the temporal environment and space out their activities at different times of the day and seasons.

Suggested readings

1. Alcock, J. 2013. Animal Behavior: An Evolutionary Approach. Tenth Edition. ISBN-13: 978-0878939664 2)

2. Sherman, P.W. and J. Alcock. 2013. Exploring Animal Behavior: Readings from American Scientist. Sixth Edition. ISBN-13: 978-1605351957

3. Dugatkin, L. A. (2013). Principles of animal behavior: Third international student edition. WW Norton & Company.
4. Breed, M. D., & Moore, J. (2015). Animal behavior. Academic Press.
5. Mellgren, R. L. (Ed.). (2000). Animal cognition and behavior (Vol. 13). Elsevier.
6. Bolhuis, J. J., Giraldeau, L. A. E. (2005). The behavior of animals: Mechanisms, function, and evolution. Blackwell Publishing.
7. Hazlett, B. (Ed.). (2012). Quantitative methods in the study of animal behavior. Elsevier.
8. Chronobiology Biological Timekeeping: Jay. C. Dunlap, Jennifer. J. Loros, Patricia J.
9. DeCoursey (ed). 2004, Sinauer Associates, Inc. Publishers, Sunderland, MA, USA
10. The Physiological Clock (3rd edition), Erwin Bunning, The English Universities Press Ltd. London, Springer- Verlag New York, Berlin Heidelberg
11. Circadian Physiology: Roberto Refinetti, CRC Press (3rded) 2016
12. Introducing Biological Rhythms: Willard L. Koukkari, Robert B. Sothern, 2006, Springer
13. Biological Timekeeping: Clock, Rhythms and Behaviour, Vinod Kumar (ed. 2017) Springer India Pvt Limited.
14. Chapter 1, The Clocks that Time Us, Moore-Ede, MC, Sulzman, FM and Fuller, CA (1982) Harvard University Press, Cambridge.
15. M. Menaker (1968) Extraretinal light perception in the sparrow. I. Entrainment of the biological clock. *Proc. Natl. Acad. Sci.* 59:414-421.
16. J.C. Dunlap (1999) Molecular bases for circadian clocks. *Cell* 96:271-290.

ZOOLIN-201: Summer Internship/ Field Work

Semester	Course	Summer Internship/ Research Work	Credits
VIII	**ZOOLIN-201**	-	8

ZOOLCC-205 Lab based on ZOOLCC201-202,203-204

Development Biology

Study of the life history stages of frog.
Removal of egg membranes and mounting,
Study, of morphogenetic movements in the embryo of frog with vital dyes
Hormonal control of amphibian metamorphosis.
Incubation and mounting of chick embryos.
Study of the embryological slides of frog, chick and any mammal

Quantitative biology

Problems related to

1. Mean
2. Standard Deviation
3. Students 't' test
4. Chi – square test

Immunology

Identification of Lymphoid organs of Rat/Mouse.
Determination of Human Blood Group & Rh typing by haemagglutination test
Immunoelectrophoresis.
Preparation of single cell suspension from bone marrow and spleen (spleenocytes) of mice.
Cell counting and viability testing of the spleenocytes prepared.
Preparation and study of phagocytosis by spleenic/peritoneal macrophages.
ELISA

Animal behaviour

Study of Taxis; Kinesis; Habituation; Trial and error learning; Visual discrimination; Feeding behavior , Pheromonal communication with reference to sexual/special behavior.
To study the geotaxis behavior of earthworm; To study the median threshold concentration of sucrose solution in eliciting feeding responses of housefly ; To study the orientation responses of larvae to volatile and visual stimuli.

Evolution

Study of sympatric species- *D. melanogaster* and *D. anannassae*
Study of few examples of homologous and analogous organs
Experiment to demonstrate Genetic drift and Natural Selection

Instrumentation

Basic principles and functioning of Microtomy, Spectrophotometry, Flame photometry, Atomicabsorption, Spectrophotometry, Paper and thin layer chromatography, Centrifugation.

Semester IX

ZOOLCC-301: Chordata

Total Credits: 04

Unit I

Protochordates and Pisces

General organization and affinities of Hemichordata
General organization and affinities of Urochordata
General organization and affinities and Cephalochordata
General organization of fishes
General organization and affinities of Ostracoderms
General organization and affinities of Dipnoi and Holocephali

Unit II

Amphibia

Origin of tetrapods
General organization of Anura
Neoteny
Peculiarities of Urodela
Peculiarities and affinities of Apoda
Extinct Amphibians

Unit III

Reptilia

Origin and evolution
Adaptive radiation
Dinosaurs
General organization and affinities of *Chelonia, Crocodilia,* Squamata, *Rhynchocephalia*

Unit IV

Aves

Origin and evolution
Flightless birds
Adaptations for flight
Adaptive radiation

Unit V

Mammalia

Origin of mammals
Adaptive radiation of Mammalia
Structural peculiarities and phylogenetic relations of *Prototheria* and *Metatheria*
Dentition
Aquatic mammals

Student learning outcomes

The student at the completion of the course will be able to:

- demonstrate comprehensive identification abilities of chordate diversity
- explain structural and functional diversity of chordate
- explain evolutionary relationship amongst chordate

Suggested readings

2. Harvey et al: The Vertebrate Life (2006)
3. Colbert et al: Colbert's Evolution of the Vertebrates: A history of the backboned animals through time (5th ed 2002,Wiley - Liss)
4. Hildebrand: Analysis of Vertebrate Structure (4th ed 1995, John Wiley)
5. Kenneth V. Kardong (2015) Vertebrates: Comparative Anatomy, Function, Evolution McGraw Hill
6. McFarland et al: Vertebrate Life(1979, Macmillan Publishing)
7. Parker and Haswell: TextBook of Zoology, Vol. II (1978, ELBS)
8. Romer and Parsons: The Vertebrate Body (6th ed 1986, CBS Publishing Japan)
9. Young: The life of vertebrates (3rd ed 2006, ELBS/Oxford)
10. Neilsen (2012). Animal Evolution: Interrelationships amongst living Phyla. Oxford

ZOOLCC-302: Environmental Biology, Wildlife and Toxicology

Total Credits: 04

Unit I

Ecosystem

Concept, production and decomposition
Biosphere and biomes
Biogeochemical cycles
Population ecology
Community ecology and ecological succession
Concept of habitat ecology and ecological niche

Unit II

Global environmental problems

Environmental pollution
Waste management
Environmental monitoring
Acid rain
Greenhouse effect and global warming
Depletion of ozone layer
Climate change

Unit III

Wildlife

Basic concept of wildlife and biodiversity
Causes of wildlife depletion
Wildlife conservation strategies
Conservation genetics

Unit IV

Exposure of toxicants

Different routes/methods of exposure, frequency & duration of exposure
Human exposure
Dose-response relationship
Selective toxicity:
concept, significance
Basic mechanisms of selective toxicity

Toxicity Tests

Bioassay
Acute toxicity tests for terrestrial and aquatic animals
Chronic toxicity tests
Concept of maximum acceptable toxicant concentration (MATC) and safe concentration

Factors affecting toxicity

Factors related to the chemical exposure
Surrounding medium and the organisms

Unit V

Toxic effects of Xenobiotics

Local and systemic effects
Immediate and delayed effects
Reversible and irreversible effects
Biochemical and physiological effects of xenobiotics

Bioaccumulation of Xenobiotics

Concept of bioconcentration, bioaccumulation and biomagnifications; Bioconcentration factor
Process of bioaccumulation in the biological system

Biotransformation of Xenobiotics

Concept of biotransformation and metabolism
Sites of biotransformation
Biotransformation enzymes and general biotransformation reactions
Factors affecting biotransformation
Safety evaluation of xenobiotics
Antidotal therapy

Student learning outcomes

The student at the completion of the course will be able to explain:

- Complexities and interconnectedness of various environmental levels and their functioning
- Global environmental issues, their causes, consequences and amelioration
- Significance and conservation of wild life
- Xenobiotics, their mode of action and damage caused

Suggested readings

1. Ecology: Theories & Applications. Peter D. Stiling, 2001, Prentice Hall.
2. Ecological Modeling. 2008. Grant, W.E. and Swannack, T.M., Blackwell.
3. Ecology: The Experimental Analysis of Distribution and Abundance. Charles J. Krebs, 2016, Pearson Education Inc.
4. Elements of Ecology. T.M. Smith and R.L. Smith, 2014, Pearson Education Inc.
5. Environmental Chemistry. 2010. Stanley and Manahan, E. CRC, Taylor & Francis. London.
6. Environment. Raven, Berg, Johnson, 1993, Saunders College Publishing.
7. Essentials of Ecology. G.T. Miller, Jr. & Scott. E. Spoolman, 2014, Brooks/Cole, Cengage Learning.
8. Freshwater Ecology: A Scientific Introduction. 2004. Closs, G., Downes, B. and Boulton, A. Wiley-Blackwell publisher, Oxford.
9. Fundamental Processes in Ecology: An Earth system Approach. 2007. Wilkinson, D.M. Oxford University Press, UK.
10. Fundamentals of Ecology. E.P. Odum& Gray. W. Barrett, 1971, Saunders.
11. Principles of Terrestrial Ecosystem Ecology. 2011. Chaplin, F.S., Matson, P.A. & Vitousek, P.M. Springer.
12. Omkar and Pervez, A.(2017). Concepts of Toxicology. A Textbook for U.G. and P.G. students. Publ. by Vishal Publishing Co. Jalandhar.

13. Derelanko & Auletta. Handbook of Toxicology, 3rd Ed. CRC Press
14. Casarett & Doull's Toxicology: The Science of Poisons" 8th Ed. Edited by Curtis A. Klaassen & John B. Watkins III
15. Principles of Biochemical Toxicology" by J.A.Timbrell, 4th Ed. Informa Press
16. Mechanistic Toxicology", U.A.Boelsterli, 2nd Ed. CRC Press.
17. Caughley, G., and Sinclair, A.R.E. (1994). Wildlife Ecology and Management. Blackwell Science.
18. Pushpesh. J. Wildlife & Forest Conservation A Status Report. Swastik
19. Anderson Stanley.Managing Our Wildlife Resources. Prentice Hall, 3rd Edition
20. Martin Winter. Wildlife Biology. Syrawood Publishing House
21. Kasen Hurst. Wildlife Conservation & Management. Larsen & Keller
22. Martin Winter. Wildlife Conservation &Management .Syrawood Publishing House
23. Martin Winter. Wildlife Protection & Management. Callisto Reference
24. Kendall W.L . Wildlife Study Design . SJ
25. Andrew Wright. Forest Ecology. Black Prints
26. Rajesh Gopal. Fundamental of Wildlife Management. Natraj Publishers
27. Biodiversity and Ecosystem functioning. edited by Michel Lorean ,ShahidNaureen and Pablo Inchausti (Oxford University Press.)
28. Biodiversity and Conservation in Forests. By Diana. F. Tomback. Publication MDPI-Multidisciplinary Digital Publishing Institute.
29. Methods and Practice in Biodiversity Conservation by David Hawks-worber. (Springer Publication)
30. Recent Studies in Biodiversity and Traditional Knowledge in India. By Chandra Ghosh and A.P. Das (Publisher: Levant Books)
31. Biodiversity and Protected Areas by Beazley, Karen, Baldwin, Robert. (Publishers: MDPI) An Advanced Text book on Biodiversity (Principle and Practice) by K.V. Krishnamurthy. (Publication-CBS)
32. Biodiversity Hotspots edited by Vittore Rescigrio and SavarioMoletta. (Publishers: Nova Science Publishers)

ZOOLEL-301A: Principles of Endocrinology

Theory Credit: 04

Unit I

Fundamentals of Endocrinology

Introduction and evolutionary perspective

Endocrine hypothalamus, structure and function

SON, PVN, POA, Arcuate nucleus

Hypophysiotropic hormones

Pituitary gland, structure and function

(adenohypophysis, Neurohypophysis, pars intermedia)

Unit II

Hormones and metabolic regulation

Thyroid gland

Biosynthesis and chemistry of thyroid hormones

Mechanism of action

Biological actions

Endocrine Pancreas

Insulin, glucagon and other secretions

Chemical regulation of feeding, digestion

Unit III

Endocrine regulatory molecules

Hormones

Chemical classification of hormones

Hormone receptors

Mechanism of hormone action

Neurotransmitters and neuropeptides, their role in sleep regulation

Regulatory pathways

Unit IV

Neuroendocrine integration

Hypothalamo–hypophyseal axis

Feedback mechanisms

Adrenal gland, cellular organization

Catecholamines and General Adaptation Syndrome,

Neuroendocrinology of sleep

Unit V

Endocrine regulation of homeostasis

Hormones and Homeostasis

Electrolytes and water balance (Renin-Angiotensin system)

Energy homeostasis

Parathyroid gland

Calcium homeostasis

Endocrine regulation of bone

Student learning outcome

The course will enable the students:

- To develop an understanding of the basic endocrinology
- To study the endocrine regulatory molecules mediating physiology and behavior
- To study the neural and endocrine components of physiological function and neuroendocrine regulation
- To understand the role of hormones in metabolic regulation and maintaining homeostasis
- To understand the integrative working of signaling system

Suggested readings

1. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press
2. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier
3. Comparative Vertrebrate Endocrinology: P. J. Bentley, 3rd Edition, Cambridge University Press
4. Neuroendocrinology: Charles B. Nemeroff, CRC, US
5. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press
6. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education
7. Molecular Endocrinology: F. F. Bolander, 3rd Edition, 2004, Elsevier Academic Press
8. Essential Endocrinology: Darville Brook, C.G. & Marshall, Wiley Blackwell
9 Endocrinology at a Glance**:** Greenstein B, Wiley Blackwell
10. Evidence-Based Endocrinology: V. M. Montori (ed.), Humama Press
11. General And Comparative Endocrinology: John B. Allard, Cunming Duan, Intelliz Press LLC (2016)

ZOOLEL-301B: Insect Taxonomy, Morphology and Ecology

Theory Credit: 04

Unit I

Insect taxonomy I

Overview of insect classification

Identification of Entognathus hexapodes

- Protura
- Collembola
- Diplura

Identification of apterygotes

- Thysanura

Unit II

Insect taxonomy II

Identification of various pterygote orders and their economically important superfamilies

- Orthoptera
- Hemiptera
- Coleoptera
- Hymenoptera
- Lepidoptera
- Diptera

Unit III

Insect morphology

General organization of the insect body

General Organization of insect head

- Sutures and area of the cranium
- Tentorium
- Gnathal appendages (antenna and mouth parts)

General Organization of insect thorax

- Pterothorax
- Legs and their modification
- Wing types
- Wing venation

General organization of insect abdomen

Unit IV

Ecology

General Principals of ecology

Abiotic factor and their effect on insect development and population with special reference to temperature and humidity

Unit V

Biotic factors, Associations and insect behaviour, Parasitism in Insects, Insect predators, Symbiosis, Parental care and social life in insects

Student learning outcomes

Upon successfully completing this course students will be able to;

- Demonstrate identification skills for all insect orders and some superfamilies
- Demonstrate an understanding of the evolutionary history of hexapod orders
- Explain and identify the external morphology of insects
- Demonstrate understanding of the interactions between the insects and ecosystem.

Suggested references

1. Richards, O. W., & Davies, R. G. (1997). Imms' General Textbook of Entomology, Volume I: Structure, Physiology and Development. London, Chapman and Hall.
2. Imms, A. D., Richards, O. W., & Davies, R. G. (Eds.). (2012). Imms' General Textbook of Entomology: Volume 2: Classification and Biology. Springer Science & Business Media.
3. B. Danforth & C. Marshall. 2003. Eickworth's Manual of Insect Morphology. (Posted PDF files on Carmen.osu.edu.
4. Snodgrass, R.E. 1993 (originally 1935). Principles of Insect Morphology (with new forward by George Eickwort). Cornell University Press. 667pp.
5. Grimaldi, D.A. and M.S. Engel. 2005. Evolution of the Insects. Cambridge University Press. 755 pp.
6. Triplehorn, C.A. and N.F. Johnson. 2005. Borror and DeLong's Introduction to the Study of Insects, 7th edition. Thomson Brooks/Cole, Belmont, CA.
7. Schowalter, T.D. (2016). Insect Ecology: An Ecosystem Approach. Academic Press.
8. Price, P.W., Denno, R.F., Eubanks, M.D., Finke, D.L., and Kaplan, I. (2012). Insect Ecology: Behavior, Populations, and Communities. Cambridge University Press.

ZOOLEL-301C: Fish Biology and Genetic Resources

Total Credit: 04

Unit I

Fish morphology and anatomy

Skin: structure, composition and function
Barbels in fishes
Scales: Types, structure and composition
Tail: structural modifications
Fins and locomotion
Air breathing organs and swim bladder: (structural modifications)
Weberian ossicles and sound producing organs

Unit II

Fish physiology

Food, feeding habits and digestion
Excretion
Osmoregulation
Respiratory system: gills, physiology of respiration
Circulatory system
Nervous system
Sense organs: eyes, olfactory and gustatory

Unit III

Reproduction and development

Gonads: male and female
Reproductive cycle and maturation
Spawning
Development in fishes
Parental care
Selective breeding and hybridization

Unit IV

Endocrinology and behaviour

Endocrine glands: structure and functions
Fish behviour (conditioned response and ethological analogies)
Fish migration
Pigments, colour changes and its significance
Electric organ

Luminescence organs in different fishes

Unit V

Fish genetic resources

Fish Biodiversity
Stock (concept and structuring)
Fish chromosome and karyotyping
Chromosome Banding (C, G and NOR)
Chromosome Manipulation (Gynogenesis, Androgenesis and Polyploidy)

Student learning outcomes

The present course provides the basic concepts of fish biology and genetic resources, which will enable the students to:

- Utilize the knowledge in fish biology researches,
- Manage the fish under controlled conditions, and
- Understand the status of fish biogenetic resources of India

Suggested readings

1. Lagler KF, Bardach, JE, Miller, RR, Passino DRM. 1977. Freshwater Fishery Biology by Ichthyology, 2nd Ed. John Wiley & Sons, New York
2. Santosh Kumar and Manju Tembhre. 2011. Fish and Fisheries.
3. Moyle PB. 1982. Fishes: An introduction to ichthyology. Printice-Hall, Englewood cliffs. Jayaram KC. 2008. Fundamentals of Fish Taxonomy.
4. Gopal Ji Srivastava. 1995. Fishes of U.P. and Bihar.
5. Paul J.B. Hart and John D. Reynolds. 1979. Handbook of Fish Biology and Fisheries.
6. Brown ME. 1966. Physiology of fishes. Vol. I and II Academic Press. New York.
7. Hoar WS, Randall DJ and Donaldson EM. 1983. Fish Physiology. Vol. IX. Academic Press, New York

ZOOLEL-301D: General Parasitology

Credits: 04

(Protozoa, Trematoda and Cestoda)

Unit 1

a. **Animal Associations & Categories:** Introduction. Basic Principles & Concepts. Symbiosis, Parasitism,
Commensalisms. Types of Parasites

b. **Parasitic Adaptation:** Evolution of Parasitism, Fate of Parasites. Adaptation to Parasitism

Unit 2

Host parasite Relationship: Host specificity: (I ectoparasite; i. Larval stages parasitic & adult free living, ii.
Adult parasitic & larval stages fredlising, iii. Both larva & adult parasites), (Endoparasite: 1. Larval stages
parasitic & adult free living: ii. Adult parasitic & larval stages free living)}- Action of Parasite upon their
House- (Effects of parasites upon invertebrates, Effects of parasites upon Vertebrates)

Unit 3

Parasitic Protozoa: Introduction, General Classification; Trypanosoma gambiense. Leishmania donovani.

Unit 4

a. **Trematoda:** Introduction, General Classification, Types of Trematodes, Larval forms

b. **Trematoda:** Paragonimus westeramani

c. **Trematoda:** Blood flukes (Schistosoma haematobium, S, mansoni & S. japonicum)

Unit 5

a. **Cestoda:** Introduction, General Classification

b. **Cestoda:** Larval forms

c. **Cestoda:** Echinococcus granulosus, Hymenolepis nana & H. diminuta

Course learning outcomes

By the end of the semester, students will be able to:

- Define variety of animal associations,
- Demonstrate an understanding of the physiology, biochemistry, ecology, evolution, and molecular biology of parasites, and
- Use the bioinformatics for molecular phylogenetic analysis.

Recommended Books

1. *Biochemical Adaptation in Parasites* by C Bryant & C Behm. Publisher: Chapmann & Hall, NY
2. *Biology of Echinicoccus and Hydatid Disease* by RCA Thompson. Publisher : George Allen & Unwin, London
3. *Biology of Eucestoda* by C Armes & PW Pappas. Publisher : Academic Press London
4. *General Parasitology* by TC Cheng. Publisher Orlando : Academic Press
5. *Handbook of Medical Protozoology* by CA Hoare. Publisher : Bailliere, Tyndall & Cox, London
6. *Perspective in Trypanosomiasis Research* by JR Barker. Publisher: John Wiley, UK
7. *Systema Helminthum I: Digenetic Trematodes* by S Yamaguti. Publisher : Interscience Publishing Co., NY
8. *Systema Helminthum II: The Cestodes of Vertebrates* by S Yamaguti. Publisher : Interscience Publishing Co.,
NY
9. *Systema Helminthum IV: Monogenea & Aspidogastrea* by S Yamaguti. Publisher : Interscience Publishing Co., NY
10. *The Biology of Trematoda* by DA Erasmus. Publisher : Edward-Arnold, London

ZOOLCC-302A: Biology of Reproduction

Theory Credit: 04

Unit I

Physiology of male and female reproductive axis

- Reproductive system
  - Gonadal differentiation and theories
  - Differentiation of reproductive tract
  - Hormones of reproductive axis (GnRH/ GnIH; luteinizing hormone [LH] and follicle stimulating hormone [FSH]; sex steroids)

Unit II

Reproductive cycles and pregnancy

- Estrus cycle and menstrual cycle
  - Cellular details and hormonal regulation
- Pregnancy and its hormonal regulation
  - Implantation window, mechanism of implantation
  - Trophoblast differentiation
- Placentation
  - Mechanism of placentation
  - Placental transport function

Unit III

Endocrinology of parturition and lactation

- Parturition and its control
  - Oxytocin and prolactin
- Lactation and its hormonal control
  - Anatomical changes in mammary glands
  - Lactogenesis, Colostrum and its composition
  - Cellular mechanism of milk secretion
- Metabolic homeostasis in human pregnancy and lactation

Unit IV

Reproduction and immunity

- Immunity during pregnancy
  - Suppression of immunity
  - Role of hormones
- Immune tolerance
- Autoimmune bases of infertility

Unit V

Seasonality in reproduction

- Pineal gland
  - Melatonin biosynthesis
  - Melatonin as clock and calendar

Neuroendocrine regulation of seasonality in reproduction

Student learning outcome

The course will enable the students:

- To study the physiology of male and female reproductive axis and reproductive cycles
- To develop understanding of endocrinology of pregnancy, parturition and lactation
- To understand the interrelationship between reproduction and immunity
- To study the seasonality in reproduction

Suggested readings

1. Encyclopedia of Reproduction: Ernst Knobil and Jimmy D. Neill, Volumes 1-4, Academic Press
2. The biology of reproduction: Giuseppe Fusco and Alessandro Minelli, Cambridge University Press
3. Biology of reproduction: Peter J. Hogarth, Blackie
4. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier

ZOOLEL-302B: Insect Physiology

Theory Credit: 04

Unit I

Digestive system

Alimentary canal and its modification
Salivary glands
Nutritional requirements of insect
Physiology of digestion
Digestion of special food stuffs (wool, collagen, keratin, pollen, silk, wax)
Intermediary metabolism of carbohydrates, fats and protein, fat body

Circulatory system

Structure of heart
Mechanism of circulation
Reversal of heart beat
Haemocytes

Unit II

Nervous system

Structure of brain
Nerve chord
Neurotransmitters and neuromodulator system

Sense organs

Mechanoreceptors
Chemoreceptors (Olfactory and gustatory)
Auditory organs & hearing;
Sound and light producing organs
Mechanism of sound and light production
Visual organs and image formation

Unit III

Respiratory system

General organization
Types of spiracles
Gaseous Exchange mechanisms and respiratory adaptations in terrestrial insects
Gaseous Exchange mechanisms and respiratory adaptations in aquatic insects
Respiratory adaptations in endoparasitic insects

Excretory system

Organs of excretion
Nitrogenous excretion

Excretory products
Production of urine and its hormonal regulation
Terrestrial and salt water insects
Control of diuresis
Water regulation
Detoxification

Unit IV

Reproductive system

Anatomy of reproductive organs
Spermatogenesis and oogenesis
Mating, insemination, oviposition
Various modes of reproduction

Insect Development

Development up to three germ layers
Physiological control of moulting and metamorphosis
Various types of larvae and pupae

Unit V

Endocrine glands

Historical perspective
Endocrine glands and concept of neurosecretion
Function of JH and ecdysteroids
Mechanism of action of JH and ecdysteroids

Photoperiodism

Diapause and its regulation in insects

Student learning outcomes

At the end of the course the students will be able to develop:

- An understanding of the various physiological systems of insects
- An understanding of structural differences in the physiological systems of insects from varied habitats
- An understanding of the functional differences in insect physiological systems

Suggested readings

1. Chapman, R. (2012). The Insects: Structure and Function (S. Simpson & A. Douglas, Eds.). Cambridge: Cambridge University Press
2. Gullan, P. J., & Cranston, P. S. (2014). The insects: an outline of entomology. John Wiley & Sons.
3. Marshall, S. A. (2006). Insects: their natural history and diversity: with a photographic guide to insects of eastern North America. Richmond Hill, Ont.: Firefly Books.
4. Nation, J.L. Insect Physiology and Biochemistry 3rd edition. CRC press

5. Klowden: Physiological Systems in Insects (2002, Academic Press)
6. McGavin: Essential Entomology (2001, Oxford Univ Press)
7. Wigglesworth: Principles of Insect Physiology (1972, ELBS)

ZOOLEL-302C: Fish Ecology, Aquaculture and Capture Fisheries

Total Credit:04

Unit I

Ecology of fishes

Water quality requirements

Temperature, salinity, osmotic pressure, pH, dissolved oxygen, carbon dioxide, nitrogen, alkalinity and turbidity

Toxic substances and their effects

International water code for responsible fisheries

Aquatic weeds and their control

Exclusive economic zone

Unit II

Pond management

Construction and lay-out of different types of ponds (nursery, rearing, and stocking)

Formulation and operation of different types of hatcheries

Productivity of the pond (planktons and Live food organism)

Stocking materials (spawn, fry and fingerlings) and their culture

Manuring, liming, eradication of predatory and weed fishes, predatory aquatic insects and their control

Fish poison

Unit III

Capture fisheries

Freshwater fisheries (River, Lakes, and Reservoir)

Cold water fisheries and Hill stream adaptation

Brackish water fisheries

Marine fish resources of India

Problems and prospects of Mariculture

Capture fisheries of India with reference to Elasmobranchs

Bombay duck, Catfishes, Eels, Thread fish, Theropon, Mackerel and Pomfrets, Crustacean and Molluscan Fisheries

Unit IV

Aquaculture

Problems and prospects of aquaculture

Breeding habits of carps: Induced breeding and Bundh Breeding (Indigenous and Exotic)

Monoculture and Polyculture
Integrated fish farming and their management
Nets, Gears and Boats used for Fishing
Aquarium fish, Ornamental fishes and their maintenance

Unit V

Fish products and fish diseases

Fish preservation and processing (traditional and advanced methods)
Fish by-products
Fish marketing and trade
Fish pathology: prevention, prophylaxis and treatment of Fungal, Bacterial, Viral and Protozoan Diseases
Fisheries Cooperative Societies of India
Fish in relation to Man and Human Welfare

Course learning outcome

The present course will prepare the students for:

- The self-employment, and
- The jobs related to the fish and fisheries.

Suggested readings

1. Jhingran VG. 1991. Fish and Fisheries of India, Hindustan Publishing Corporation.
2. A Hatchery Manual for the Common, Chinese and Indian Major Carps by V.G. Jhingran and R.S.V. Pullin, Asian Development Bank, ICLARM, Manila, Philippines
3. Reid GR.1961. Ecology and Inland waters and Estuaries. Rein Hold Corp., New York.
4. Pilley, TVR and Dill, WMA. 1979. Advances in Aquaculture. Fishing News Books, Ltd. England. 11.
5. Pillay TVR and Kutty MN. 2005. Aquaculture- Principles and Practices. Blackwell.
6. Nikolsky GV. 1963. Ecology of Fishes, Academic Press.
7. Norman JR and Greenwood PH. 1975. A History of Fishes, Halsted Press.
8. Potts GW and Wootten RJ. 1984. Fish Reproduction: Strategies and Tactics, Academic Press.
9. De Silva SS & Anderson TA. 1995. Fish Nutrition in Aquaculture. Chapman & Hall Aquaculture Series.
10. Ojha JS. 2005. Aquaculture Nutrition and Biochemistry. Daya Publ.
11. Rath RK. 2000. Freshwater Aquaculture. Scientific Publ.
12. Landau M. 1992. Introduction to Aquaculture. John Wiley & Sons.

ZOOLEL-302D: Biology of parasites

Credits: 04

(Nematoda and Arthropoda)

Unit 1

a. General, Organization, Classification & General Pattern of life cycle of Nematodes (animals, plant parasitic &
Entomopathogenic), Parasitic Adaptation

b. **Introductory:** Nematology: Introduction, General Morphology, Economic importance, Types of Plant nematodes, Host Range, Biology

Unit 2

a. **Family-** Strongyloidate: Strongyloides stercorales

b. **Family -** Ancyclostomatidae: Ancylostoma duodenale

c. **Family-** Filaridae: Wuchereria bancrofti

Unit 3

a. **Techniques in Nematology**: Methods of sampling (soil & plant samples), Methods of extracting nematodes from soil & plant samples, Methods of processing nematodes for observation

b. **Plant Nematode Relationship:** Host parasite relationship, Mechanism involved in injury & histopathology of infected tissue, Interaction with other microorganism

Brief Structure. Life Cycle. Epidemiology. Pathogenicity and Control of Root knot and Cyst Nematodes.

Unit 4

Acanthocephala - General Organization and Classification

Units 5

a. **Medically Important Insects :** Arthropods and sectors of human diseases (mosquitoes, lice, flies and ticks);

Mode of transmission of pathogens by vectors. Chemical, biological and environmental control of anthropoid vectors

b. Insects carrying Vesication. Urtricatino and Venomenization

Course learning outcomes

By the end of the semester, students will be able to:

- Recognize significant morphological characteristics for identification of each of the major parasite group,
- Value the diversity of parasites,
- Describe the basic biology, morphology and life history of selected parasites, and
- Apply the knowledge to generate novel ideas for the management of diseases.

Suggested readings

1. *Handbook of Parasitology* by AK Awasthi and BD Patnaik. Publisher : Dominant *Publishers* & Distributors
India

2. *Veterinary Parasitology* by MA Taylor and R. L. Coop & RL Wall. Publisher : John Wiley & Sons, USA

3. *Modern Parasitology: A Textbook of Parasitology* by FEG Cox. Publisher : John Wiley & Sons, USA

4. Arthropod Born Diseases by Carlos Brisola Marcondes (ed.). Publisher : Springer

5. *Tylenchida: Parasites of Plants and Insects* by Mohammad Rafiq Siddiqi. Publisher : CABI *Publishing, UK*

6. Imm's General Textbook of Entomology by OW Richard & RG Davies. Publisher *: Chapman & Hall, London*
7. An Ecological Approach to Acanthocephalan Physiology by DWT Crompton. Publisher *: CambridgeUniversity Press*
8. *Nematode Parasites of Domestic Animals and man* by Norman D Levine. Publisher : Burgess Publishing Co., London
9. Plant Nematology: , 2nd Edition by Roland N Perry, Maurice Moens. Publisher: CABI
10. Entomopathogenic Nematology by Randy Gaugler. Publisher: CABI

ZOOLCC-303 Lab based on ZOOLCC 301,302 and elective paper

General character and classification of chordate phyla.
Urochordata : study of museum specimens/ whole mount *: oikopleura, Herdmania , Ascidia ,pyrosoma , doliolum, salpa.*
Cephalochordate: study of museum specimen: Branchiostoma .
Cyclostomata : study of museum specimens /models : *peltromyzon ,Myxine; Ammocoete* larva.
Pisces: study of museum specimens/ models :*sphyrna(hammer – headed shark), Trygon,(string –rays) , pristis , Raja (skate), Torpedo(electric –rays), chimaera, polypterus, Acipener, polydon, Amia, Lepidosteus, hilsa,harppodon , notopyerus, labeo, catla, cyprinus,cirrhina, ariys, heteropneustes,clorias, wallago, mystus, Anguilla, exocoteus, hippocampus, channa ,amphipinous, ansbas,synaptura, echeneis,neoceratodus, protopterus, lepidosiren;study of disarticuklated bone of carp.*
Amphibia: Study of museum specimen /models *:Ichthyophis, uraeotyphlus,cryptobrunchus,ambystoma,axolotl, latrva , salamandra, amphiuma, triturus, proteus,Necturus , siren,alyles,bufo, hyla, rhacophorus, study of adisarticulated bone to frog*
Reptilia *:* Study of museum specimen/models chelone*, kachuga, sphenodon , hemidactylus, calotes, draco , phrynosoma , lguana, heloderma , varanus , ophisarus, typhlops, python, natrix , ptyas, dendrophis, bungarus , naja , russlle's viper, pit viper, hydrophis , cerotalus, crocodilus , alligator , gavialis, ichthyosarus, dimentron , brontosarus , tyranosarus, stegosarus, study of disarticulated bones of varanus*
Aves : Study of museum specimens */ models :Arhaeopterys,Milvus(kite), gyps(vulture). Pavo(peacock), Columba (pigeon), eudynamys (koel) , psittacula (parrot) , bubo (owl), coracias (nilkanth), dinopium (woodpecker), house sparrow , corvus (crow) ; study of disarticulated bones of fowl .*
Mammalians : study of museum specimens / models : echidna , ornithorhynchus , macropus , erinaceus , shrew, pteropus , bat , loris , manis , hystrix, funambulus, rattus, oryctologus or lepus, herpestes, lutra, (otter), civet cat , macacar ,study of disarticulated bones of rabbit , skull of dog .

Study of different structural adaptation of animals to ecological conditions ; Study of micro and macro fauna of soil by froth floatation method; Comparative estimate of physicochemical eco factor of in different localities; Temperature , pH , Carbonate, sulphate , nitrate, and turbidity , in fresh water sample; moisture contenting soil sample; Study of seasonal variation in plankton population demonstration of parallax vision and height perception ; Analysis of plant community and biodiversity and biomass ; Study of seasonal in plankton population both qualitative and quantitative

Study of wildlife of local and suburban areas and submission of the report.
Study on wild life in adjoining area with biodiversity of wild flora & fauna.
Study on wild animals and their behaviour
Comparison of dissolve oxygen (D.O) in water samples from different sources.
Determination of the chloride demand and chloride residue.
Estimation of chemical oxygen demand.
Estimation of biological oxygen demand.
Estimation of free carbon dioxide demand.
Estimation of chloride concentration.
Estimation of pH
Effect of UV radiation on animals
Demonstrations of vectors of different diseases

Study on environmental awareness in different group of society
Estimation of LC50, LC10, LC90.
Study of selected biological effect of selected pollutants, especially on the behaviour on animals

ZOOLEL-301 and 302 A (Endocrinology)

Dissect and display of Endocrine glands rat (virtual)
Study of the permanent slides of all the endocrine glands
Estimation of plasma level of any hormone using ELISA
Designing of primers of any hormone Course
Histology of testis and ovary of different age groups of rats to understand the sequence of events related to spermatogenesis and folliculogenesis and ageing effect.
Gonadectomy and sex steroids replacement therapy to see the effect on accessory sex organs of rats.
Isolation of testicular cells and ovarian follicular cells.
In vitro experiments with different testicular cells to provide the direct evidence related to humoral and cellular control of testicular functions.
Vaginal smear preparation.
Induction of superovulation and oocyte retrieval from oviduct of immature rat/mouse.
Sperms count and motility: Role of epididymal proteins, mono- and di-valent cations and pH in control of sperm motility.
Capacitation and acrosome reaction under experimental conditions.
Surgical sterilization of male and female rats.
Pseudopregnancy and delayed implantation in adult lactating rats.
Isolation of various stages of germ cells following flow cytometry
SDS-PAGE analysis of placental proteins.

ZOOLEL-301 and 302 B (Entomology)

Detailed study of the external features of grasshopper
Dissection of nervous systems of Grasshopper, Gryllotalpa, Housefly/Moth/Wasp, honey bee,
Permanent preparation of testis of Cockroach, salivary gland of dysdercus, ovary, spermatheca and accessory gland of house fly.
Spiracles of the caterpillar and wing scales of a lepidopteran insect.
Legs of tresterrial and aquatic insects showing simple adaptation concerning locomotion.
Study of prepared slides of : T.S / L.S. of the various region of gut, ovary, testis and brain.
Whole mounts of thoracic/ abdominal spiracles, different types of antennae, legs, moth parts , wings and sting apparatus of honey bee/ wasp.
Determination of pH of insects guts and haemolymph .
Qualitative assay of free amino acids and haemolymph and fat body.
Quantitative estimation of glycogen, protein and lipid.
Qualitative determination of uric acid from fat body/ Malpighian tubules.
Determination of the rate of passage of food through gut.

Permanent preparation of mouth parts, antennae, wings, legs, Spiracles and external genitalia of insects from different groups.

To study histology and to demonstrate the presence of lipid and glycogen in microtomy sections of suitable material.

ZOOLEL-301 and 302 C (Fish and fisheries)

Study of organ system of Sc*oliodon, labeo* and *wallago*; study of accessory respiratory organs and their blood supply in *heteropneusus*. *Clarias, Channa* and Amphibians: Study of air bladder and ear connection in Notopterus and Gudusia or Hilsa; Morphology of olfactory organs and their innervations on teleosts: preparation of a skeleton and an alizarine mount of fish, Study of prepared microslides

Quantitative estimation of liver glycogen and blood sugar; demonstration of color change.

Systematics of freshwater fishes with special reference to identification of local forms; structural adaptations in fishes.

Qualitative and quantative study of freshwater plankton; estimation of Dissolved oxygen, free carbondioxide, alkanity in a local fish pond; oxygen consumption in local fish sin different habitats.

Study of food and structural modifications due to feeding habits, gills and gill-rackers, mouth eye alimentary canal, olfactory organs etc: Study of age and growth in fishes; Study of amphibians, exotic poisonous, venomous larvivorous and sound producing fishes.

Study of common aquatic vegetation and aquatic insects: study of fishing gears, with particular reference to Uttar Pradesh: soil factors; estimation of hydrobiogical parameters temperature, pH, conductivity, salinity, dissolved oxygen, primary productivity, ammonia, nitrite, nitrate, phosphate, biological oxygen demand, chemical oxygen demand, of nursery rearing, shocking nad breeding ponds.

Estimation of ovarian egg counts: culture of live food organisms and assay of nutritional quality of live food; estimation of popular density of live food organisms; decapsulation and hatching of *Artemia* cysts for use in hatcheries; Demonstration of breeding pools and hatcheries. Induced breeding of Indian major carps and catfishes. Identification of eggs, spawn, fry and fingerings of cultivable fishes of india.

Collection and identification of aquatic weeds and aquatic insects: Study of feeding habits of fishes by gut content analysis, isolation and estimation of fish immunoglobulins; Molecular techniques in fish health management: Aquarium design and maintenance formulation and preparation of artificial fish food for Indian major carps and Prawns; Analysis of proximate composition of fish and processed products.

Visit to freshwater marine fish farm

ZOOLEL-301 and 302 D (Parasitology)

Study of prepared slides and museum specimens of selected parasites of representative groups of protozoans, helminths and arthropods

Smear preparation for protozoa

Study of life cycle, role as vector & control measures of: Ticks (*Argas, Boophilus*)

Mosquito - anyone from- *Anopheles/ Aedes/ Culex*

Any two flies: *Tabanus/ Phlebotomus/ Sarcophaga*. *Cyclops*
Ectoparasites & Endoparasites of wild rat, cattle, dog, chick & human including stages in excreta.
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Semester X

ZOOLCC-401: Molecular Biology and Genetics

Total Credits: 04

Unit I

DNA replication

DNA polymerases & Enzymes involved in replication
Origin of replication and formation of primosome
Unit of replication
Replication fork and replisome
Fidelity of replication
Termination of replication

Unit II

Transcription & Translation

Fine structure of gene, transcription unit
Initiation, elongation and termination of transcription in prokaryotes and eukaryotes
RNA polymerases, Transcription factors and machinery
Formation of initiation complex
Initiation, elongation and termination of translation in prokaryotes and eukaryotes
Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase

Unit III

Regulation of gene expression

Regulation at transcriptional level: Operon system, *lac, trp* operons
Post-transcriptional modifications: Capping, Splicing, Polyadenylation, RNA editing
Role of chromatin in gene expression
Regulation at translational level
Post- translational modifications: Protein folding, Intracellular protein degradation

Unit IV

Mendelian Genetics

Mendel's laws and their chromosomal basis
Extension of Mendel's principles: incomplete dominance and co- dominance, basis of dominant and recessive mutations, complementation test, multiple alleles, pseudoalleles
Gene action- from genotype to phenotype–penetrance and expressivity, gene interaction,epistasis, pleiotropy, phenocopy, genomic imprinting
Linkage and crossing over, sex linkage, sex limited and sex influenced characters
Extra chromosomal inheritance: Mitochondrial genes, maternal inheritance

Sex determination and dosage compensation

Sex determination- in humans, *Drosophila* and other animals
Dosage compensation of X-linked genes–hyperactivation of X-linked gene in Male *Drosophila*
Inactivation of X-linked genes in female mammals

Unit V

Gene mutation and DNA repair

Types of gene mutations
Methods for detection of induced mutations
P-element insertional mutagenesis in *Drosophila*

DNA damage and repair
Mutant types (lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis)

Course Outcome

- The course offers a detailed and conceptual understanding of molecular processes *viz.* Replication, transcription, translation *etc.* underlying survival and propagation of life at molecular level. It will help students to understand how genes are ultimately expressed as proteins which are responsible for the structure and function of all organisms. To learn how four sequences (3 letter codons) generate the transcripts of life and determine the phenotypes of organisms.

- The student will have awareness about genetic diseases, their types and causes. Also the understanding of molecular techniques will provide improved diagnosis and management of these diseases.
- The principles of inheritance, linkage and crossing over which lead to variations will be made clear as well as the application thereof in gene mapping

Suggested Reading

- Genetics Strickberger 1985 Mcmillan
- Modern Genetic Analysis: Integrating Genes and Genomes, Griffiths *et al* 2004 Freeman& Co.
- Principles of Genetics Gardner *et al*1991John Wiley
- Genetics-Principles and Analysis Hartl and Jones 1998 Jones & Bartlett
- Genetics: From Genes to Genomes Hartwell *et al* 2004 McGraw-Hill
- Developmental Biology Gilbert 2003 Sinauer
- Principles of Genetics Snustada and Simmons JohnWiley& Sons
- Genetics Russell Benjamin- Cummings
- Molecular Biology of the Cell Alberts *et al* 2002 Garland
- Molecular Cell Biology Lodish*et al* 2004 Freeman
- Cell: A Molecular Approach Cooper 2000 ASM Press
- Cell and Molecular Biology Karp 2002 Wiley
- Molecular Biology of the Gene Watson et al Pearson
- Lehninger Principles of Biochemistry Nelson & Cox Freeman & Co, USA
- Genetics Pierce Freeman

ZOOLCC402: BASIC CONCEPTS OF BIOTECHNOLOGY

Total Credits: 04

UNIT I

Tools and techniques of Genetic Engineering: Basic Principles of Genetic Engineering; Restriction enzymes, Linkers/Adaptors; Cloning Vectors – Salient Features and Types – Plasmids, Phages, Cosmids, Transposons, Shuttle and Expression Vectors; Techniques – Strategies of rDNA Technology, Gene Library, Insertion of a Foreign DNA into a Vector, Transfer of rDNA into a Bacterial Cell, Selection & Screening of Recombinants, Blotting Techniques.

UNIT II

Industrial & Environmental Biotechnology: Fermentation – Types, Fermenter Designs, Upstream and Down Stream Processing, Product Recovery and Purification; Production of Alcohol and Vitamins. Biofuels, Bioremediation, Biodegradation, Biomining and Biosorption.

UNIT III

Enzyme Biotechnology: Microbial Production of Enzymes, Immobilisation of Enzymes and its applications.

Agricultural Biotechnology: Agrobacterium as a natural genetic engineer; Single Cell Protein, Nitrogen fixation – nitrogen fixing organisms, mechanism and genetics of fixation; Bio-pesticides; Biofertilizers

UNIT – IV

Introduction to Pharmaceutical Biotechnology; Basics on Products of Pharmaceutical Biotechnology (Lymphokines, Interferon's, Human Growth Hormone and Insulin).

Genetic Engineering for the production of Insulin.

Production and Applications of Monoclonal Antibodies (MAbs).

Vaccines: Preparation and role of Genetic Engineering in the production of Vaccines.

UNIT V

Animal and Human Health Care: Diagnosis and Treatment of Diseases; Genetic Counseling; Forensic Medicine (DNA Finger Printing).

Gene Therapy: Human Diseases Targeted for Gene Therapy; Vectors and other Delivery systems for Gene Therapy.

Gene Therapy for Genetical and Acquired Diseases; Gene therapy using Nanotechnology.

TEXT BOOK

- Molecular Biotechnology by john Wiley & Sons Primrose Published by parima publishing
- corporation.
- Principles and practice of Animal tissue culture by Sudha Gangal Published by University Pren
- Laboratory procedures in Biotechnology--- Alam Doyle ,J.Bryan Griffiths.wiley publisher
- Animal Biotechnology- A Laboratory course, --- Jeddrey M.Beeker. Elsevien IInd edition,2007.
- Tools & Techniques in Biotechnology – Mousami Debnath, pointer publishers,2002
- Principles & techniques of Biotechnology & Muecular Biology-- 6th edition, keith Wilson& John
- Walker
- Gene cloning & manipulation, Christopher howe, Combridge Publications.
- Text Book of Biotechnology, S. Chand & Co, New Delhi. By . Dubey, R.C. 2008.

ZOOLEL-401A: Endocrine Disorders and their Diagnostics

Theory Credit: 04

Unit I

Classical endocrine techniques

- Organ/ Tissue manipulation
  - Histological methods
  - Surgeries
  - Tissue dissection and serum collection
  - Subcutaneous injections
  - HRT
- Hormone assays
  - RIA, ELISA, HPLC
  - Hormone pellet construction
  - Hormone content extraction

Unit II

Modern endocrine techniques

- RNA extraction
  - RT PCR
  - qPCR
- Hormone localization
  - Northern Blot
  - ICC, ISH

Unit III

Endocrine disorders and pathophysiologies

- Disorders of major glands
  - Pituitary Disorders
  - Thyroid disorders
  - Adrenal disorders
- Other disorders
  - Osteoporosis
  - Polycystic Ovary Syndrome
  - Polyendocrine disorders
  - Oligospermia

Unit IV

Infertility and reproductive technologies

- Primary and secondary infertility
  - implantation failure, recurrent abortions, preeclampsia
- Reproductive techniques
  - Invitro fertilization, Embryo transfer
  - GIFT, ZIFT, Cryopreservation of gametes and embryos

Contraceptives, HRT

Unit V

Current state of endocrinology and reproductive biology

Disease patterns across India

Endocrine diseases (Diabetes, PCOD, Thyroid hormones related)

Endocrinology of diseases

Breakthrough researches

Indian contribution in the field

Student learning outcome

The present course has been designed to:

1. Provide students the knowledge and understanding of the concepts and theories related to endocrine disorders.
2. Carry out the researches related to the basic and modern aspects of endocrinology.

Suggested readings

1. Vertebrate Endocrinology: David O. Norris, James A. Carr, 2013, 5th Edition, Academic Press

2. Williams Textbook of Endocrinology: H. M. Kronenberg, S. Melmed, K. S. Polonsky and P. R. Larsen, 2008, 11th Edition, Saunders, Elsevier

3. Comparative Vertrebrate Endocrinology: P. J. Bentley, 3rd Edition, Cambridge University Press

4. Neuroendocrinology: Charles B. Nemeroff, xxxx, CRC, US

5. An Introduction to Neuroendocrinology: Richard E. Brown, 2005, Cambridge University Press

6. Endocrinology: Mac E. Hadley, Jon E. Levine, 2009, 6th Edition, Pearson Education

7. Molecular Endocrinology: F. F. Bolander, 3rd Edition, 2004, Elsevier Academic Press

8. Essential Endocrinology: Darville Brook, C.G. & Marshall, Wiley Blackwell

9. Endocrinology at a Glance**:** Greenstein B, Wiley Blackwell

10. Evidence-Based Endocrinology: V. M. Montori (ed.), Humama Press

11. Encyclopedia of Reproduction: Ernst Knobil and Jimmy D. Neill, Volumes 1-4, Academic Press

ZOOLEL-401B: Applied Entomology and Pest Management

Theory Credit: 04

Unit I

Agricultural and horticultural pests–1

Characteristic features, biology, nature of damage and management measures of:
Important insect pests of cotton
Important insect pests of sugarcane
Important insect pests of vegetables
Important insect pests of oil seeds

Unit-II

Agricultural and horticultural pests–2

Characteristic features, biology, nature of damage and management measures of:
Important insect pests of fruit crops, especially mango
Important insect pests of cereals and pulses
Important insect pests of stored grains
Polyphagous insects
Structural Pests

Unit III

Urban entomology

Medical Entomology
Veterinary Entomology
Forensic Entomology

Unit IV

Industrial entomology

Apiculture
Sericulture
Lac-culture

Unit V

Pest management

Components of Insect Pest Management including Mechanical, Physical, Cultural, Chemical, Legal, Ecological, Biological, Microbial, Recent trends
Concept and Procedure of Integrated Pest Management
Mode of action of organochlorine, organophosphorous and carbamate pesticides
Pyrethroids and neem products

Student learning outcomes

At the end of the course the students will be able to:

- identify insect pests
- understand pest population dynamics
- understand pest management measures

Suggested readings

1. Alford: A textbook of Agricultural Entomology, Blackwell 1999
2. Atwal and Dhaliwal: Agricultural pests of India and South-East Asia, Kalyani Publishers,
Byrd and Castner: Forensic Entomology, CRC Press, 2001
3.Dhaliwal and Arora: Principals of Insect pest management, National AgriculturalTechnology Information Centre, Ludhiana, 1996
4. Dhaliwal and Arora: Trends in Agricultural Insect pest Management, Commonwealth Publ., 1994
5. Hill: Pest of stored foodstuffs and their control, Springer, 2002
6. Metcalf and Flint: Destructive and useful insects and their control, McGraw Hill, 1962
7. Mullen and Durden: Medical and Veterinary Entomology, Academic Press, 2002
8. Norris et al: Concepts in Integrated Pest Management, Prentice-Hall, 2002
9. Pedigo: Entomology and Pest Management (4th ed.), Prentice Hall, 2002
10. Pruthi: A Text Book of Agricultural Entomology, ICAR, New Delhi, 1969
11. Purohit: Agricultural Biotechnology (2nd ed.) Agrobios (India), 2003
12. Racheigl and Racheigl: Biological and biotechnological control of insect pests, CRCPress, 1998
13. Schoonhoven et al.: Insect-plant Biology- from physiology to evolution (1st ed.)Chapman & Hall, 1998
14. Srivastava: A Text Book of Applied Entomology (Vol. I & II, 2nd ed.) Kalyani Publ., 2001
15. A Textbook of Applied Entomology Vol. I and II by Srivastava and Dhaliwal
16. Agricultural Pests Of South Asia And Their Management by Atwal and Dhaliwal
17. Industrial Entomology by Omkar. Springer Nature
18. Ecofriendly Pest Management for Food Security by Omkar, Academic Press
19.Introduction to General and Applied Entomology by Awasthi
20. Handbook of Agricultural Entomology by van Emden
21. Pests and Their Management by Omkar, Springer Nature

ZOOLEL-401C: Applied Fish and Fisheries

Total Credit: 04

Unit I

Fish biology

Study of morphometric and meristic characteristics
Study of length-weight and length-length relationship
Determination of age and growth using scale, otolith and operculum
Estimation of absolute and relative fecundity
Artificial breeding of Indian major carp

Unit II

Fish ecology

Physicochemical analysis of pond water
Estimation of DO
Estimation of hardness
Estimation of alkalinity
Estimation of pH
Estimation of temperature

Unit III

Fish biodiversity assessment

Biodiversity: concepts, patterns and measurement
Relative abundance
Measurement and estimation of species richness and evenness
Species diversity indices
Phenotypic Plasticity and Genetic Differentiation in Traits

Unit IV

Fish taxonomy and biosystematics

Fish collection and preservation
Identification of ichthyo-fauna through keys
Fish fin formula

Unit V

Chromosome manipulation and genotoxicity assessment

DNA isolation of fish
Karyotyping of selected fish
DNA polymorphism through RAPD
Micronuclei test (MNT)
Chromosomal aberration test (CAT)

Course learning outcome

The present course has been designed to provide students the knowledge of tools and techniques:

To carry out the researches related to the basic and modern aspects of fish and fisheries.

Suggested readings

1. William RD and Matthew G. 1984. Multivariate Analysis, Methods and Applications. John Wiley & Sons.
2. Biradar RS. 2002. Course Manual on Fisheries Statistics. 2nd Ed. CIFE, Mumbai.
3. Welch PS. 2003. Limnological Methods. Narendra Publ. House.
4. Nelson JS. 2006. Fishes of the World, John Wiley and Sons, Inc., New Jersey.

ZOOLEL-401D: IMMUNOPARASITOLOGY

Credits: 04

Unit 1

a. **Introduction:** Early theories of immunity, historical prospective, recognition, kinds of immunity, normal immune response

b. **An overview of immune system:** innate immunity, acquired immunity (Humoral & cell mediated immunity)

c. **Cells of immune system:** Lymphoid cells (T-lymphocytes. B-lymphocytes), null cells, mononuclear cells, granulocytic cells, mast cells, basophils, dendritic cells. MHC molecules and compliments

Unit 2

a. **Immune system:** Lymphoid organs of the body, thymus, bone marrow, lymph nodes spleen. GAIT. MALT. CAI.T

b. **Immunoglobulin:** Basic structure of immunoglobulin. Fine structure of IgG, IgM. lgA, IgE,monoclonal antibodies, parasite antigen

c. **Antigen antibody interactions:** Strength of antigen-antibody interactions, cross reactivity, precipitation reaction, agglutination reaction

Unit 3

Immunobiology of Protozoans: Malaria (Host response against Plasmodium infection, design of malaria vaccine). African sleeping sickness

Unit 4

Immunobiology of trematodcs: General considerations, immunological problems of trematode infection, immunological response against trematode infection, Schistosomiasis, fascioliasis, immunodiagnosis of
trematodes

Unit 5

a. **Immunobiology of cestodes**: General consideration, immunity to adult cestodes, immunity to travel cestodes, immuno-diagnosis

b. Vaccines: Passive immunization active immunization, designing of vaccines for active immunization, whole organism vaccines, recombinant vector vaccines. DNA vaccines synthetic vaccines

Recommended Books

1. Fundamental of Immunology by William E. Paul. Publisher: Lippincott Williams & Wilkins
2. How helminthes alter immunity to infection by William Horsnell. Publisher: Springer
3. How the Immune System Works 4th Edition by L Sompayrac. Publisher : Willey Blackwell.
4. Immunoparasitology by Phillip Scott. Publisher: Blackwell Munksgaard
5. Immunity to Parasites: How Animal Controls Infections by D Wakelin Publisher : Edward Arnold, London
6. Immunoparasitology by André R.G. Capron. Publisher: Saunders, Philadelphia
7. In vitro cultivation of Parasitic Helminths by JD Smyth. Publisher : CRC Press, Boca Raton, USA
8. Introductory Immunology by Jeffrey K. Actor. Publisher: Academic Press
9. Malaria Immunology by P Perlmann & M Troye-Blomberg. Publisher: Karger
10. Parasite Antigens in Protection, Diagnosis and Escape by R.M.E. Parkhouse. Publisher: Springer Science & Business Media

Course learning outcomes

By the end of the course, students should be able to:

- Examine and identify grossly parasites and their stages and parasitic lesions in different organs,
- Examine and identify the microscopic morphology of parasites and their larval stagesof medical importance in fixed stained smears, and
- Use different kinds of microscopes and modern equipments used in Parasitology.

Suggested literature

1. *Animal Parasitology* by JD Smyth. Cambridge University Press.
2. *Essentials of Parasitology* by GD Schmidt. Brown Publishers
3. *Foundation of Parasitology* by GD Schmidt LS Roberts. McGraw Hill Publishers.
4. *General Parasitology* by TC Cheng. Academic Press
5. *Helminths, Arthropods and Protozoa of domesticated animals* by EJL Soulsby. ELBS and Bailliere Tindall. London.
6. *Human Parasitology* by BJ Bogitsh, CE Carter, TN Oeltmann. Academic Press.
7. *Introduction to Parasitology* by AC Chandler & CP Read. John Wiley & Sons Inc.
8. *Parasite genomics protocols* by SE Melville. Humana Press.
9. *Parasitology* by Chaterjee K.D. Medical Publisher Calcutta.
10. *Parasitology. The Biology of animal Parasites* by ER Noble GA Noble
11. *Modern Parasitology* by FEG Cox. Blackwell Scientific Publications.
12. *Molecular Parasitology* by JE Hyde. Open University Press. London.

ZOOLMT-401: Master Thesis/Dissertation
(Project/ Assignment/ Case report/ Literature review)

Credits: 08

Course objectives

It will be a unique opportunity for the students to study intensively a biological question of their interest. They will have to make a choice from the syllabus and then work on it in the guidance of a teacher.

Aims

- Literature searching to research a specific scientific topic.
- Interpretation and analysis of scientific literature.
- Scientific writing to enable production of a comprehensive literature review.
- Allow students to explore in depth a topic that is of interest to them.

Learning outcomes

Students will be able to-

- Understand in depth a scientific area of interest
- Critically appraise research papers
- Develop literature searching and scientific writing skills
- Develop lay writing skills (abstract)
- Develop organizational and time management skills
- Develop oral presentation skills (in tutorials)
- Develop written and oral communication skills

ZOOLCC-404 Lab based on ZOOLCC 401 and 402

Molecular Cell Biology exercise by demonstrations

Sub cellular fractionation of functional mitochondria
- Isolation of mitochondria from mouse liver by differential centrifugation.
- Determination of protein yield in the fractions by Lowry method.
- Identification of mitochondrial fraction by assay of marker enzyme.

Microtubules in vesicle transport in fish chromatophores.
Mammalian cell culture
Observation of DNA fragmentation in apoptotic cells.
Glut mediated transport of glucose across the plasma membrane in mammalian cells.
Electrophoretic mobility shift assay (EMSA) for Protein-DNA interactions.
Introduction to FACS analysis.

Genetics
Problems based on multiple alleles – Blood groups
Problems based on Mendel's Laws – monohybrid and dihybrid ratios
Problems based on gene frequency – Hardy Weinberg Law
Karyotype studies
Haemoglobin variations

Biotechnology practical by demonstrations:

Laboratory demonstration on safe handling of microorganisms.
Isolation of plasmid DNA from E-Coli .
Isolation of yeast DNA and Transformation of E-Coli.
Qualitative assay of Beta-Galactosidese in yeast Colonies/cell extracts.
Propagation & maintenance of tissue culture.
Isolation of Bone marrow and culture of mesenc hymel stem cells from isoleted urine/sleep/rat bone marrow.
Try pan blue exclusion method for cell viability estimation.
Mycoplasma detection method using PCR.
Production of penicillin and testing of antimicrobial activity.
Production of monoclonal of tissue culture.

ZOOLEL-403 Lab based on ZOOLEL Elective paper 401A,B,C,D

Elective paper 401A

PRACTICALS: (All experiments involving live animals are for demonstration only)
Demonstration of gross anatomical regions of brain.
Isolation of hippocampus, preparation of AchE, staining, protocol of hippocampal cell culture.
Identification of different types of neural and glial cells.
Estimation of acetylcholine in different regions of brain.
Estimation of acetyl cholinesterase sodium and potassium ATPase activity.
Isolation of protein horonstration of bio-activity in an in-vivo bio-assay (eg: FSH);

Immunocytochemical localization of a pituitary hormone using light or electron microscopy (e.g; Prolactin), In vivo bio-assay for estrogen; In vivo Bio-assay for testosterone; vivo bio-assay for luteinizing hormone; In vitro biochemical assay for a hormone (LH or PRL); Effect of hCG on poly A rich RNA content in ovary; Quantification of specific transcript (mRNA) after ovarian stimulation by hCG or FSH;affinity purification of bobine/bubaline pituitary TSH; Preparation and characterization of hormone-enzyme conjugate, ELISA for any one hormone and estimation of plasma level; Estimation of cAMP in a rat tissue (example adipose) with and without hormone stimulation; Streptozotocin administered rat model for diabetes; Demonstration of phosphlipase C action; Molecular cloning of a protein hormone (eg.,buffalo prolactin); Expression of recombinant buffalo prolaclin in *E.coli*.

Elective paper 401B

1. Collection, preservation and identification of locally available insects.
    a. Identification of Apterygote and Exopterygote insects with the help of key.
    b. Identification of various insects pests of different crop plants and stored products, their life -history and materials damaged by them.
    c. Identification of insects (up to genus/species level) of economic importance:
        Lice, bedbug, Rice seed bug/Gundhi bug, White fly, mustard aphid, red cotton bug, thrips, mango leafhopper, Tea mosquito bug, encrusted lac of lac insect, *Bombyx mori* (adult, cocoon)
2. Mounting of sting apparatus of wasp/ honey bee.
3. Mounting of insects and their body parts.
4. Study of various groups of insecticides and equipment's used for insecticide application.
5. Study of life -history of beneficial insects and their products.
6. Methods of insect collection and preservation of Apterygote and Exopterygote insects
7. Submission of collected Apterygote and Exopterygote insects
8. Use of micrometers and camera lucida.
9. Morphological and anatomical studies of various castes of *Polistes, Apis* and *Odontotermes*
10. Collection of various type of social insects and their nests.
11. Visit of agriculture field and forest for spot study.

Elective paper 401 C

1. Histological studies of different tissues and their identification
2. Limnological studies
3. Diet formulation and preparation of artificial fish feed
4. Analysis of proximate composition (moisture, dry matter, crude protein, ether

extract,crude fibre, ash, NFE etc.) of fish tissue and feed samples
5. Quantitative detection of digestive enzymes (protease, α-amylase and lipase)
6. Isolation of fish gut microorganisms and qualitative evaluation of microbial enzymeproduction (protease, α-amylase and cellulase)
7. Identification and mounting of some common freshwater Zooplankton, benthos, aquatic weeds and insects.
8. Electrophoretic separation of proteins and nucleic acids.
9. Field study/Institute visit.

Elective paper 401D

Demonstration based on parasitology.
Culturing insect parasitic nematode, and chasing the lifecycle of the nematode on the insect host.
Preparation of whole mounts for helminthes
Collection of Parasites from digestive tract of Cockroach/ gut/ parasites of hen and their identification and preservation