West Bengal State University
Department of Zoology

SYLLABUS FOR TWO-YEAR POST GRADUATE COURSE OF ZOOLOGY UNDER CHOICE BASED CREDIT SYSTEM (CBCS)

(With effect from the session 2021-2022)

Semester	Paper	Theory/ Practical		Paper Full marks	Semester Full marks	Paper Credit	Semester credit
Semester 1 (Odd)	ZOOPCOR01T	Theory	Life Forms, Genetics & Evolution	50		4	
	ZOOPCOR02T	Theory	Cell Biology & Developmental Biology	50		4	
	ZOOPCOR03T	Theory	Molecular Biology & Immunology	50		4	
	ZOOPCOR04P	Practical	Lab Course I	50		4	
	ZOOPCOR05P	Practical	Lab Course II	50		4	
	ZOOPAEC01M	AECC	Industrial Biology	50		2	
Total					**300**		**22**
Semester 2 (Even)	ZOOPCOR06T	Theory	Biochemistry & Biophysics	50		4	
	ZOOPCOR07T	Theory	Parasitology & Microbiology	50		4	
	ZOOPCOR08T	Theory	Ecology & Quantitative Biology, Taxonomy	50		4	
	ZOOPCOR09P	Practical	Lab Course III	50		4	
	ZOOPCOR10P	Practical	Lab Course IV	50		4	
	ZOOPSEC01M	SEC	Histopathological Techniques	50		2	
Total					**300**		**22**
Semester 3 (Odd)	ZOOPCOR11T	Theory	Physiology, Endocrinology	50		4	
	ZOOPCOR12T	Theory	Animal Behaviour & Conservation Biology	50		4	
	ZOOPCOR13T	Theory	Cancer Biology & Toxicology	50		4	
	ZOOPCOR14P	Practical	Lab Course V	50		4	
	ZOOPCOR15P	Practical	Lab Course VI	50		4	
	ZOOPGEC01T	GEC	Ecosystem and Environmental Hazards	50		4	
Total					**300**		**24**
Semester 4 (Even)	Any Two courses (Theory and Practical) from the following: i. ZOOPDSE 01(T & P) ii. ZOOPDSE 02 (T & P)	Theory	Options offered within the department *****	50		4	
		Theory	Options offered within the	50		4	

	iii. ZOOPDSE 03 (T & P) iv. ZOOPDSE 04 (T & P) v. ZOOPDSE 05 (T & P) vi. ZOOPDSE 06 (T & P)		department *				
		Practical	Options offered within the department *	50		4	
		Practical	Options offered within the department *	50		4	
	ZOOPCOR16M	Project Work/Dissertation		100		8	
Total					**300**		**24**
Total Course Credit					**1200**		**92**

CBCS PG Zoology

Table: For PG Programme

* Options- Students will have to opt for 2 courses (2 Theory papers and their corresponding practical papers)

Elective 1- Applied Entomology and Vector Biology (ZOOPDSE01T) & Applied Entomology and Vector Biology (ZOOPDSE01P)
Elective 2- Applied Conservation Biology (ZOOPDSE02T) & Applied Conservation Biology (ZOOPDSE02P)
Elective3- Advanced Immunology and Vector Molecular Biology (ZOOPDSE03T) & Advanced Immunology and Vector Molecular Biology (ZOOPDSE03P)
Elective 4- Advanced Molecular Oncology and Biochemical Techniques (ZOOPDSE04T) & Advanced Molecular Oncology and Biochemical Techniques (ZOOPDSE04P)
Elective 5- Behavioural Endocrinology (ZOOPDSE05T) & Behavioural Endocrinology (ZOOPDSE05P)
Elective 6- Cell Signaling & Cancer Biology (ZOOPDSE06T) & Cell Signaling & Cancer Biology (ZOOPDSE06P)

CBCS –PG Zoology, WBSU

Preamble

We are living in a golden age of biology. There is a vast domain of knowledge to teach and learn about biology especially zoology and its applications for the Welfare of society. Reading the newspaper or watching news reminds us daily that the subject of biology is woven into the fabric of our society as never before. As the discovery of biology advances, so does the number of ways that it impacts our lives. Medicine agriculture, forensics, ecology, psychology, environmental issues- these are just a few of the subjects to which zoology especially biology has made significant contributions in recent times. While the present age is rich with learning opportunities it also creates teaching and learning challenges. The present syllabus has been designed very carefully with a view not to create a suffocating condition for students under an avalanche of information/s. Focus on the most important areas of zoology has been organized within core areas like cells, genes, evolution, taxonomy and their useful applications for the welfare of society. This entire process of framing up of curriculum is a holistic product of feedback and suggestions from students, peers and corporate society.

Syllabus-1st Semester

ZOOPCOR01T: Life Forms, Genetics & Evolution (Total Credits: 4)

1. Evolution of structural organization of life forms in animal world: Key structural changes in the evolution of animal life forms: Coelom, Metamerism, Bilateral and Radial Symmetry, Notochord and Vertebral Column, Adaptations to lands, Adaptations to fly. Bipedalism and Human brains.
2. Contributions of Mendel's experiments, Hardy-Weinberg theorem and its applications.
3. Population Genetics- Simplemathematical modelling of Natural Selection, concepts of Genetic Drift, Gene Flow, Mutation rates as agents of evolutionary changes.
4. Mendelian Genetics: Laws of Probability and Mendel's experiments, Mendel's reappraisals
5. Human genetics: Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.
6. Role of Genetics in evolutionary interpretation
7. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
8. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
9. Recombination: Homologous and non-homologous recombination including transposition.
10. Different impacts of natural selections on continuously variable traits.
11. Concept of Adaptations and Critical Evaluation of "Adaptationist Story Telling".
12. Coevolution- Evolutionary Arms Race.
13. Human Evolution: Ancestry of early modern Man and Pre-historic Migrations.

Suggested Readings:

Evolutionary Biology by D. Futyuama;

Principles of Genetics by Gardner (Author), Simmons (Author), Snustad (Author) Wiley; 8th edition

Course Objectives:

Course Objectives: "Nothing makes sense in biology except in the light of evolution"- Theodesius Dobzhansky. This oft-quoted and most agreed upon statement among scientists suggest that the theory of evolution is the scientific paradigm for biology and must be taught to every student of life sciences. This Evolution and Genetics part of the course is highly updated and tailor-made to make a PG student strong in the most fundamental aspect of biological sciences. The course is designed to prepare students with knowledge and skills of Taxonomy for exploring and assessing biodiversity and ecosystem health. There are emerging scopes of jobs as ecologists with good taxonomic knowledge in India and abroad.

ZOOPCOR02T: Theory- Cell Biology & Developmental Biology (Total Credits: 4)

Group A: Cell Biology

1. Evolution of cell
2. Membrane structure and function: Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.
3. Structural organization and function of intracellular organelles: Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.
4. Transport of Ions and Molecules across cell membranes: Passive diffusion, facilitated diffusion, uniporters, symporters, antiporters , Ion channels, ATP-powered pumps,
5. Extracellular matrix and Cell junctions and cell-cell signaling.
6. Cell Function: Dynamic movements, trafficking, targetting, sorting and localization of macromolecules and signal transduction in the living cells.
7. Cell cycle: Molecular genetics of cell cycle control, cdc mutants, Loss of cell cycle control and cancer, programmed cell death and apopotosis.
8. Biology of excitable (nerve or contractile cells) cells.

Suggested Readings: Text Book: Molecular Cell Biology By Lodish, Cell by Cooper, Molecular Biology of the Cell by Bruce Alberts

Group B: Developmental Biology

1. Basic concepts of development: Potency, induction, competence, differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells.
2. Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development; zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals.
3. Morphogenesis and organogenesis in animals: Axes and pattern formation in Drosophila, amphibian and chick; organogenesis-vulva formation in Caenorhabditiselegans, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons.

4. Programmed cell death, aging and senescence

Suggested Reading:

Developmental Biology by Scott F. Gilbert

Course Objectives:

The cell is a powerful case study to help us explore the functional logic of living systems. All organisms are made up of cells. This course is designed to explore the fundamentals of cell biology. We hope learners will develop a deep intuition to understand the functional logic of a cell. To underscore the importance of cell biology in our lives, we will address questions of cellular disorders, and associated health implications in the human society.

Developmental biology studies the mechanisms involved in growth and development of complex organisms. In many ways the basic understandings of developmental biology provide an invaluable foundation for other aspects of biology as well as medicine, especially as many health issues can be related back to early developmental defects during embryogenesis. This course aims to provide a broad, comprehensive look at embryology with special emphasis on vertebrate models, focusing on both classical experiments and modern molecular and genetic techniques.

ZOOPCOR03T - Theory: Molecular Biology & Immunology (Total Credits: 4)

1. DNA replication, repair and recombination (Unit of replication, enzymes involved, replication origin and replication fork, fidelity of replication, extrachromosomal replicons, DNA damage and repair mechanisms, homologous and site-specific recombination).
2. RNA synthesis and processing (transcription factors and machinery, formation ofinitiation complex, transcription activator and repressor, RNA polymerases, capping, elongation, and termination, RNA processing, RNA editing, splicing, andpolyadenylation, structure and function of different types of RNA, RNA transport).
3. Protein synthesis and processing (Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA-identity,

aminoacyl tRNA synthetase, and translational proofreading, translational inhibitors, Post- translational modification of proteins).

4. Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).
5. History and philosophy of immunology, Development of the concept of immunologic specificity.
6. Organs, cells, receptors and molecules that are part of the innate immune defense, Innate immune cells development, characteristics and function.
7. Antigen presentation and structure and function of antigen-presenting molecules, Structure, function and organization of major histocompatibility complex (MHC), Antigen presenting cells, Process of antigen presentation, MHC-TCR recognition.
8. T cell development and function, cytokines and their essential functions, and effects on the immune system.
9. B cell development and function, antibody formation, structure and effector function.
10. Immunization: Passive and active
11. Comprehend the overreaction by our immune system (cell-mediated effector functions, inflammation) leading to hypersensitive conditions and its consequences
12. Primary and secondary immune modulation, the complement system.

Suggested Readings

Text Book**:** David L. Nelson and Michael M. Cox. Lehninger Principles of Biochemistry, Molecular Cell Biology Lodish, Molecular Biology of the Cell by Bruce Alberts

Kindt, T., Goldsby,R.A and Osborne, B.A. Kuby Immunology, Sixth Ed, WH Freeman and Company, New York. ISBN 13:978-1-4292-0211-4 Page 9 of 32

Rosen F. A. and Geha R. S. Case Studies in Immunology: A Clinical Companion, 5 th ed. New York: Garland Publishing. 2007. ISBN: 978-0-8153-4145-1.

Abul Abbas, Andrew Lichtman, Shiv Pillai. Cellular and Molecular Immunology,

9th ed. Saunders publication. ISBN: 9780323479783

Course Objectives:

The course aims to equip students with a basic knowledge of the structural and functional aspects of biological macromolecules, viz., DNA, RNA and proteins. After completion of the course, the students can apply this knowledge in their fields of research and higher education. Basic concepts on microbiology and antibiotics for general information (useful for day-to-day life) and further advanced knowledge on the topic.

ZOOPCOR04P - Lab Course I (Total Credits: 4)

1. Viable cell counting.
2. Organellar fraction isolation by differential centrifugation
3. Assessment of cell size, cell granularity and cell cycle analysis by Flowcytometer
4. Genomic DNA isolation.
5. DNA gel electrophoresis.
6. Semiquantitative PCR
7. Protein Gel electrophoresis
8. PBMC/ Splenocyte isolation and study on cell types

Course Objectives:

Lab course I is intended to introduce students to standard biochemical techniques common in a molecular biology lab, such as DNA isolation, agarose-gel electrophoresis etc. The course also will provide students with a hands-on understanding of how modern cell and molecular biology techniques can be used to discover and understand cellular function.

ZOOPCOR05P - Lab Course II (Total Credits: 4)

1. Computer Simulation of models of Natural Selection, Drift and Gene flows
2. Calculating Frequencies of alleles from Population data
3. Pedigree Analyses

Course Objectives:

In Lab Course II students will be trained in practical and conceptual issues in taxonomy, biodiversity and evolutionary biology. It will provide methodological background and quantitative skills in morphological and molecular techniques of taxonomy and systematics. Hands-on training in conducting research in this area

will be provided.

Ability Enhancement Compulsory Course (AECC)
ZOOPAEC01M- Industrial Biology (2 credits)

1. Microbial fermentation and production of small and macro molecules.
2. Application of immunological principles, vaccines, diagnostics.
3. Tissue and cell culture methods for animals.
4. Transgenic animals
5. Genomics and its application to health and agriculture, including gene therapy.
6. Bioresource and uses of biodiversity.
7. Bioremediation and phytoremediation
8. Biosensors

Course Objectives:

To integrate scientific and technological knowledge on the use of biological processes for industrial products at the cell and process level enable students to carry out research / investigation to solve practical problems associated with society and industrial applications independently.

Suggested Reading:

Industrial Microbiology, Lester Earl Casida (Jr),Wiley

Bioremediation, Editors: Valdes, J.J. (Ed.), 2000.

Introduction to Cell and Tissue Culture Theory and Technique. Authors: Mather, Jennie P., Roberts, Penelope E. Springer Publication

2nd Semester

ZOOPCOR06T - Theory Course: Biochemistry & Biophysics (Total Credits: 4)

1. Biochemistry Basics: Solutions, Ways Of Expressing Concentration: Molarity Molality Normality formality, part per million, volume percentage and weight percentage. Mole Fraction
2. Structure of atoms, molecules, chemical bonds. reaction kinetics, thermodynamics
3. Stabilizing interactions (van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.).
4. Weak Interactions in Aqueous Systems: Ionization of Water, Weak Acids, and Weak Bases, Buffering against pH Changes in Biological Systems, Water as a Reactant, Fitness of the Aqueous Environment for Living Organisms.
5. Composition, structure and function of biomolecules (carbohydrates, lipids, and vitamins).
6. Amino acids, peptides and proteins: Structural Features, classification, as Acids and Bases, isoelectric point, peptide bond, types of peptides
7. Structure of Proteins: Primary Structure, Secondary Structure, Tertiary and Quaternary Structures, Protein Denaturation and Folding, secondary structure, domains, motif and folds)
8. Separation and purification of proteins: chromatographic methods, Electrophoresis, Isoelectric focusing, Two-dimensional electrophoresis,
9. Nucleotides and Nucleic Acids: Conformation of nucleic acids (helix (A, B, Z), DNA super coiling, linking number.
10. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reaction, group transfer, biological energy transducers.

Suggested Readings

1. David L. Nelson and Michael M. Cox. Lehninger Principles of Biochemistry
2. Voet, D., Voet, J. G. & Pratt, C. W. Principles of Biochemistry. Wiley, 4th edition, 2013.
3. Berg, J. M., Tymoczko, J. L. and Stryer, L. Biochemistry. Freeman, 7th edition, 2011.

Course Objectives:

Identify different classes of biomolecules and structures, explain fundamental relationships between their structure and function and describe the principal organisation of prokaryotic and eukaryotic cells. Understanding Biochemistry enables students to understanding the central theme of life and its associated mechanisms. This stream is the bridge between the physical science and its application in biological processes. Students can intermingle with the different streams of science to create unison of understanding of any topic of biology.

ZOOPCOR07T - Theory: Parasitology & Microbiology (Total Credits: 4)

Group A: Parasitology

1. Understanding of the evolution of parasitic associations.
2. Emerging parasitic diseases.
3. Understanding of the modifications (physiological, morphological, and behavioral) needed to assume a parasitic lifestyle.
4. Vector-Borne Parasites and Pathogens of Public Health Importance.
5. Zoonoses and its significance.
6. Myiasis and its evolutionary pathway.
7. Nosography of protozoans
8. Helminthology: Phylum Platyhelminthes: Class Cestoda
   Phylum Platyhelminthes: Class Trematoda
   Phylum Nemathelminthes: Class Nematoda

Group B: Microbiology

1. Structure and organization of bacteria and virus
2. Microbial Physiology: Growth yield and characteristics, strategies of cell division, stress response.
3. Sterilization techniques
4. Molecular mechanisms of commonly used antibiotics.

Suggested Readings:

Foundation of Parasitology by John Janovy& Larry Roberts,
Parasitology by KD Chatterjee

Course Objectives:

The course examines the general biology, life cycles, modes of transmission, and pathogenesis of major parasites on global human health. It will enable students to explore a number of important diseases, along with the diverse protozoans, helminths, worms, and arthropods responsible for them. The course will enable students to explore a number of important diseases, along with the diverse protozoans, helminths, and arthropods responsible for them. Another portion of the course has been prepared to help understand the ability of our immune system to defend against invading pathogens or parasites in a logical fashion.

ZOOPCOR08T - Theory: Ecology & Quantitative Biology, Taxonomy (Total Credits: 4)

Group A: Ecology

1. Population Growth Models: Continuous and Discrete Population Growths; Exponential and Logistic Models
2. Community level interactions: Defining a Community; Lotka-Volterra equations, Niche Dynamics, Ecological Successions
3. Metapopulations: Defining metapopulations, different populations, modelling metapopulations
4. Island Biogeography: MacArthur-Wilson model

Suggested Readings:

- A Primer of Ecology by Gotelli;
- Ecology by Charles Krebs

Group B: Quantitative Biology & Taxonomy

1. Statistic,Variables, Population, Small; Normal and Binomial distribution
2. Hypothesis Testing
3. Central Tendencies and Measures of Dispersion
4. Parametric and Non-Parametric tests; t-Test, Chi-Square, ANOVA, Kruskal-Wallis, Mann-Whitney U tests
5. Evolution of Taxonomy: Pre-Darwinian and Post Darwinian Concepts.
6. Applied Taxonomy: ICZN rules regarding Types and Nomenclatures.
7. Taxonomic Keys.
8. Concept of cladistics.
9. Short introduction to Molecular Phylogeny.

Suggested Readings: Biostatistics by Zar

Principles of Systematic Zoology by Ernst Mayr and Web Resources

The Ecology section of the course is designed to help students in understanding the ecological dynamics in endangered ecosystems. Conservation biology part would make them capable to participate in conservation activities as professionals or volunteers. This course is designed to prepare the students to be ready for such professions. Quantitative biology section of the course has been designed to remove the alleged traditional fears of biology students in numerical methods of science. The topics included are expected to help the students in designing experiments or surveys, scientific data collection and management, finally in statistical interpretations from the data, the skills demanded in so many types of professions including research. Taxonomical studies will help to identify the identity and interrelationship of the animal kingdom.

ZOOPCOR09P - Lab Course III (Total Credits: 4)

1. Titration curve of acids of monoprotic and Diprotic acids using a pH meter: preparation of buffers
2. Determination of acid dissociation constant Ka and pKa
3. Assay of enzyme activity
4. Identification & staining of relevant protozoan and helminthic parasite.
5. Microbiome Variation Study

Course Objectives

Lab Course III is intended to familiarize students with basic biochemical techniques to plan and carry out experiments. In addition, the course will also provide students with knowledge of identification of parasites which can facilitate

ZOOPCOR10P - Lab Course IV (Total Credits: 4)

1. Field identifications of Birds, Butterflies, Fishes and Plants.
2. Field study to quantify populations, community parameters in the fields by Quadrats, Transect Methods
3. Water parameter analyses in the fields
4. Field visits to study the management practices in any Protected Area or local community reserve
5. Study of taxonomic characters and key preparations of ants, other insects, fishes and Birds

Course Objectives

Lab Course IV will provide an understanding of fundamentals of tropical ecology, including key habitat features, biodiversity, ecological processes and biotic interactions. The course will provide first-hand experience of ecological research in the topics, through group exercises and field visits

ZOOPSEC01M: Histopathological Techniques (Total Credits: 2)

1. Theory and principles of different staining procedures in Histopathology.
2. Histochemistry.
3. Immunohistochemistry.
4. Study on Histophysiology of – Liver, Spleen, Kidney, Cardiac Muscle, Ovary, Gut.
5. Preparation of various fixatives & Stain solution.
6. Decalcification of calcified tissue before sectioning.
7. Special staining techniques.
8. Processing of tissue for routine paraffin sections and other methods of embedding.
9. Histochemical identification from processed tissue section.
10. Preparation of biopsy report of – Liver, Spleen, Kidney, Cardiac Muscle, Ovary & Gut.

Course Objectives and Scope of Employability

The skill gained through this course in histopathology will introduce students to microscopic features of tissues and organs, giving them the opportunity to compare and contrast the normal with the abnormal in various disease states. Students will use logical and systematic thinking to solve problems with this diagnostic technique and procedure. This course will give students an edge to pursue career in various histopathological laboratories, diagnostic centres or paramedical institutions.

Suggested Reading:

Junqueira's Basic Histology: Text and Atlas, Book by Anthony L. Mescher and L.C.U. Junqueira. McGraw-Hill Education / Medical.

3rd Semester

ZOOPCOR11T- Theory: Physiology & Endocrinology (Total Credits: 4)

1. An overview of anatomy and physiology
2. Muscles and Muscle tissue
3. Neurophysiology
4. Cardiovascular system
5. Respiratory system
6. Physiology of chemical digestion and absorption
7. Metabolism and body temperature regulation
8. Fluid, electrolyte and acid-base balance
9. Physiology of male and female reproductive system
10. Outline of endocrine glands, mechanism of hormone action and regulation of hormone secretion
11. Hormone receptors and regulation
12. The second messenger system
13. Reproductive immunology and tolerance.
14. Neuroendocrine-Immune interaction

Suggested Books-

Elaine N Marieb, Guyton and Hall, Schmidt Nielsen, Williams, Franklyn Bolander, Greenspan and Baxter, Hadley

Course Objectives:

The basic "Physiology & Endocrinology" is a powerful study to help the students to explore the functional logic of living systems. All organisms are made up of cells & systems. This course is designed to explore the fundamentals of body structure & its function. We hope learners will develop a deep intuition to understand the functional logic of a basic anatomy & physiology. To underscore the importance of physiology in our lives, we will address anatomy of our body parts, physiological function and disorders endocrinological system associated with health implications in the human society.

ZOOPCOR12T - Theory: Animal Behaviour & Conservation Biology (Total Credits: 4)

Group A: Animal Behaviour

1. Evolutionary approach in Behavioural studies
2. Critical perspectives of Imprinting and learning behaviours
3. Reviewing Bee-Dance language
4. Sexual selections- modern perspectives
5. Social Behaviours in insects and primates from evolutionary perspectives
6. Human Behaviours- Critical evolutionary analyses

Suggested Reading

Animal Behaviour by Lee Dugatkin

Group B: Conservation Biology

1. Threats to Biological Diversity
2. Conservations at the Population and Species Levels
3. Conserving Biological Communities, Regional Unique Biodiversity
4. Man-Wildlife conflicts and Development vs Conservation
5. Traditional Ethics and Role of Local Communities in Conservation

Suggested Readings:

- Conservation Biology: A Primer for South Asia by Bawa, Primack and Oommen; Univ. Press. Kolkata

Course Objectives:

Studies of animal behaviours brought one of the only two Nobles for Zoology so far. Emerging fast from its psychological capsules, since then, study of animal behaviours in evolutionary approach has become one of the most attractive fields in biology. In a country of high biodiversity like India, students can flourish in research careers in this low-cost demanding field much more easily than any high cost equip dependent fields of biology. The course is hence designed and offered.

ZOOPCOR13T - Theory: Cancer Biology & Toxicology (Total Credits: 4)

1. General principles of Toxicology
2. The absorption, distribution, metabolism and excretion of Xenobiotics: Toxicokinetics
3. Interaction of toxicants with their target site: Toxicodynamics
4. Toxins and toxicants
5. Environmental Toxicology & Ecotoxicology
6. General Introduction to Oncology
7. Carcinogenesis: the concept of multistage mutations
8. Cell cycle disruption and cancer
9. Oncogenes
10. Tumour suppressors
11. Growth Factors and Signal Transduction in Cancer
12. Tumor Immunology
13. Tumor antigens
14. Life style and cancer

Course Objectives:

The course intends to equip students with the knowledge of effects of toxic substances on molecular and cellular levels and on public health. The principal aim of the course is to make the students familiar with essential toxicological concepts based on toxicodynamics and toxicokinetics to develop an understanding about drug/toxicant disposition, side-effects of drugs and awareness regarding environmental exposures to toxic substances including carcinogens. Life style factor affecting the incidence of cancer is also being dealt with as it will help the students in acquiring knowledge of preventive strategies against cancer incidence.

ZOOPCOR14P - Lab Course V (Total Credits: 4)

1. Measurement of serum biochemical markers of hepatotoxicity (ALT, AST, ALP) in murine/piscine models.
2. Assessment of biomarkers of genotoxicity: a) Micronucleus assay
3. Asssessment of Immunotoxicity: Isolation and staining of murine peritoneal macrophages induced by xenobiotics
4. Measurement of oxidative stress: Assessment of Lipid peroxidation in different organs of murine/piscine system.
5. Measurement of antioxidant enzymes after exposure to toxicants /chemotherapeutic agents
6. Identifying the differences between normal and cancer cells
7. Maintenance of transplantable tumor cell line, development of in vivo tumors and identifying dysplastic.

Course Objectives:

Lab Course V will provide practical training in toxicological methods, to introduce the students to the study of cytotoxicity, genotoxicity, oxidative stress markers in various experimental setup as well as familiarize students with the basic differences between normal and cancer cells.

ZOOPCOR15P - Lab Course VI (Total Credits: 4)

1. Blood pressure estimation
2. TC, DC, Arneath count, Blood Group
3. Haemoglobin count
4. Blood sugar estimation
5. Preparation of hypothyroid rat model
6. Study of Social Behaviour in Crows / Street dogs
7. Study of facial expressions and other behaviours in humans
8. Study of feeding behaviour in Butterflies/Fishes

Course Objectives

Lab course VI will provide a thorough understanding of the concept of homeostasis in humans by studying vital physiological parameters. The animal behavior practical course will provide valuable skills to equip students for work in a wide range of fields relating to animal behavior which is vital for wider habitat conservation and handling zoo animals.

ZOOPGEC01T: Ecosystem and Environmental Hazards (Total Credits: 4)

1. Biodiversity: different levels and aspects
2. Biodiversity Usages
3. Threats to Biodiversity and Consequences of Biodiversity loss
4. Biodiversity Regulations: Global Treaties, Indian Acts and Laws, Biodiversity Authority and state Boards
5. Concept of Ecosystem
6. Major Indian Ecosystems
7. Study of Resources in Water, Forests, Soil
8. Ecosystem Services- concepts and examples
9. Environmental movements in India relating to the forests and other ecosystems
10. Conservation policies and laws in India
11. Environmental Stressors: Chemicals, Radiations, Noise, climate change.
12. Response to Environmental Stress: Health and cellular impacts of environmental stress, Endocrine Response to Stress, Stress and adaptation, altered cellular signalling.

Suggested Readings:

- Conservation Biology: A Primer for South Asia by Bawa, Primack and Oommen; Univ. Press. Kolkata
- F. J. Roe Occupational cancer: interaction with life style factors. Postgrad Med J. 1990 May; 66(775): 378–383.

Course objectives:

There is very little scope to argue against the claim that the entire life on earth is now highly endangered due to extreme loss of biodiversity and degradation of natural ecosystems. Thus, this course is offered to make all graduate students aware and sensitized well regarding this survival issue, irrespective of their academic specializations. The course content would make a student enriched with basic knowledge regarding the roles of biodiversity and ecosystem services in sustaining humans and other lives on earth and information on how both are threatened by irresponsible human activities. Upon completion of the course the students will understand the major concepts of environmental science, Identify how toxic chemicals used for many purposes are affecting ecosystem and human health and apply the scientific method and quantitative techniques to describe, monitor and understand environmental systems.

4th Semester

Students will have to opt for 2 courses (2 Theory papers and their corresponding practical papers) from the following list of Electives:

ZOOPDSE01T - Applied Entomology and Vector Biology (Total Credits: 4)

Theory:

1. Classifications of Insects with salient identifying characters (till Order level)
2. Important insect structures and functions (flight, vision, reproductive structures, sensory structures)
3. Concept of Applied Entomology
4. Economically Beneficial Insects and their cultures: Bees and Apiculture, Lac and Lac Culture, Silk Moths and Sericulture
5. Insect Pests: Agricultural Pests (Rice, wheat, vegetable pests)
6. Insecticides: Chemical and Biological Controls, Insecticide resistance and mechanism of resistance, IPM (Integrated Pest Management)
7. Vector Biology of Plasmodium sp, Japanese Encephalitis, Dengue, Leishmaniasis
8. Methods of Vector Control
9. Forensic entomology

ZOOPDSE01P Practical (Total Credits:4)

1. Identification of insect pests and different species of honey bees, mosquitoes, sandfly, lac insects, silkworms
2. Identification of pollen plants from corbicular pollen
3. Study of any crop pest- ecology, behaviour, life history strategies and control
4. Identification of different stages of Lac-insects and their host plants
5. Methods of insecticide application
6. Determination of LC50 and LD50
7. Study of the ecology, behaviours and life history strategies of major vector mosquitoes

/sand flies

Suggested Readings:

1. Insects by R.F. Chapman
2. Agricultural pests of South-East Asia and their management – A.S Atwal &G.S. Dhallwal
3. An Introduction to Sericulture- by J Ganga; SulachanaChetty
4. Bees & Beekeeping in India by D.P. Abrol
5. Lac-culture in India- N. Ghorai, International Books and periodical supply service, New Delhi
6. Medical Entomology – A.K. Hati
7. Medical Entomology- Bruce F. Eldridge, John D. Edman, Kluwer Academic Publishers

Course Objectives:

The mission of this course ranges from basic aspects of arthropod ecology, morphology, parasitology, physiology and systematics to applied subjects in apiculture, agricultural, medical and veterinary pest management.

ZOOPDSE02T - Applied Conservation Biology (Total Credits: 4)

Theory:

1. Biodiversity and Gamut of Conservation Biology
2. Major Wildlife Areas of India
3. Major Wildlife Species of India, their Ecology and Behaviours, Population status and Existence crisis
4. Critical review of Conservation Policies and Actions in India and globally

ZOOPDSE02P Practical (Total Credits: 4)

1. Field Study of Ecology and Management of any Wildlife PA
2. Field Study of Behaviour and Ecology of any wild species
3. Field Study of man-wildlife conflicts

Suggested Reading:

1. Conservation Biology: A Primer for South Asia by Bawa, Primack and Oommen; Univ. Press. Kolkata
2. Conservation Biology: Voices from the Tropics by Editor(s): Peter H. Raven, Navjot S. Sodhi, Luke Gibson; Wiley

Course Objectives:

The elective course of Applied Conservation Biology is designed for those PG students who aspire to become a professional in the emerging field of Conservation, as researcher / teacher or a conservation manager of Indian/State Forest Services, Non Gov. conservation related agencies.

ZOOPDSE03T - Advanced Immunology and Vector Molecular Biology

(Total Credits: 4)

Theory:

Advanced Immunology:

1. Understand the fundamental concepts of immunity, contributions of the organs and cells in immune responses; Realize how the MHC molecules function and host encounters an immune insult.
2. Lymphocyte recirculation and homing: roles of adhesion molecules and chemoattractants, generation of memory T Cells; Chemokines and chemokine receptors.
3. Regulatory T cells (Tregs) and maintenance of peripheral tolerance.
4. Immunity at mucosal surfaces, Generation of lymphocyte antigen receptors, Immunoglobulin gene rearrangement, Generation of antibody diversity, Synthesis, assembly, secretion of immunoglobulins.
5. Dendritic cells: generation, types, functions, and antigen trapping technology, a revolution in vaccine/immunotherapy strategy.
6. The pattern of monocyte subpopulations in health and diseases**.**
7. Pattern recognition receptors and inflammation; Toll-like receptors, RIG-I-like receptors, NOD-like receptors, and C-type lectin receptors.
8. Natural Killer cells: Development, maturation, and clinical utilization.
9. Tolerance and autoimmunity; Influence of cytokines, infections, and gender on autoimmunity.
10. Essential concepts of transplant immunology for clinical practices.

Vector Molecular Biology:

1. Concept of vector molecular biology: History, philosophy, and development.
2. Insect vectors' saliva: Epidemiological consequences of immune sensitization by pre-exposure to vector saliva; Vectors' saliva in vaccines for protozoan and viral diseases: progress up to date.
3. Insect vectors' gut microbiota: Association with pathogens and influence on hots.
4. Influences on insect vector competencies.
5. Genetic control of insect vectors, Genome engineering in insects for the control of vector-borne diseases.

ZOOPDSE03P: Practical (Total Credits: 4)

1. *In vitro* cell culture techniques for primary cells and cell lines.
2. Establishing and maintenance of *in vivo* infectious disease model.
3. Immunological methods and applications: ELISA, Isolation and purification of carbohydrate adjuvants, Detection of apoptosis/cell death.
4. Cell proliferation assay by MTT.
5. Multicolor staining of the immune cell population through flow cytometry: Issues and optimization.
6. Species-level identification of sandflies and mosquito vectors.
7. Laboratory rearing techniques of vectors related to infectious diseases, sandflies, and mosquitoes.
8. Techniques related to laboratory infection of Sandflies with Leishmania parasites and study on the parasitic development inside the gut.
9. Isolation of bacteria from insect-vector gut and identification through gene sequencing thereafter.

10. Isolation and quantification of insect vectors' salivary proteins.

Course Objectives:

This course has been designed to provide students with a fundamental understanding of immunology, infectious diseases, and the recent concept of vector molecular biology. Students will learn about the critical aspects of the immune system and how it can fight infection and its limitations. Students will learn how infectious agents can overcome the natural immune response and cause disease. In addition, students will be exposed to examples of natural protections against infectious diseases, and the type of immunity they activate. The course will also illustrate the ways to fight against infectious diseases.

ZOOPDSE04T - Advanced Molecular Oncology and Biochemical Techniques (Total Credits: 4)

Theory:

1. Oncogenes,
2. Growth Factors and Receptors,
3. Stem Cell Biology and Cancer
4. Non-Coding RNA Biology and Cancer
5. Cancer Immunotherapy
6. Current Methods and Technologies Used In Cancer Diagnostics And Research
7. Vaccines: past, present and future
8. Cell death modalities: classification and pathophysiological implications
9. Enzymes: Principles of Catalysis, Enzymes And Enzyme Kinetics, Enzyme Regulation, Mechanism Of Enzyme Catalysis, Isozymes
10. Methods for Purifying And Analysis Of Biomolecules (Gel Chromatography, Ion Exchange Chromatography, Affinity Chromatography, Electrophoresis).
11. Western Blot, Elisa, RIA, Chip Assay, Use of shRNA, siRNA in Cancer Biology
12. Dna Sequencing Methods, Strategies for Genome Sequencing.
13. Methods for Analysis of Gene Expression At RNA And Protein Level, Large Scale Expression, Such As Micro Array Based Techniques
14. Expression Of Recombinant Proteins Using Bacterial, Animal Vectors.
15. Flowcytometry, Histochemical and Immunohistochemical techniques

ZOOPDSE04P: Practical (Total Credits: 4)

1. Zymography
2. Western Blot
3. ELISA
4. CHIP
5. Enzyme Kinetics
6. Flowcytometry:
7. Fluorescence Imaging Techniques
8. Isolation and quantification of Non-Coding RNA from cancer cells

Suggested Reading:

1. Weinberg, Robert A.The biology of cancer 2. ed.: New York: Garland Science, cop. 2014[dvs. 2013]
2. David L. Nelson and Michael M. Cox. Lehninger Principles of Biochemistry
3. Voet, D., Voet, J. G. & Pratt, C. W. Principles of Biochemistry. Wiley, 4th edition, 2013.
4. Berg, J. M., Tymoczko, J. L. and Stryer, L. Biochemistry. Freeman, 7th edition, 2011.

Course Objectives

The aim of the course is to provide an in-depth understanding of the molecular mechanisms underlying the development of cancer. The course will provide students with the knowledge and training needed to approach and formulate scientific questions relevant to the cancer biology. The course will also survey the frontiers of cancer research and aims to make the students acquainted with to the applied advanced methods, technologies and state-of-the-art web-tools used in cancer research.

ZOOPDSE05T - Behavioral Endocrinology (Total Credits: 4)

Theory:

1. The approach of Behavioral Endocrinology
2. Sex Differences in Behavior: Sex Determination and Differentiation
3. Male & female Reproductive Behavior: Endocrinological aspect
4. Hormones and Social Behavior: affiliation & aggression (including parental behavior)
5. Biological Rhythms
6. Hormones & Stress
7. Hormonal aspect of Learning and Memory

ZOOPDSE05P: Practical (Total Credits: 4)

1. Sexual behaviours: Case study
2. Social Behaviours of Humans: Case study
3. Study of play & painting patterns of male & female child
4. Detection of hormones by ELISA
5. Semiquantitative PCR

Suggested Readings:

An Introduction to Behavioral Endocrinology Book by Randy J. Nelson, Publisher- Sinauer

Course Objectives:

The field of behavioural endocrinology is a truly interdisciplinary effort. It involves the study of phenomena ranging from genetic, molecular, and cellular levels of analysis to the study of individual and social behaviour. The course deals about the interaction of hormones and behaviour from diverse perspectives. This course inspires students to enter the exiting field of Behavioral Endocrinology and to work in such an exciting research discipline too.

ZOOPDSE06T - Cell Signaling & Cancer Biology (Total Credits: 4)

Theory:

1. Principles of Cell Signaling Systems**:** General Introduction. Receptors; transducers; Second messengers
2. Cell signaling and signal transduction: G-protein coupled receptors signaling, TGFbeta signaling, Wnt pathway, Notch signaling, Receptor Tyrosie Kinase Pathway, Ras-MAPK signaling, JAK-STAT pathway, NF-kappa B, Hedgehog pathway, PI3-Akt/mTOR pathway
3. Cellular communication Regulation of hematopoiesis, general principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins.
4. Characteristics of cancer cells, Transformation and Mutagenesis
5. Deregulated Signaling Pathways in Cancer.
6. Oncogenes, tumor suppressor genes, virus-induced cancer,
7. Cancer and the cell cycle
8. Proteases and Signaling Ubiquitin-proteasome pathways in signaling; Apoptosis Caspase pathways ; Cytokine Receptors Janus kinase and signal transducer and activator of transcription (JAK-STAT) signaling; Toll-Like Receptors; Signaling in innate immunity
9. Cancer types and Staging : General introduction: Staging, Staging in solid cancer and fluid cancer
10. Tumor micro Environment - Angiogenesis and Molecular aspects of metastasis and
11. Cancer cell metabolism**:** How is the metabolism of a resting cell different from a proliferating cell. What molecules are important for the altered cancer cell metabolism. What pathways contribute to the altered cancer cell metabolism.
12. Therapeutic interventions of uncontrolled cell growth and Therapeutic resistance

ZOOPDSE06P: Practical (Total Credits: 4)

1. Establishing and maintenance of in vivo tumor models
2. Gene expression studies in cancer cells
3. Studying proliferation and apoptosis in cancer cells
4. Techniques to study angiogenesis and metastasis

Suggested Readings:

1. Weinberg RA. The Biology of Cancer, 2nd Edition. Garland Science, 2013.
2. Molecular Biology of Cell: Lodish

Course Objectives:

The impact of cancer on all our lives emphasizes the need to continue training individuals to pursue research into its cure and prevention. The goal of this course is to provide students with education and training that enables them to make significant contributions to tackle this ever-increasing burden of cancer. Students also learn about the current state of the epidemiology, clinical diagnosis, treatment, and prevention of human cancers. Given this huge investment in cancer research, the job market for individuals with doctoral degrees in cancer biology is very large and growing. This course will provide students an edge to pursue a career in the field of cancer biology.

ZOOPCOR16M: Project Work/Dissertation (Total Credits: 8)

Includes project on an original problem under the supervision of any faculty from WBSU or from other Institute of National repute.