SYLLABUS

for

MASTER OF SCIENCE

IN

ZOOLOGY

under

CHOICE BASED CREDIT SYSTEM

VIDYASAGAR UNIVERSITY
MIDNAPORE – 721102
WEST BENGAL

EFFECTIVE FROM 2018 - 19 ACADEMIC SESSION

COURSE STRUCTURE OF M.Sc. IN ZOOLOGY

SEM-ESTER	PAPER CODE	CONTENT	Marks	Credit
I	ZOO 101	Non- Chordates& Chordates	50	4
	ZOO 102	Histochemistry& Animal Physiology	50	4
	ZOO 103	Immunology and Methods in Biology	50	4
	ZOO 104	Cell Biology &Cytogenetics	50	4
	ZOO 195	Non- Chordates, Chordates, Histochemistry& Animal Physiology (Practical)	50	4
	ZOO 196	Immunology, Methods in Biology,Cell Biology &Cytogenetics (Practical)	50	4
	TOTAL		**300**	**24**
II	ZOO-201	Biosystematics & Ecological principles	50	4
	ZOO-202	Biophysics &Biochemistry	50	4
	ZOO-203	Molecular Biology &Parasitology	50	4
	C-ZOO	***Wildlife & Eco-Management and Aqua informatics***	50	4
	ZOO-295	Ecological principles, Biochemistry & Field Study)	50	4
	ZOO-296	Biosystematics, Molecular Biology, Parasitology & Biophysics	50	4
	TOTAL		**300**	**24**
III	ZOO-301	Basic & applied Entomology and Ecotoxicology	50	4
	ZOO-302	Molecular Evolution and Microbiology	50	4
	SPECIAL PAPER (A:Fishery; B:Ecology; C:Genetics & mol. Biology; D:Prasitology)			
	ZOO-303A	Fish Taxonomy & Biology and Oceanography	50	4
	ZOO-303B	Biodiversity and Conservation Ecology & Aquatic Ecology		
	ZOO-303C	Genetics & Molecular Biology		
	ZOO-303D	Diversity and Biology of Parasite &Immunoparasitology		
	C-ZOO-304	***Genetics and Haematology(CBCS)***	50	
	ZOO-395	Entomology, Ecotoxicology, Molecular Evolution and Microbiology	50	4
	SPECIAL PAPER BASED PRACTICAL			
	ZOO-396A	FISHERY PRACTICAL –I & Field trip	50	4
	ZOO-396B	ECOLOGY PRACTICAL –I & Field trip		
	ZOO-396C	GENETICS & MOL. BIOLOGY PRACTICAL –I & Institute /Lab visit		
	ZOO-396D	PARASITOLOGY PRACTICAL –I & Institute /Lab visit		
	TOTAL		**300**	4
IV	ZOO-401	Environmental pollution & management and Biostatistics	50	4
	ZOO-402	Developmental Biology and Neuro-endocrinology	50	4
	SPECIAL PAPER (A:Fishery; B:Ecology; C:Genetics & Mol. Biology; D:Prasitology)			
	ZOO-403A	Aquaculture & Inland and Marine Fisheries	50	4
	ZOO-403B	Systems Ecology & Human Ecology		
	ZOO-403C	Human Disease & Molecular Analysis and Applied Genetics		
	ZOO-403D	Vector Biology &Vector borne Parasites and Molecular Diagnosis & Clinical Parasitology		
	ZOO-494	Environmental Management, Biostatistics, Developmental	50	4

		Biology &Neuro-endocrinology		
	SPECIAL PAPER BASED PRACTICAL			
	ZOO-495A	FISHERY PRACTICAL –II	50	4
	ZOO-495B	ECOLOGY PRACTICAL –II		
	ZOO-495C	GENETICS& MOL. BIOLOGY PRACTICAL –II		
	ZOO-495D	PARASITOLOGY PRACTICAL –II		
	SPECIAL PAPER BASED PROJECT/DISSERTATION			
	ZOO 496A	FISHERY SPECIAL Pr.	50	4
	ZOO 496B	ECOLOGY SPECIAL Pr.		
	ZOO 496C	GENETICS& MOL. BIO SPECIAL Pr.		
	ZOO 496D	PARASITOLOGY SPECIAL Pr.		
	TOTAL		**300**	24
GRAND TOTAL			1200	96

Programme Outcome: The course curriculum of the department has been designed and developed giving due importance to both classical components of subject Zoology along with its different ramifications in tune with the modern scientific development across the world. The classical aspects of zoology includes basic structural functional organization of the Non-Chordates and Chordates, taxonomy, biosystematics, histology, animal physiology, evolution and adaptation whereas the modern dimension of the course curriculum has attached most significant aspects of molecular biology, genetics, biotechnology, bioinformatics, biochemistry, immunology and biostatistics. The effort appears to be very fruitful by virtue of the results and academic performance of the existing and former students which are being reflected in their success in different national and state level competition. Keeping pace with the above mentioned course curriculum the department although has initiated its journey with only one special paper now it is offering four different special papers (Fishery, Ecology, Genetics & Molecular biology and parasitology) which also enabled rural based students of the University to get proper recognition both nationally and also getting different subject based services. Moreover the outreach and extension program involving the students in their practical curriculum have provided significant contribution of livelihood generation of marginalized people of the region. All the courses in the program are carefully designed to equip the students for competitive exams like CSIR NET, SET etc. and also to write research proposals for grants.

M.Sc. ZOOLOGY SEMESTER MARKS DISTRIBUTION

SEM	Theory	Practical
I	200	100
II	200	100
III	200	100
IV	150	150
Total	**750**	**450**

Practical papers	
ZOO-195	**Marks (Total=50)**
Non- Chordates	10
Chordates	12
Histochemistry	12
Animal Physiology	06
Internal assessment- (Viva & LNB)	10
ZOO-196	**Marks (Total=50)**
Immunology	10
Methods in Biology	05
Cytogenetics	15
Cell Biology	10
Internal assessment- (Viva & LNB)	10

ZOO-295	**Marks (Total=50)**
Biosystematics	05
Ecological principles	15
Biophysics	05
Biochemistry	15
Internal assessment- (Viva & LNB)	10
ZOO-296	**Marks (Total=50)**
Molecular Biology	15
Parasitology	15
Field Study	10
Internal assessment- (Viva & LNB)	10

ZOO-395	**Marks (Total=50)**
Entomology	10
Ecotoxicology	13
Microbiology	17
Internal assessment- (Viva & LNB)	10

ZOO-396	**Marks (Total=50)**
Special paper	
ZOO-396AFishery	30
ZOO-396BEcology	30
ZOO-396C Genetics& Mol. Bio.	30
ZOO-396D Parasitology	30
Field trip/Institute /Lab visit	10
Internal assessment- (Viva & LNB)	(10) for each special paper

ZOO-494	**Marks (Total=50)**
Biodiversity and Environmental stress	05
Biostatistics	15
Developmental biology	12
Neuroendocrinology	8
Internal assessment- (Viva & LNB)	10
ZOO-495	**Marks (Total=50)**
Special paper	
ZOO-495A Fishery	40
ZOO-495B Ecology	40
ZOO-495C Genetics& Mol. Bio.	40
ZOO-495D Parasitology	40
Internal assessment- (Viva & LNB)	10

ZOO-496(PROJECT/DISSERTATION)	**Marks (Total=50)**
Special paper	
ZOO-496AFishery	50
ZOO-496BEcology	50
ZOO-496CGenetics	50
ZOO-496D Parasitology	50

SEMESTER I

Paper ZOO101

(Non- Chordate & Chordates)

Group A. Non-chordates

1. Origin & Evolution of Metazoa; Phylogenetic overview of major invertebrate phyla.
2. Comparative account about different larval forms of coelomate non-chordates.
3. Biology of the free living nematods – feeding mechanisms and role of nematodes in ecosystem.
4. Bryozoa – anatomical peculiarities feeding mechanisms and phylogenetic relationship.
5. Rotifera – general organisation, mastax, reproduction and cyclomorphosis.
6. Foraminifera – characteristics, origin, distribution, biology and ecological role of foraminifera.
7. Conservation strategies of invertebrates: invertebrate diversity, importance and threats; alternative approaches to species focused conservation; conservation status evaluation for invertebrate species.

Reference Books/ Journal Article:

1. Animal Evolution-Interrelationships of the living Phyla: Claus Nielsen (Oxford University Press)
2. Diversity of Life (Invertebrates): Harry D. Rounds (East-West Press Pvt. Ltd.)
3. Assembling the Tree of Life (Edited by Joel Cracraft and Michael J.Donoghue (Oxford University Press)
4. An introduction to the invertebrates: Janet Moore (Cambridge University Press)
5. The History of Life -A very short introduction: Michael J. Benton (Oxford University Press)
6. Invertebrate structure and function: Barrington E J W, Thomas Nelson and Sons Ltd, London
7. Invertebrate Zoology: Ruppert and Barnes
8. Biology of the Invertebrates: J A Pechenik
9. Invertebarte Zoology: Anderson
10. Invertebrate Zoology: Meglitsch and Schram
11. PatWillmer: Invertebrates Relationships

Course outcome: At the end of the course, the students will be acquainted with the non-chordate biology. Students will be able to identify the invertebrates and classify them.

Non-chordates (Metazoa) representing largest groups of animal kingdom are characterised by several unique features and display various phenomena (polymorphism, torsions, matamorphosisetc), based on which an array of theories, hypothesis, scientific principles have been advocated in the gamut of the subject of Zoology. The syllabus has provided more stresses on three different aspects:--1) Evolution based on existing theories and hypothesis explaining non-chordate, especially metazoans origin and evolution; 2) Phylogenetic relationships among metazoans based on superphyletic concepts; and 3) Conservation strategies of metazoans for the ecological and economic benefits.

Group B. Chordates

1. **Origin of Chordates:**

   Hemichordata, Cephalochordata, Urochordata, Origin of craniates, Evolution of primates with special reference to *Homo sapiens sapiens.*

2. **Protochordates** :

   Endostyle and Iodine binding capacity inProtochordates.

3. **Fishes:**

   Taxonomy of Fishes, Inland and Marine fisheries of India, Problems & Prospects.

4. **Respiratory system & Gas bladder:**

   General functional and requirements; ventilation of Internal gills; Agnathroxs, Cartilaginous fishes, Bony fishes, larval gills; arial respiration in long fishes; swim bladder and the origin of lungs, lung and other ducts, evolution.

5. **Excretory System and Osmoregulation:**

   General nature of kidneys; Evolution of kidneys, Kidney structure in relation to Osmoregulation; Basic pattern and the Archinephros, Pronephros, Mesonephros, Metanephros: External salt excretion, Osmoregulation in freshwater and marine water fishes; Association of Urinary System & General system.

6. **Echolocation:**

General consideration of organs of hearing balance and Echolocation; Morphological adaptation for echolocation. Bat Echolocation.

Reference Books/ Journal Article:

1. Wolff, R. G. (1991). Functional chordate anatomy, D. C. Heath Canada, Limited. The University of Michigan.
2. PANDEY, B. N. and V. MATHUR (2018). BIOLOGY OF CHORDATES. PHI Learning Pvt. Ltd., 2018.
3. Satoh, N. (2016). Chordate Origins and Evolution: The Molecular Evolutionary Road to Vertebrates, Elsevier Science.Academic Press, 2016
4. Kardong (2005). Vertebrates, 4/E, McGraw-Hill Education (India) Pvt Limited.

Course Outcome: Through the course, the students will be accustomed with the chordate biology. Students will be able to identify the chordates and classify them.

Paper ZOO102

(Histochemistry& Animal Physiology)

Group A: Histochemistry

1. Introduction to Microtechnique
2. Fixation
3. Dyes
4. Histological staining
5. Enzyme histochemistr
6. Immunohistochemistry

Reference Books/ Journal Article:

1. Bancroft, JD (1975) Histochemical Techniques (Second Edition), Butterworth-Heinemann.

2.Kirenan, JA (1981) Histological and Histochemical Methods, Theory and Practice (Third Edition).

3.Suvarna, SK, Layton, C, Bancroft, JD (1977) Bancroft's Theory and Practice of Histological Techniques. Churchill Livingstone.

Course Outcome: Students will understand the Scope and importance of histology and histochemistry. General principles for the preparation of tissue for histological studiesand histochemical localization of various cellular components would be another significant aspect of the course

Group B: Animal Physiology

1. Blood, Circulation and Respiration:
   - Haemopoiesis, haemoglobin, blood groups, haemodynamics.
   - Regulation of blood volume and blood pressure, haemostasis.
   - Respiratory response to extreme conditions like hypoxia & diving.
   - Body oxygen stores –blood, muscle and pulmonary.
   - Oxyhaemoglobin and Myoglobin; Oxygen dissociation curve.
   - Cardiovascular System:
   - Cardiac cycle,
   - Electrical and mechanical properties of myogenic and neurogenic hearts;
   - Heart as a pump; regulation of heart pumping;
   - Neural and chemical regulation of excitation & conduction in heart;
   - Frank-Starling mechanism;
   - Principle of ECG.
2. Stress physiology:
   - Homeostasis, Feedback control systems
   - Oxidative stress. Cellular response. Free radicals and anti-oxidants.
3. Thermoregulation:
   - Body temperature and determinants of body heat – production and loss.
   - Physiological events for thermoregulation; counter-current system.
   - Thermal biology of ectotherms, heterotherms and endotherms.

Reference Books/ Journal Article:

1. Textbook of Medical Physiology - Arthur C. Guyton & John Edward Hall. 13th Ed.

2. Ganong's Review of Medical Physiology- Kim E. Barrett, Susan M. Barman, Scott Boitano, Heddwen Brooks. 25th Ed.
3. Biochemistry - Debajyoti Das, 1978.
4. A Textbook of Practical Physiology- C. L. Ghai. 2012.

Course outcome: The course will provide detailed knowledge on the various physiological organ-systems and theimportance to the integrative functions of the human body.To have an enhanced knowledge and appreciation of mammalian physiology; to understand the functions of important physiological systems including the cardio-respiratory, renal, reproductive and metabolic systems; to understand how these separate systems interact to yield integrated physiological responses to challenges such as exercise, fasting and ascent to high altitude, and how they can sometimes fail; to be able to perform, analyze and report on experiments and observations in physiology; to be able to recognize and identify principal tissue structures.

Paper ZOO103
(Immunology and Methods in Biology)

Group A: Immunology

1. a) Cells and organs involved in Immune System, Types of Immunity
2. a) Antigenicity and Immunogenicity
   b) Concept of Epitope, Paratope, Agretope, Hapten and Adjuvants
3. a) Origin and maturation of T and B lymphocyte, Humoral and cell mediated Immune Response
   b) T-cell subpopulation
4. a) Antigen processing and presentation
   b) Major Histocompatibility Complex (MHC) Mechanism of immune response and generation of immunological diversity
5. Complement system: classical, alternative and lectine pathway, MAC formation and related disorders
5. a) Structure and function of Immunoglobulin (Ig) and its Isotypes.
   b) Enzymatic activity on Ig molecule.

6. Applied Immunology:-

   a) ELISA, RIA, Southern blotting hybridization, Immunohistochemistry

Reference Books/ Journal Article:

1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.
2. Abbas, A. K. and Lichtman, A. H. (2006). *Basic Immunology*. 2nd ed. Elsevier.
3. Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5th ed. Wiley-Liss: New Jersey.
4. English, L. S. (1994). *Technological Applications of Immunochemicals (BIOTOL)*. Butterworth- Heinemann, Oxford Freeman and Co.
5. Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2013). *Immunology*. 7th ed. W. H. Freeman and Co.
6. Khan F. H. (2009). *The Elements of Immunology*. Prentice Hall India.
7. Kindt, T., Goldsby, R. Osborne, B. (2007). *Kuby*'s *Immunology*. 6th ed. W.H. Freeman and Co.
8. Male, D., Brostaff, J., Roth, D. and Roitt, I. (2006). *Immunology*. 7th ed. Mosby.
9. Rao, C. V. (2002). *Immunology*. Narosa Publishing House, New Delhi.
10. Roitt, I. M. and Delves, P. J. (2001). *Roitt's Essential Immunology*. 10th ed. Blackwell Science Ltd.

Course outcome: This course will describe the immune systems of vertebrates that enable them to recognize and respond specifically to foreign substances. The students will be able to comprehendthe roles of lymphoid organ, cells of immune system, antigens, antibodies, MHC, antigen presentation and immunity to infectious diseases.

Group B: Methods in Biology

1. Molecular Biotechnology

a) Recombinant DNA technology

b) Restriction Endonuclease

c) Production of recombinant DNA molecule

d) Cloning Vector

e) Amplification by PCR

f) DNA finger printing and its application

2. Environmental Biotechnology

a) Bioremediation
b) *In situ* bioremediation
c) *Ex situ* bioremediation
d) Bioremediation of Xenobiotic components and hydrocarbons
e) Phytoremediation
f) Cryopreservation; Integration of different rural biotechnological tools

3. Techniques and Bioinstrumentation

a) Principles and application of gel-filtration, ion-exchange and Affinity Chromatography, Thin layer and Gas Chromatography- MS.
b) Basic Principles of Electrophoresis, Agarose Gel Electrophoresis, SDS-PAGE, Cell fractionation, Ultracentrifugation, , Western Blotting Hybridization.
c) Flow Cytometry, 2D Gel Electrophoresis, FISH, FTIR.

Reference Books/ Journal Article:

1. Principle and techniques of biochemistry and Molecular Biology by K.Wilson and J. Walker 7thEdn, Cambridge low price edn.

2. Physical biochemistry- Principles and Applications by David Sheehan, 2 ndedn.

Course Outcome: On completion of this course students will be able to: address a research problem in biotechnology, Provide examples of current applications of biotechnology and advances in the different areas like medical, microbial, environmental and bioremediation. After getting theoretical knowledge students would be acquainted with some modern instruments and methods which are indispensible to pursue advance research in the field of biotechnology.

Paper ZOO104
(Cell Biology &Cytogenetics)

Group A: Cell Biology

1) Biomembrane Structure

The Lipid Bilayer: Composition and Structural Organization, Membrane Proteins: Structure and Basic Functions, Phospholipids, Sphingolipids, and Cholesterol: Synthesis and Intracellular Movement

2) **Transmembrane Transport of Ions and Small Molecules**

Overview of Transmembrane Transport, ATP-Powered Pumps and the Intracellular Ionic Environment, Overview of Transcellular Transport

3) **Moving Proteins into Membranes and Organelles**

Targeting Proteins to and across the ER Membrane, Insertion of Membrane Proteins into the ER, Targeting of Proteins to Mitochondria and Chloroplasts, Transport Into and Out of the Nucleus

4) **Signal Transduction**

Basic idea of Cell signaling, G Protein–Coupled Receptors: Structure and Mechanism, G Protein–Coupled Receptors and Regulation of Ion Channels, Signaling through second messengers, Receptor tyrosine kinase signaling, MAP Kinase

5) **Cytoskeleton & Cellular Motility**

Microtubule Dynamics and regulation, Microtubular motor proteins: Kinesins&Dyneins and Cellular motility

6) **Cell cycle & its regulation:** A cycle of cyclin dependent kinase activities regulates cell proliferation, Regulation of CDK-cyclin complexes, Protein kinases in cell cycle

7) **Interactions between Cellsand Their Environment:**

Overview of major cell-cell and cell-matrix adhesiveinteractions, Cell-Cell and Cell–ExtracellularJunctions and Their Adhesion Molecules, The Extracellular Matrix:The Basal Lamina and Connective tissue

Reference Books/ Journal Article:

1. Cell And Molecular Biology by Gerald Karp
2. Lewin's Cells by Gorge Plopper, David Sharp
3. Molecular Cell Biology by Harvey Lodish
4. Molecular Biology The Cell by Bruce Alberts
5. The Cell by Geoffrey M. Cooper
6. Molecular Biology by Robert F. Weaver

Course outcome: Students will be well informed with the membrane structure and composition, transport and trafficking of protein, the cytoskeleton, cell movement and extra cellular matrix. The mechanism of cell division and their regulation through different check points will be

thoroughly understood. Cell cycle, apoptosis, signal transduction and cancer biology are the important part of the course.

Group B. Cytogenetics

1. **Genetic Fine structure** :

   The CIS-TRANS or complementation test for functional allelism, Fine structure of the phage T4 rII locus, Complementation mapping and deletion mapping.
2. **Recombination in Bacteria** :

   F factor, episomes, Hfr, integration of F factor, Interruptedmating Experiment, conjugation mapping, transformation and transduction
3. **Tumor Inducing Viruses – Viral Oncogenes**

   Life Cycle of Rous Sarcoma Virus, RSV genome organization, mechanism of integration, formation of transducing retroviruses, protein products of protooncogene, Oncoproteins regulate gene expression and signal transduction Cancer induction by Retroviruses, tumor suppressor gene and their function.
4. **Genetic structure of Populations** -

   Genotypic frequencies, Allelic Frequencies, the Hardy Weinberg Law, calculation of genotypic and allelic frequencies where multiple alleles are present, derivation the Hardy-Weinberg Law

Reference Books/ Journal Article:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Genes viii by Benjamin Lewin
3. Genetic: Analysis and Principles by Robert J. Brooker
4. An Introduction to the Genetic Analysis by David T. Suzuki
5. Genetics:A Conceptual Approach by Benjamin A.Pierce
6. iGenetics: A Molecular Approach by Peter J. Russell
7. Principle of Genetics by Peter Snustad

Course outcome: The course will provide an understanding of genetic analysis at the gene, genome and population levels. Understanding the Drosophila genetics. Evaluation of the various aspects of structural, functional and comparative genomics. Designing and development of experiments using Drosophila and their evaluation through genetic analysis and interpretations

Paper ZOO-195
Practical Paper

1) Non- Chordates:
   i) Identification of common Invertebrate and Vertebrate taxa
   ii) Minor Dissection:
      (1) Grasshopper - Reproductive system/ Nervous system
      (2) Cockroach – Stomatogastric Nervous system
      (3) Achatina – Reproductive system & Nervous system
2) Chordates:
   i) Major Dissection
   ii) Bony fish - Vth, VIIth cranial nerves
3) Histochemistry

a. Microtechniques and tissue identification from chordates
b. Enzyme histochemistry
c .Staining for nucleic acid/ connective tissue
d. Demonstration of research article.
e. General idea about modern tools of histological techniques.

4) Animal Physiology
   i) Estimation of pH and its impact on plankton.
   ii) Observation of gut movement in frog/rat/fish under hypoxia using Dale's apparatus

Paper ZOO-196
Practical

1. Immunology:
    a. Study of macrophage.
    b. Study of phagocytosis.
    c. Determination of human blood group
2. Methods in Biology
    a. Characterization of macromolecule through Gel electrophoresis
3. Cell Biology-
    a. Identification of different stages of cell division and cell organelle.
    b. Mitochondrial Staining
4. Cytogenetics:
    a. Life cycle of *Drosoplila*.
    b. Analysis and interpretation of genetic crosses with special reference to *Drosophila*
    c. Study of polytene chromosome of *Drosophila*.

SEMESTER II

Paper ZOO201

(Biosystematics & Ecological principles)

Group A. Biosystematics

1. **Microtaxonomy:**Phenon, Taxon,Category, type; stages of taxonomy; Aims and tasks of Taxonomists; Importance of taxonomy in Biology.
2. **Macrotaxonomy:**Theory and practice of Biological classification; Basic principles, Rules for the classification of organisms, Identification criteria, Taxonomic characters, Classification and phylogeny, Is classification a Theory?The functions of a classification.
3. **Concept of Species:**Typological species concept, Nominalistic species concept, Biological species concept, Evolutionary species concept; other kinds of species; Polytypic species, Subspecies, Infraspecies and Superspecies.
4. **Newer Systematics:**Morphological approach, Immature stages and Embryological approach, Ecological approach, Behavioural approach, Ecological approach, Behavioural approach, Cytological approach, Biochemical approach, Numerical systematics, Differential systematics.
5. **Molecular Systematics:** Immunological aspect, chromatographic aspect, Electrophoresis, Infrared spectrophotometry, Histochemical studies, genetic complement, DNA hybridization, Karyological studies.
6. **Macromolecular &Micromolecular Systematics:** based on DNA, RNA, Protein, amino acids, fatty acids and phenols.
7. **Role of Systematics in applied Biology:**Agriculture& Forestry, Biological control, wild life management, National defence, Environmental problems, soil fertility, Mineral prospecting, Quarntine measure, Commercial application.
8. **Systematics and Public Health Management**

Reference Books/ Journal Article:

1. Mertens, T. R. and J. L. Lines (1978). Principles of biosystematics, Educational Methods.
2. Daniel, M. (2009). Taxonomy: Evolution at Work, Alpha Science International. PublisherAlpha Science International, 2009
3. Mayr, E. and P. D. Ashlock (1991). Principles of systematic zoology, McGraw-Hill. Publisher McGraw-Hill, 1991
4. Hickman, C. P., S. L. Keen, et al. (2016). Integrated Principles of Zoology, McGraw-Hill Education. 17th Eds.

Course outcome: This course will describe the importance of taxonomy in biology, historical resume of systematics and stages of taxonomy. The course would be dealt with biological classification, basic principles and rules for the classification of organisms. The course would

enlighten the students with modern trends in biosystematics-concepts of different conventional and newer aspects.

Group B: Ecological principles

1. Basics of Ecology

Biosphere and Ecosphere; Types of food web : Connectedness, energy and functional webs; Features of food web – nodes, links, linkage density, connectance, chain length; cybernetic nature of ecosystem; stability through feedback control and through redundancy of components; resistance and resilience stability, Gaia hypothesis.

2. Population Ecology

Survivorship; Life table, fertility schedule.Reproductive strategies; semeloparity, iteroparity, r & k strategies, population interactions- direct and indirect, positive and negative.Lotka-volterra model of competition and predator-prey interaction.Causes of extinction and endangerment of populations.Anthropogenic impact on species extinction, habitat destruction and fragmentation, introduction of exotic species.

3. Community and Ecosystem

Structure of biotic community. Community patterns: diversity and stability. Community boundary: Ecotone and edge types, Edge effect and edge species, Edge/Area ratio in relation to size, shape and fragmentation of habitat. Organismic and individualistic concepts of community.Leibig's Law of tolerance.

4. Habitat Ecology

Habitat and niche: spatial, trophic and multi-dimensional niche concepts, fundamental and realized niche, niche breadth and niche overlap. Competitive exclusion: experimental and natural evidence. Keystone species.Foundation species.Species abundance hypothesis.Ecological guilds and ecological equivalents.

5. Evolutionary Ecology

Definition; different approaches.Bet-Hedging strategies.Hamilton's role and limitations of inclusive fitness model.

Reference books:

- Fundamentals of Ecology- Eugene P. Odum, 2005.
- Biological Science – Scott Freeman. 2018.
- Ecology- Robert E. Ricklefs, Gary Leon Miller. 2000.

Course outcome: The subject ecology dealing with the relationship among different life forms in respect of their environment is a blend of concepts and contents (information). In order to understand the applicability of this subject, the students must have an acquaintance with the different definitions, terminologies, scientific principles, hypothesis, theories etc. with proper examples. The contents of this syllabus have been identified with an eye to make the students understand the basics of ecology putting more emphasis on the system ecology , habitat ecology, population and community ecology and evolutionary ecology so that ecology students can not only understand the ongoing ecological processes but also can contribute to the proper eco-management.

Paper ZOO202

(Biophysics & Biochemistry)

Group A: Biophysics

1. Biophysical principles.
2. Thermodynamics
3. Coloidial system
4. Microscopy in biology and medicine
5. Biophysics of membrane
6. Dynamics of circulation

Reference books:

1. Cotterill, R. (2005) Biophysics: An Introduction. Jhon Wiley & Sons.

2. Bialek, W. Biophysics: Searching for Principles.

3. Cleri, F. (2016) The Physics of Living System. Springer.

Course outcome: At the end of the course the student will be able tounderstand fundamental concepts in biophysics that underlie biological processes. Thorough knowledge of biophysics of

membrane and laws of thermodynamics. The course would be dealt with principle of thermodynamics, electromagnetic and ionizing radiation and principles of biophysical chemistry.

Group B: Biochemistry

1. **Stablizing**interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction)
2. **Protein Conformation**: Primary, secondary, tertiary and quaternary structures; Ramachandran plot; domains; motif and folds.
3. **Enzymes:** Enzyme kinetics, Michaelis-Menton equation, hyperbolic and Lineweaver-Burke plot; co-enzymes and Cofactor; competitive and non-competitive inhibitor and their effects on enzyme kinetics; Active site of an enzyme; Enzyme regulation, allosteric modification, its kinetics, covalently modulated enzymes.
4. **Biological Oxidation:** Redox potential, mitochondrial electron carriers, the respiratory chain (electron transport chain); Mitchell's chemiosmotic theory of oxidative phosphorylation; FoF, ATPase
5. **Lipid Metabolism**: denovo synthesis of fatty acids, microsomal fatty acid elongase&desaturase systems; oxidation of saturated fatty acids and unsaturated fatty acids.
6. **Protein metabolism**: deamination, transamination, ammonotelism, ureotelism, uricotelesim, formation of urea, formation of specialized products from amino acids: catecholamine, serotonin, melatonin, glutathione, T_3, T_4.
7. **Carbohydrate metabolism**: anabolic role of TCA cycle, integration of carbohydrate, fat and protein metabolism. Regulation of Glucolysis TCA cycle, Gluconeogenesis, Pentose phosphate pathway, Glycogenesis, glycogenolysis with special reference to rate limiting steps.

Reference books / Journal articles:

1. Biochemistry by Jeremy M. Berg, John L. Tymoczko, LubertStryer
2. Biochemistry by D Voet and J G. Voet
3. Biochemistry by Mary K. Campbell, Shawn O. Fa
4. LehningerPrinciples of Biochemistry by David L. Nelson and Michael M. Cox
5. Biochemistry by David E. Metzler

Course outcome: The course will provide an understanding of fundamental biochemical principles such as biomolecules, metabolic pathway and regulation of biological process. On completion of the course, students are able to: Understand about the agencies responsible for Production of various products using biochemistry. Understand the term pH, Buffer. Understand the structure and function of carbohydrate, amino acids, proteins, and lipids. The students will understand the fundamental energetic of biochemical processes and chemical logic of metabolic pathways. The course also deals with the integration of metabolic process in cellular systems and organization of cellular pathways.

Paper ZOO202

(Molecular Biology & Parasitology)

Group A: Molecular Biology

1. **DNA Replication:**
   The chemistry of DNA synthesis, the mechanism of DNA polymerase,the replication fork,the specialization of DNA polymerase,finishing replication
2. **The Transcription Process –**
   Role of RNA polymerase in prokaryotes, initiation of transcription at Promoters, elongationand termination of an RNA in prokaryotes , Initiation, elongation,DNA methylation andcontrol of transcription in eukaryotes
3. **Protein Synthesis**
   Charging tRNA, initiation of translation; role of initiation factors, Elongation: binding of AminoacyltRNA, peptide bond formation and translocation.Termination of translocation.
4. **Regulation of Gene Expression in Prokaryotes:**
   The Operon Model; lac, an inducible Operon, Positive Control of the lac Operon by CAP and Cyclic AMP. Repressible operon, Gene organization of the Tryptophan biosynthesis

gene, Regulation of the trp operon.

Reference books / Journal articles:

1. Molecular Biology of the Gene by James D. Watson
2. Genes viii by Benjamin Lewin
3. Genetics:A Conceptual Approach by Benjamin A.Pierce
4. iGenetics: A Molecular Approach by Peter J. Russell
5. Principle of Genetics by Peter Snustad
6. Concept of Genetics by William S. klug, Michael R. Cummings
7. Introduction to genetics A Molecular Approach by Terry Brown
8. Molecular Biology by Robert F. Weaver

Course outcome: The course will able to explain the fundamentals of genetics and the Mendelian laws, the concept of alleles, concept of linkage and crossing over of genes. The course will open an avenue to be familiar with a variety of types of genetic data (genotyping, expression, and sequence data), chromosomal mapping, genetic composition of biological population and evolutionary factors that explain the variation. An in-depth knowledge of chemical and molecular processes that occur in between cell including the central dogma will be assured at the end of this course.

Group B: Parasitology

1. a) Types of Parasites and hosts.
   b) Basic concept of Parasitism, symbiosis, phoresis, commensalisms and mutualism.
2. Molecular, cellular and physiological basis of host-parasite interactions.
3. Life cycle and immunology of *Plasmodium falciparum,* African Trypanosomiasis.
4. Epidemiology and transmission of parasitic diseases. Malaria, Kalazar, Filaria.
5. a) Zoonosis and Zoonotic diseases with special reference to Balantidiasis, Giardiasis Filariasis and Paragonimiasis.
   b) Life cycle and biology of *Leishmania, Schistosoma.*
6. Structure and composition of helminthes cuticle.

7. Vector biology with special reference to mosquito/Sand fly/ticks.

Reference books:

1. Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.
2. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley andSons Inc.
3. Chatterjee, K. D. (1981).*Parasitology (Protozoology and Helminthology*).13th ed. CBS.
4. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
5. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
6. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.
7. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
8. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts' Foundation of Parasitology*. 9th ed. McGraw-Hill International.
9. Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd ed. McGraw Hill Publishers.
10. Schmidt, G. D. (1989). *Essentials of Parasitology*. Wm. C. Brown Publishers (Indian print;1990, Universal Book Stall).
11. Smyth, J. D. (1994). *Animal Parasitology*. 3rd ed. Cambridge University Press.

Course outcome: The course will provide an understanding of the diversity and biology of parasites, besides the epidemiological aspects of different parasitic diseases would be explored and students will able able to gain knowledge regarding the mode of transmission of parasitic diseases and preventive measures.

C-ZOO-204

Theory (CBCS)

(Wildlife & Eco-management and Aqua informatics)

Group A: Wildlife & Eco-Management

a) Wildlife diversity and distribution in India – Mammals, Avifauna and Reptiles; IUCN threatened categories.

b) Threatened wildlife in India with special reference to Eastern India.

c) Root causes of depletion of wildlife wealth.

d) Wildlife conservation strategies-

Protected areas-National Parks, Sanctuaries, Biosphere Reserve; Cores and Buffer; Nodes and Corridor.

e) Management of wildlife-Taxonomic Status, Distribution, Habitat Utilization Patterns, Threats and conservation of Mask Deer; Vultures; Olive Ridley turtle.

f) Tools and Techniques-

PRA methods ; Molecular Techniques; Tele satellite images; Radio coloring ; Peoples Participation; Ground truth Assessment-Pugmarks, Call counts, Capture-Recapture.

Wild life trades, Crimes, Laws & Ethics.

g) Environment –different relevant terminology.

h) Environmental Management-Basic steps Sustainability, Ecomonitoring Impact Assessment.

i) Pollution-Types: Mode of action and Environmental Consequences; Global Scenario.

j) Conservation Biology –different concepts and approaches.

Reference books / Journal articles:

1. An Introduction to Disturbance Ecology-A road map for Widlife Management and Conservation(Springer)
2. Wildlife in India: B Bsaharaia
3. A manual for wildlife Radio Tagging by Robert E Kenward
4. Conservation of Expoitedspecies(Edted by John D. Renolds, GeorginaM. Mace, Kent H. Redford and John G. Robinson) (Cambridge University Press)
5. Ecological Census techniques: Sutherland
6. Wild life Biology: R F Dasnan
7. A manual of wild life conservation: R D Teague
8. Animal Behavior: A synthesis of ethology and comparative psychology: RA Hinde
9. Animal behavior: Dugartkin
10. Animal behavior: Alcock

Course outcome: The syllabus of this subject includes some pertinent aspects on biodiversity dealing with identifying the threats and conservation of biodiversity alongside highlighting some basic aspects of wildlife and its conservation with special reference to the diversity, distribution and conservation of wildlife of South West Bengal, India. This course is expected to generate

interest to the students across the disciplines so that they can become a part of wildlife and biodiversity conservation.

Group B: Aqua informatics:

1. Spatial database development through different survey information analysis, Decision base support system formation.

2. Climate change and policy research design on Aquatic resources from beginning to end. Role of Information Communication Technology (ICT) in Aquaculture sector.

3. Recent approaches in Aquatic floral -faunal conservation/ assessment through Web based system.

4. Technology Innovation and Integrated Information Management System (software Program) in Aquaculture.

Reference books / Journal articles:

1. Roy, A. K. and N. Sarangi (2008).Applied Bioinformatics, Statistics & Economics in Fisheries Research, New India Pub.Agency.
2. Burnell, G. and G. L. Allan (2009). New Technologies in Aquaculture: Improving Production Efficiency, Quality and Environmental Management, CRC Press.
3. Food and A. O. o. t. U. Nations (1964).FAO Fisheries Technical Paper, Food and Agriculture Organization of the United Nations (ISBN 9251055548, 9789251055540).
4. Zazueta, F. S. (2006). Computers in Agriculture and Natural Resources: Proceedings of the 4th World Congress: Orlando, Florida, USA, July 24-26, 2006, American Society of Agricultural and Biological Engineers.
5. Bank, T. W. (2012). Agricultural Innovation Systems: An Investment Sourcebook, World Bank Publication. (ISBN 0821389440, 9780821389447).Length 680 pages.

Course outcome: Aquaculture is now viewed as a strong option to increase fish production as it plays a vital role in providing food security in India. Aquaculture informatics can be described as the scientific application of Information technology in biological concepts that enhance the productivity and economic viability of aquaculture sectors. Advances in electronic communication, combined with specific cooperative efforts, should be used to increase the

information exchange in the region. It is nation's part to educate the fish farmers through community based organization and to provide an information system, in low cost, to fulfill their requirements.

Paper ZOO-295
(Practical Paper)

1. Biosystematics
   i) Preparation of taxonomic key
2. Ecological principles
   a. Estimation of primary productivity in aquatic ecosystems
   b. Estimation of transparency of water
   c. Measurement of intensity of light – using Lux meter.
   d. Determination of the minimum size and number of quadrat – Species area curve method.
   e. Study of density, diversity, frequency and abundance of plant community.
3. Biophysics

a. Membrane biology dynamics
b. USIC/ SIF visit for Lab Demonstration
c. Demonstration of Scientific Techniques using local Species as an experimental tool

4. Biochemistry

a) Quantitative estimation of protein- Lowry method or by FolinCiocalteu reagent.
b) Estimation of Glucose by Dinitrosalicylic (DNS) acid reagent.
c) Estimation of Fructose by Resorcinol reagent.
d) Estimation of DNA by Diphenylamine reagent.
e) Detection of reducing sugars by Benedict's, Barfoed's& Fehling's reagents.
f) Detection of amino acids by Ninhydrin reaction.
g) Determination of Km &Vmax of enzymes Amylase and/or Alkaline phosphatase. Preparation of Progress Curve of the above mentioned enzymes.

Paper ZOO-296

1. Parasitology
   a) Smear preparation and staining of rectal content of Bufo sp./Cockroach
   b) Preparation and staining of blood parasite from pigeon blood.
   c) Identification:

      Plasmodium sp., Leishmania sp., Ascaris sp., Fasciola sp., Paramphistomum sp., Anopheles sp., Culex sp., Aedes sp. Columbicola sp., Pediculus sp., Cimex sp.

2. Molecular Biology
   a) Isolation & purification of DNA from tissue.
   b) Principle & method of Agarose Gel Electrophoresis
3. Field report & viva

SEMESTER III

ZOO-301

(Basic & applied Entomology and Ecotoxicology)

Group A: Basic & applied Entomology

1. **The importance, diversity and conservation of insects** – Insect biodiversity, uniqueness and adaptability, insect conservation. Insect for food and silk – prospects and problems of sericulture in drought prone lateritic tracts of South West Bengal, India.
2. **General characters and classification of Insects up to order** - Insect's head, capsule, antennae, legs, wings, digestive system with special emphasis to midgut, filter chamber and peritrophic membrane; integument, Insects' neuro-endocrine system – components, chemical structure of hormones and functions; molting and metamorphosis, insects' egg-type, hatching, growth, development, diapause and aestivation.
3. **Biology, nature of damage and control of Insects' pests** - Jute, cashew, betel vine and stored grains; Integrated approach to pest management.
4. **Aquatic insects** – Diversity of freshwater and marine insects, Adaptation – water balance; Importance for environmental monitoring.
5. **Insect behaviour** - Pheromones – Structure of pheromone glands; types and functions; biochemical synthesis of pheromones. Bioluminescence – Light producing organs, Mechanism of light production, Control and significance of light production.
6. **Insects and Plants –** Insect plant interaction and co-evolutionary interactions between plants and animals; Plant chemicals and their effect on insects; Pollination by insects; Organic compounds and their biosynthesis pathways in insects

Reference books / Journal articles:

1. Principal of Insect morphology R E Snodgrass
2. Imms general Text Book of Entomology O W Richards & R G Davies
3. The Insects: Structure & Function R F Chapman
4. General and Applied Entomology K KNayar, Ananathakrishnan& David
5. The science of Entomology Romser&Stoffolans
6. Insect Pest Management :D Dent
7. Entomology & Pest management L P Pedigo
8. Insect Pests in Tropical Forestry: Martin R.Speight(CABI Publishing)
9. Entomology: C Gillot
10. Insect evolutionary ecology: M D E Fellowery, G J Holloway

11. Insect Physiological Ecology-Mechanisms and Patterns: Steven L. Chown and Sue W. Nicolson(Oxford University Press)
12. Pheromones and Animal Behaviour: TristramD.Wyatt(Oxford University Press)

Course outcome: The subject entomology dealing with the study of different aspects of insects, the largest animal taxa of the world has been included in the general syllabus of Zoology in third semester mainly to give the students an understanding on three different aspects of entomology—morphology and classifications, insects' physiology and some unique phenomena in the insects life such bioluminescence, pheromones, secondary adaptation aquatic insects, insects-plants interactions , integrated management of insects pats etc. so that the students can develop not only the interest on this interesting and important faunal components but can undertake measures for the conservation of beneficial insects and control of the harmful ones.

Group B. Ecotoxicology

1. **Xenobiotics**

   General idea of Xenobionts and their Physical & Chemical Properties; Corrosive, Metabolic, Neurotoxic, Mutagenic & Carcinogenic toxins; Characteristics of toxin, Route of Entry, Mechanism of Action.

2. **Toxicity test & bioassay**

   LC_{50}, LD_{50}, Dose response curve; Biotransformation, Bioaccumulation &Biomagnification of Xenobionts in food chain; Hazardous heavy metals and their toxicity and probable antidotes; Elementary idea on Chelation therapy.

3. **Aquatic Toxicology**

   A short history of Aquatic toxicology, The aquatic environment, Factors affecting the Environmental Contraction of Chemicals, Toxicological Concept and Principles, Factors influence Toxicity, Toxic agents and their effects, concentration – Response Relationships, toxicity testing, Biomonitoring Toxicity data and Environmental regulation.

4. **Immunotoxicology**

   Immunology – Defensive responses, Immunological methodology; Immunotoxicology – Effects of classes of Toxicants.

5. **Environmental Genotoxicology**

Basic mechanism of DNA damage, Analytical techniques, In situ Environmental Genotoxicity studies with Aquatic species, potential value of Environmental genotoxicity.

Reference books / Journal articles:

1. Newman, M. C. and W. H. Clements (2007). Ecotoxicology: A Comprehensive Treatment, CRC Press. CRC Press, 2007.
2. Jorgensen, E. (2010). Ecotoxicology, Elsevier Science. Academic Press, 2010.
3. Walker, C. H., R. M. Sibly, et al. (2016). Principles of Ecotoxicology, FourthEdition, CRC Press.
4. Hoffman, D. J., B. A. Rattner, et al. (2002). Handbook of Ecotoxicology, Second Edition, CRC Press.
5. Forbes, T. L. (1993). Ecotoxicology in Theory and Practice, Springer Netherlands. Springer Science & Business Media, 1993.

Course outcome: The purpose of toxicity testing is to generate information about a substance's toxic properties so that the health and environmental risks it poses can be adequately evaluated. In aquatic sector toxicological study may ensure the health of the local aquatic organism and related to human health.

PaperZOO-302

(Molecular Evolution and Microbiology)

Group A. Molecular Evolution

1. Neo-Darwinism

a. Hardy-Weinberg law of genetic equilibrium

b. A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration

2. Molecular phylogenies

a. Construction of phylogenetic trees

b. Phylogenetic inference-Distance methods, parsimony methods, maximum likelihood method

c. Immunological techniques

d. Amino acid sequences and phylogeny

e. Nucleic acid phylogeny, DNA-DNA hybridizations, restriction enzyme sites, nucleotidesequence comparisons and homologies

Reference Books/ Journal Article:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Genetic: Analysis and Principles by Robert J. Brooker
3. An Introduction to the Genetic Analysis by David T. Suzuki
4. Genetics:A Conceptual Approach by Benjamin A.Pierce
5. iGenetics: A Molecular Approach by Peter J. Russell
6. Principle of Genetics by Peter Snustad

Course outcome: The curriculum in evolution includes modern aspects of evolution and molecular phylogenetic tree. DNA and amino acid sequences study by genomics and proteomics data analysis and find out the similarities and dissimilarities between different species of same group or different group. By nearest neighbor analysis and by principle of parsimony a gene tree could be made. PG students are benefitted by study of genome analysis and by finding the sequences they may be able to find out the molecular systematic position.

Group B: Microbiology

1. Outline classification of microorganisms: 5-kingdom, 8-kingdom system, Bergey's manual.
2. Classification & morphology of Bacteria
3. General accounts of Algae, Protists, Fungi & Virus.
4. Microbial Physiology:
    i. Growth in Bacteria: normal growth curve; methods of measuring growth.
    ii. Yield and characteristics, strategies of cell division.
    iii. Bacterial chemotaxis and quorum sensing.

5. Nutrition of microbes
    i. Principles behind formulating culture media
    ii. Culture techniques; pure cultures.
6. Microbes in soil ecology: fertility, petroleum formation; Role of soil microbial community as a key component of the soil ecosystem.
7. Microbial fermentation: manufacture of industrially important products.

Reference books:

- Prescott's Microbiology - Christopher J. Woolverton, Professor, Linda Sherwood, Joanne Willey. 2016.
- Microbiology: An Introduction - Gerard J. Tortora, Berdell R. Funke, Christine L. Case. 2018.

Course outcome: To gain knowledge on importance of microorganisms as primary decomposers, produce food products, produce Antibiotics, synthesize chemicals that our body needs, as test organisms, prevent potential pathogens, Insect Pest Control, Bioremediation, Genetic Engineering. With this exposure, students can be employed in testing/pathology laboratories alternatively.

Paper: ZOO-303A: FISHERY SPECIAL
(Fish Taxonomy & Biology and Oceanography)

Group A: Fish Taxonomy & Biology

1. Classification of fishes
2. Fish nutrition and growth
3. Fish reproduction and development
4. Fish endocrinology
5. Fish migration

Reference books / Journal articles:

1. Helfman, G., B. B. Collette, et al. (2009). The Diversity of Fishes: Biology, Evolution, and Ecology, Wiley. John Wiley & Sons, 2009
2. Nelson, J. S., T. C. Grande, et al. (2016). Fishes of the World, Wiley.Publisher
3. John Wiley & Sons, 2016
4. Jhingran, V. G. (1991). Fish and Fisheries of India, South Asia Books. South Asia Books, 1991
5. Talwar, P. K. and A. G. Jhingran (1991). Inland Fishes of India and Adjacent Countries, Taylor & Francis. CRC Press, 1991

Group B:Oceanography

1. Basic concept of Oceanography
2. Physical oceanography
3. Chemical oceanography
4. Biological oceanography
5. Oceanic resources
6. Oceanic pollution

Reference books / Journal articles:

1. Trujillo, AP., Thurman, HV. (1983) Essentials of Oceanography. (ISBN-13: 978-0134073545)

2. Garrison, T., Ellis, R. Oceanography: An Invitation to Marine Science. (9^{th}Eds).

3.Knauss, JA. Introduction to Physical Oceanography.(2^{nd}Eds).

Course outcome: A sustainable approach to fisheries and aquaculture will help to protect our natural resources and ensure that fish stocks are available for future generations. Currently, overfishing, ineffective management practices, industrial development and agricultural pollution have reduced fish stocks.

Paper: ZOO-303B:ECOLOGY SPECIAL
(Biodiversity & Conservation Ecology and Aquatic Ecology)

Group A: Biodiversity & Conservation Ecology

- Biodiversity - Utility and concept. CBD, Megadiversity countries, Biodiversity hotspots. Estimating biodiversity, biodiversity indices. IUCN Red List Category Version 3.1; IUCN categories of Protected Areas- National Parks, Sanctuaries, Biosphere Reserve. Biodiversity convention, criteria for measuring conservation value of areas. Types of conservation: (i) Ex-situ conservation of animals; captive breeding; species reintroduction, species translocation; population reinforcement; (ii) In-situ conservation- conserving ecosystem function and management. Bioindicators for biodiversity monitoring.

- Wildlife Ecology: Evolution of Approaches in Wildlife Conservation. Diversity, ecology, threats & conservation strategies of major Wildlife in West Bengal. Wildlife Habitat management for conservation. Wildlife crime. Social forestry: Joint Forest management-Arabari concept. Biodiversity profile of Ganga River and restoration activities.

- Conservation of biodiversity– Conservation process; Enhancing & conserving environmental resources. World Heritage Sites. Red datasheet for India. Critically Endangered Vertebrates of India with special reference to West Bengal. Distribution, habitat utilization, threats to survival of Endangered fauna (Tiger, Wild Elephant), and conservation strategies. Climate change and its effect on wildlife (amphibians & reptiles) and their habitat (eg. alpine vegetation). Human-animal conflict with special reference to elephant migration.

- Endemic Avifauna of India– IBAs of West Bengal. Distribution, habitat preference, migration, biology, threats to survival, conservation strategy of Vulture and Great Indian Bustard. Wetland and forest as complementary habitats for the conservation of Avifauna.

- Tools and techniques for wildlife census and survey. Technologies for Wildlife Research and Management. Molecular techniques for wildlife biology; DNA fingerprinting in wildlife forensics. Remote sensing: basic idea of GIS and GPS and their application in habitat & wildlife conservation.

Reference books:

- Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach- David B. Lindenmayer, Jerry F. Franklin. 2013.

- Valuation and Conservation of Biodiversity: Interdisciplinary Perspectives… Michael Markussen, Ralph Buse, HeikoGarrelts, MaríaManez Costa, Susanne Menzel, Rainer Marggraf. 2005.

- Practical Approaches to the Conservation of Biological Diversity- Richard KenithBaydack, Henry Campa, Jonathan B. Haufler. 1999.

Group B: Aquatic Ecology

1. **Water as resource** - types and distribution; past changes and present status; Hydrological cycles – different phases, factors contributing to degradation of water quality and management. **Socio-Ecohydrological balancing**: Sustainable water management- surface & groundwater relationships; Base flow, porosity, permeability, transmissurity and storativity.

2. **Structure and function of aquatic ecosystems and their management : -**

   a) Conservation strategies of river, floodplains, lakes, freshwater wetlands, salt marsh and coastal dunes – in respect of climate change.

   b) **Marine Ecosystem:** Origin, extent and zonation of sea, physical properties and physical processes, chemical composition, behaviour and fate, biological components and their interactions.

   c) **Coastal Ecosystem:** Definition, extent and types, zonation and geomorphological features, significance, human induced problems, global and marine diversity, integrated coastal zone management.

   d) **Estuarine Ecosystem:** Definition, classification, structure – biotic assemblage and their interactions, function.

   e) **Mangrove Ecosystem:** Definition; specialty of this ecosystem; structure and function with special reference to Sundarbans, India; Problems and Management.

   f) **Coral Ecosystem:** Definition, types and distribution, specialty with regard to biodiversity, productivity and ecosystem functioning, problems and management.

   g) **Wetland Ecosystem:** Definition, distribution, causal factors, wetland classification, zonation and succession, significance and values, Ramsar sites in India.

   h) **River Ecosystem:** Fluvial hydrosystem approach; catchment size and drainage basin from selected major rivers, hydrochemical dynamics, biological productivity, human impacts and management perspective.

3. **Wastewater management** – types, source, physical-chemical properties, recycling and bioremediations.

4. **Aquatic biota, types and trophic interactions** – Macrophytes, phytoplankton, zooplankton, periphyton, benthos and nekton.

Reference books:

- Limnology: Lake and River Ecosystems - Robert G. Wetzel. 2001.
- Freshwater Ecology: Concepts and Environmental Applications of Limnology - Walter K. Dodds, Matt R Whiles. 2010.

Course outcome: Both theory and practical learning process are to acquaint students with both the basic traditional/conventional components of the ecological science in order to develop proper knowledge base to tackle the ongoing ecological changes in and around human settlements with special emphasis to the landscapes & ecosystems of south West Bengal. The entire syllabus has four dimensions- Systems Ecology, Human Ecology, and Aquatic Ecology & Wildlife Ecology. The major emphasis was laid in developing the syllabus to cover not only on traditional aspects of Ecological but also on modern developments in the sphere of ecological sciences: system, mathematical, molecular, urban, restoration and aquatic ecology.

Paper ZOO-303C: GENETICS & MOLECULAR BIOLOGY SPECIAL

(Genetics & Molecular Biology)

Group A:Genetics

1. **Organisation of the eukaryotic genome**:

   Nucleosome structure, Chromatin remodeling, Histone modification-acetylation, methylation, Centromeric&Telomeric DNA, Epigenetics, Apoptosis.

4. **Mechanism of RNA Splicing & Transcription of rRNA gene**:

   Production of Mature mRNA in Eukaryotes, 5¢and 3¢mRNA, RNA editing, transcription ofrRNA genes.Self splicing reaction.

2. **Mechanism of Crossing Over:**

   The holliday model of Crossing over, The Meselson-Radding Model of Recombination, The Double-Strand-Break repair Model of Recombination.

4. **Sex determination and Dosage compensation in Mammals and Drosophila:**

Primary and Secondary sex determination in mammals. The Y chromosome sex determinant; Sry, Sox 9 gene product, role of DAX 1 gene, hormonal regulation of the sexual phenotype, Mechanism of sex determination in Drosophila; role of sxl gene, transformer gene and double sex protein.

Reference Books/ Journal Article:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Genes viii by Benjamin Lewin
3. Genetic: Analysis and Principles by Robert J. Brooker
4. An Introduction to the Genetic Analysis by David T. Suzuki
5. Genetics:A Conceptual Approach by Benjamin A.Pierce
6. iGenetics: A Molecular Approach by Peter J. Russell
7. Principle of Genetics by Peter Snustad

Group B: Molecular Biology

1. **DNA repair mechanism**

Mechanism of DNA mutation, Repair mechanism, Base excision repair, Mismatch Repair, Error prone repair.Recombination repair in *E.coli*

2. **Signal Transduction pathway**

TGF□ pathway, Wnt pathway, Jak-Stat pathway, Hedgehog Pathway, Notch Delta, TLR pathway, NF-□B pathway

3. **Transposable Genetic Element:**

IS element: its property and transposition, Non-composite and Composite Transposition.Cointegration model for transposition.The AC-DC Controlling elements in Corn, Hybrid dysgenesis and P elements in Drosophila.Sleeping Beauty model of transposon.Retroposons&retrotransposons

4. **Genetics of Cancer**

Cell transformation, tumorogenesis, Oncogenes, Tumor suppressor genes, Genomic instability, Epigenetic modification, Angiogenesis, Metastasis and Current therapies.

5. **Epigenetics and genome imprinting** - DNA methylation in mammals, genomic imprinting in mammals, germ line and pluripotent stem cells, epigenetic control of lymphopoiesis,

nuclear transplantation and the reprogramming of the genome. Epigenetics and human disease, epigenetic determinants of cancer.

6. Gene Therapy

Methods of Gene targeting, ex vivo and in- vivo therapy, Stem cell therapy,siRNA and miRNA basics, regulation of transcription and translation of proteins by miRNA. **Transgenesis:** transgenic animal and plants and their application.

Reference books:

1. Molecular Cell Biology by Harvey Lodish
2. Molecular Biology by Robert F. Weaver
3. Molecular Biology of the Gene by James D. Watson
4. iGenetics: A Molecular Approach by Peter J. Russell
5. Human Molecular Genetics by Tom Strachan
6. Introduction to genetics A Molecular Approach by Terry Brown
7. Gene Cloning and Manipulation by Christopher Howe
8. Principles of Gene Manipulation and Genomics by S.B.Primrose

Course outcome: The course will acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology. A sound knowledge on methodological repertoire allows students to innovatively apply these in basic and applied fields of biological research. Students will introduced to properties, application and limitation of versatile DNA modifying enzymes, gene cloning, sequencing and genetic transformation etc. This course may be deemed as a foundation course serving as a platform for introduction of more advanced cutting-edge technologies that essentially are an amalgamation of basic techniques combined in diverse forms of modern applications. Understand and apply the principles and techniques of molecular biology which prepares students for further education and/or employment in teaching, basic research, or the health professions.

Paper: ZOO-303D PARASITOLOGY SPECIAL

(Diversity & Biology of Parasite andImmunoparasitology)

Group- A: Diversity and Biology of Parasite

1. Introduction to Parasitology

1.1 Basic concepts- parasite systematics, ecology and evolution

1.2 Host parasite interactions

2. Protozoology

2.1 Classification of Protozoa with suitable example up to subclasses following Levine et al. (1980)

2.2 Structure of Apical complex

2.3 Life cycle, pathogenecity and control of *Entamoebahistolytica, Balantidium coli*

2.4 Primary Amoebic Meningoencephalitis

3.Helminthology

3.1 Structure, composition and function of tegument of parasitic helminthes

3.2 Life cycle, pathogenecity and control of

Diphyllobothriumlatum, Echinococcusgranulosus,Schistosomahaematobium, Paragonimuswestermani, Trichenellaspiralis, Loa loa

3.3 Carbohydrate and protein metabolism in Nematode and Trematode

3.4 Different types of scolex in Cestoda

3.5 Mode of action of anthelmintic drugs

3.6 Types of cercariae in digenetic trematode

4. Major parasitic diseases of fin fish

Group- B: Immunoparasitology

1. Immunity and host defense:

Immune response to the bacteria, Immune response to the Virus, Immune response to the Parasites

2. The Complement System

The Major Pathways of Complement Activation, the Regulation of Complement Activity, Complement Deficiencies

3. Hypersensitivity

Allergy: A Type I Hypersensitivity Reaction, Antibody-Mediated (Type II) Hypersensitivity Reactions, Immune Complex-Mediated (Type III) Hypersensitivity, Delayed-Type (Type IV) Hypersensitivity (DTH), Chronic Inflammation

4. Inflammation and Immunity

Overview of Inflammation, Inflammatory mediators, Inflammation and disease, Therapeutic Aspect

5. **Transplantation Immunology and Immunomodulation**

Molecular basis of graft vs host reaction. Acute, Hyperacute and chronic Graft rejection, Modern techniques of transplantation (e.g.BMT, liver, cornea etc) Mechanism of action of common immunosuppressant drugs, Immunoboosters

6. Tumor Immunology

Concepts of Immune surveillance, Mechanism of Immune escape by tumor, Anti-tumor Immune response. Modern Immunotherapy of Cancer

7. Tolerance and Autoimmunity

Tolerance and Autoimmunity, Peripheral and Central Tolerance of T and B cell, Malfunction and different autoimmune disease

8. Techniques in Clinical parasitology

Gel electrophoresis, Southern blotting, Western blotting, Immunofluorescence, Immunohistochemistry, Hybridoma technique for MAb, PCR

Reference books:

1.Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.

2.Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley andSons Inc.

3. Chatterjee, K. D. (1981).*Parasitology (Protozoology and Helminthology*).13th ed. CBS.

4 Cheng, T. C. (1986).*General Parasitology*.2nd ed. Academic Press, Inc. Orlando.U.S.A.

6. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.

6 Hati, A. K. (2001).*Medical Parasitology*.Allied Book Agency, Kolkata.

7Noble, E. R. and Noble G. A. (1989).*Parasitology*.*The Biology of animal Parasites.*6th ed. Lea and Febiger, Philadelphia.

8 Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts' Foundation of Parasitology*.9th ed. McGraw-Hill International.

9 Schmidt, G. D. and Roberts, L. S. (2001).*Foundation of Parasitology*.3rd ed. McGraw Hill Publishers.

10 Schmidt, G. D. (1989).*Essentials of Parasitology*. Wm. C. Brown Publishers (Indian print;1990, Universal Book Stall).

11 .Smyth, J. D. (1994).*Animal Parasitology*.3rd ed. Cambridge University Press.

12. Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of domesticated animals.* ELBS and BailliereTindall. London.

13. Heinz Mehlhorn (2007) Parasitology in focus. (Encclopedic approach) ,3rd Ed. Springer-Verlag, Germany

14. W. Peters and R. Killick-Kendrick (1897) THE LEISHMAANIASIS in Biology and Medicine. Academic Press (Inc) Ltd.

15. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2006). *Cellular and molecular Immunology*. 6th ed. Saunders.
16. Abbas, A. K. and Lichtman, A. H. (2006). *Basic Immunology*. 2nd ed. Elsevier.
17. Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5th ed. Wiley-Liss: New Jersey.
18. English, L. S. (1994). *Technological Applications of Immunochemicals (BIOTOL)*. Butterworth- Heinemann, Oxford Freeman and Co.
19. Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2013). *Immunology*. 7th ed. W. H. Freeman and Co.
20. Khan F. H. (2009). *The Elements of Immunology*. Prentice Hall India.
21. Kindt, T., Goldsby, R. Osborne, B. (2007). *Kuby*'s *Immunology*. 6th ed. W.H. Freeman and Co.
22. Male, D., Brostaff, J., Roth, D. and Roitt, I. (2006). *Immunology*. 7th ed. Mosby.
23. Rao, C. V. (2002). *Immunology*. Narosa Publishing House, New Delhi.
24. Roitt, I. M. and Delves, P. J. (2001). *Roitt's Essential Immunology*. 10th ed. Blackwell Science Ltd.

Course outcome: The course will acquaint the students to understand host parasite interactions, complement activation, mode of recognition by TLR and its signaling, hypersensitivity with special reference to asthma. The course will enlightened the students regarding different modern diagnostic methods to identify parasitic infections. Vector biology and epidemiology will be another focus to know the propensity of the vector borne diseases and proper formation of vector control.

Paper: C-ZOO-304 (CBCS) Theory
(Genetics and Haematology)

Group A: Genetics

1. Sex-chromosome inheritance

i) Chromosomal Determination of Sex, X-linked inheritance

ii) Pedigree characteristics of Human, X-linked inheritance

iii) Nondisjunction as proof of the chromosome theory of heredity

iv) Chromosome theory of Heredity

v) Sex Determination in *Drosophila*

2. Probability in the prediction of progeny distributions

i) Using the binomial distribution in genetics

ii) Testing goodness of fit to a genetic hypothesis, The Chi-Square Method

3. Genetic Linkage and Chromosome Mapping

i) Linkage and recombination of genes in a chromosome

ii) The Chi-square test for linkage

iii) Each pair of linked genes has a characteristics frequency of recombination

iv) Genetic Mapping, Map distance and frequency of recombination

v) Crossing –over

vi) Recombination between genes results from a physical exchange between chromosomes

4. Genetic Mapping in a Three-Point Testcross

i) Chromosome Interference in a double crossovers

ii) Genetic Mapping Functions, Genetic Map Distance and physical distance

5. Central dogma of Life

i) Overview of Organisation of DNA in chromosome

ii) Basic concept of Replication, transcription and translation

Reference books:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Genes viii by Benjamin Lewin
3. Genetic: Analysis and Principles by Robert J. Brooker
4. An Introduction to the Genetic Analysis by David T. Suzuki
5. Genetics:A Conceptual Approach by Benjamin A.Pierce
6. iGenetics: A Molecular Approach by Peter J. Russell
7. Principle of Genetics by Peter Snustad

Course outcome: The course will provide an understanding of genetic analysis at the gene, genome and population levels. Understanding the Drosophila genetics.Evaluation of the various aspects of structural, functional and comparative genomics.Designing and development of experiments using Drosophila and their evaluation through genetic analysis and interpretations.

Group B: Haematology

1. Haemopoetic tissues: Structure & function [Annelida/ Arthropoda/ Mollusca; Chordata (Class-Fish/mammals)]
2. Blood cells: Structure & function
3. Red cell abnormalities: (Anemia: Introduction, Classification, Iron deficiency anemia & other hypochromic, microcytic anemia)
4. White cells and their disorders: Acute leukemia/ Chronic myeloid leukemia/ Chronic Lymphocytic leukemia
5. Physiology of coagulation &Haemostasis (Congenital bleeding disorders/ Acquired bleeding disorders/ Congenital platelet disorders/Acquired platelet disorders/ Thrombophilic disorders)

Course outcome: The course will provide a reflection of physiological homeostasis of human.

Paper ZOO-395
Practical

1) Entomology
   a) Method of collection and preservation of insects
   b) Study of the behavioural modification of legs in honey bee.
   c) Entomological comments on common Pests, Aquatic insects, Insects of medical and economical importance. Galls & Seed cocoon
   d) Mounting of sting apparatus & coupling device of Honey bee.
2) Ecotoxicology
   a) Dose response curve
   b) Lethal dose estimation
   c) MATC in a fish species
   d) Lethal dose50 mortality curve
3) Molecular Evolution
4) Microbiology
   a. Staining and identification of bacteria, endospores, etc. from a culture media.
   b. Different methods of staining: Gram staining, Negative and differential staining.

c. Preparation of different culture media with Sterilization techniques.
d. Inoculation of microbes to respective culture media through proper culture methods.
e. Enumeration of Coliform bacteria using multiple tube fermentation method.

Special paper Practical
ZOO-396A Fishery

1. Identification of Indian fish fauna
2. Identification of fish food organism/ artificial fish food
3. Dissection – Urinogenital system of Tilapia, ARO of catfishes, Weberianossicles of IMCs.
4. Fecundity estimation
5. Identification of oceanic hemichordates, cephalochordates and urochordates
6. Demonstration of organic carbon, salinity, phosphates and nitrogen
7. Anatomical demonstration of caudal – neural structure of marine fish
8. Field trip

ZOO-396B Ecology

1. Preparation of Climograph
2. Estimation of transparency, TSS, TDS, conductivity, hardness, salinity and alkalinity of water.
3. Estimation of N, P, K content of water/ soil.
4. Basic principle pertaining to acid digestion for the estimation of heavy metals in water sample.
5. Ecological comments on major biotic components in Aquatic system
6. Recording/documentation and submission of terrestrial / aquatic faunal components in and around University campus – (Collection, preservation, identification and analysis of aquatic biota – phytoplankton, zooplankton, benthos, periphyton, aquatic insects, nekton and macrophytes).
7. Applicability of GPS/GIS in recording bioresources and mapping of landscape.
8. Submission of Laboratory notebook.
9. Viva-voce
10. Field trip

ZOO-396C Genetics & Molecular Biology:

1. Probability in Mendelian Inheritance
   a. Chi-square, degree of freedom, test for Independence (contingency Chi square),
   b. Homogeneity Chi-square, Independent Assortment and probability(binomial expansion)
2. Preparation of mitotic metaphase chromosome of rat.
3. Plasmid isolation and restriction digestion and Agarose gel electrophoresis.
4. Lab /Institute visit

ZOO-396D Parasitology

1. Stain preparation of blood film from pigeon for identification of protozoan parasite
2. Smear preparation and staining of rectal content of Bufo /gut content of Cockroach for identification of protozoan parasites/examination of gut of fish for identification of endoparasites
3. Whole mount preparation of Ectoparasites
4. Staining and identification of helminth parasites
   4.1 Cestode and Trematode with acetocarmine
   4.2 Nematode with lactophenol
5. Identification of parasites (Protozoa, Helminths, Arthropods) with reasons
6. Submission of prepared slides (minimum ten (10) slides)
7. Laboratory Note Book
8. Viva-Voce
9. Lab /Institute visit

SEMESTER IV

Paper ZOO-401

(Environmental pollution & management and Biostatistics)

Group A: Environmental pollution & management

1. Global environmental problems;Bioinvasion-Principles, threats and management
2. **Environmental pollution**: Types, natural versus man made; Global scenario.
3. **Air pollution**: Composition of air, zonations of atmosphere; classification, properties/ behaviour and fate of air pollutants; properties and role of oxides of nitrogen, and sulphur as air pollutant, green house effect and global warming; photochemical smog, acid rains, effect of pollutants on human health and plants, Noise pollution.
4. **Water pollution**: Classification and behaviour of water pollutants, point and non-point pollution, pollution of water by agricultural wastes (fertilizers and pesticides); sewage, oil, thermal power plants; and eutrophication.
5. **Soil pollution**: Soil pollution through agricultural and solid wastes; soil erosion – types and causative agents; Bioinvasion and its environmental impact; Biosafety and its significance.
6. **Environmental management:** Ecodegradation and pollution; sustainable environmental management; indicators of quality of life. Objectives of conservation; world conservation strategies. Biomonitoring. Green movements; traditional environmental knowledge and people's participation.

Reference books:

1. Biological diversity-Exploiters and Exploited—Paul Hatcher and Nick Battey(Wiley-Blackwell)
2. The Root Causes of Biodiversity Loss(Edited by Alexander Wood, Pamela Stedman-Edwards, Johanna Mang) EARTHSCAN Publisher
3. The Science of Environmental Pollution—Frank R. Spellman(CRC Press)
4. Environmental Management –N.K.Uberoi9 Excel books)
5. Climate Change-A Multidisciplinary Approach-William James Burroughs(Cambridge University Press)
6. Estuarine and Marine Pollution: Michael J. Kennish(CRC Press)
7. Environmental Biotechnology-A Biosystems Approach-Daniel A. Vallero(Elsevier)
8. Environment, Technology and Development(Edited by Rohan D'Souza0 (Orient Black Swan)

Course outcome: The students would be provided with current status of environmental pollution and global environmental change. The course would cover biodiversity: status, monitoring and documentation; major drivers of biodiversity change and biodiversity management approaches.

Group B: Biostatistics

1. **Concepts of Biostatistics:** Data, population, sample and sampling, frequency distribution, graphical representation of data, parametric and nonparametric statistics
2. **Measures of Central Tendency:**Mean, median and Mode
3. **Measures of Dispersion:** Range, quartile deviation, mean deviation and standard deviation, standard error, variance and covariance
4. **Probability distribution**: Normal distributions, Properties and uses of binomial distributions and Poisson's distributions
5. **Set theory and probability**
6. **Testing of Hypothesis**: Null Hypothesis. Level of significance. Error of interferenceand degrees of freedom.
7. **Analysis of frequencies**: Chi-square test for goodness of fit.
8. **Student 't' distribution**
9. **Z test and Fisher's F test**
10. **Correlation and regression**: Properties and types of correlation. Pearson's product-moment correlation coefficient- properties, assumptions, computation from ungrouped data and significance test. Partial and multiple correlations. Rank correlation Regressions- types and models, simple linear regression – assumption, properties and computation. Multiple regression.
11. **Analysis of Variances**: Types and models of analysis of variances. Assumption for ANOVA. One-way ANOVA- computation and interpretation of F ratio, multiple comparison t-test, Scheffe's multiple comparison f-test.
12. **Nonparametric Test**

Reference books:

1. Fundamentals of biostatistics.-7 th ed./Bernard Rosner
2. Principles of Biostatistics/Marcello Pagano/Duxbury Press 1993

3. Statistics in scientific investigation its basis, application and interpretation/Glen McPherson/Springer Verlag 1990
4. Introduction to Biostatistics/Robert R Sokal and F James Rohlf/Dover Publication
5. Biostatistical Analysis, 5th Edition, Jerrold H. Zar
6. Biostatistics by D Das

Course outcome: To learn about key biostatistical concepts and efficient tools for summarizing and plotting data, make decisions in the presence of uncertainty.Student will be acquainted with parametric and nonparametric statistics, sample and data. The will be able to understand t test, Chi square, correlation, regression and anova.

Paper ZOO-402

Developmental Biology & Neuroendocrinology

Group A: Developmental Biology

1. **Early development and molecular mechanism of Amphibian axis foramation:** Inductive interactions,organisation of a secondary axis,dorsal and ventral signal of the organizer,functions of the organizer, epidermal inductioin.
2. **Regeneration:**Regeneration of animals with special emphasis on the process of regeneration in Hydra and Amphibia.
3. **Beginning a new organism:** Fertilization in sea urchin and Mammals, the chemoattraction of sperm and egg,species specific binding of acrosomal process, the fast and slow block of polyspermy,role of calcium and egg activation in sea urchin. egg, Translocation and Capacitation in mammals,recognition at zonapellucida,mouse acrosome reaction and gamete fusion

Reference books:

1. Developmental biology, 11th edition 2016 by S. F. Gilbert
2. Principles of Development. Fourth Edition. Lewis Wolpert

Course outcome: The course will provide a broad area from embryology to developmental biology. The students will be able to understandthe embryonic development, reproductive function and fertilization.

Group B: Neuro-Immuno Endocrinology

1. Basic concept of neural system
2. Development and differentiation of neural circuit in vertebrates
3. Neuroendocrine glands in animal
4. Neuro-immuno endocrine pathways
5. Neural/ endocrine disorder

Reference books:

1. Brown RE (1994) An Introduction to Neuroendocrinology. Cambridge University Press.
2. Van De Kar, LD. Methods in Neuroendocrinology, C R C Press.

- Clinical Neuroscience - Kelly Lambert, Craig H. Kinsley. 2004.
- Text Book of Medical Physiology -Arthur C. Guyton& John Edward Hall. 13th Ed.

Course outcome: The course will provide an understanding of basic concept of neural system. Students would be acquainted with electrical signaling and mechanism. The course will cover evolutionary perspective nervous system, functional organization of the CNS and endocrine disorder

ZOO-403A FISHERY SPECIAL

Aquaculture &Fish Technology and Inland & Marine fisheries

Group A: Aquaculture &Fish Technology

1. Aquaculture – Problems and prospects in India
2. Integrated fish farming system and fish breeding
3. Fishing methods, harvesting, by-products and export
4. Fish disease
5. Fisheries planning, economics and extension

Reference books:

1. Stickney, R. R. (2016). Aquaculture, 3rd Edition: An Introductory Text, CABI.
2. Safran, P. (2009). Fisheries and Aquaculture - Volume III. EOLSS Publications, 2009.
3. Pandey, B. N., S. D. Pande, et al. (2007). Aquaculture, A.P.H. Pub.

Group B. Inland and Marine fisheries

1. Freshwater resources/ marine water resources and their biology
2. Trends in aquaculture
3. Estuary
4. Reservoir
5. Waste water management
6. RS-GIS in aquaculture
7. Fishery traits

Reference books:

1.Jhingran, VG (1975) **Fish and Fisheries of India.** Hindustan Publishing Corporation (India).
2. Nelson, J. (2006) Fishes of the World (4th Edition). John Wiley and Sons.
3. Collette, BB, Facey, DE, Helfman, G. (1997) The Diversity of Fishes: Biology, Evolution, and Ecology. Wiley- Blackwell.

Course outcome: A sustainable approach to fisheries and aquaculture will help to protect our natural resources and ensure that fish stocks are available for future generations. Currently, overfishing, ineffective management practices, industrial development and agricultural pollution have reduced fish stocks.

ZOO-403B ECOLOGY SPECIAL
Systems Ecology & Human Ecology

Group A: Systems Ecology

1. **Community Ecology:** Biotic community: Abundance, Frequency, Relative Abundance, Dominance and Dominance index, Species Diversity and Evenness indices. a, b, g diversity. Species diversity hypotheses, Species diversity in ecological gradient. Metacommunity concept: Metapopulation structure. Fragmentation of habitat. Metacommunity dynamics: empirical examples.
2. **Restoration Ecology:** Definition, Philosophy and rationale for ecorestoration, Ecological restoration and sustainability, Process of ecorestoration – in the context of landscape to species level.
3. **Ecotourism:** Definition, sustainable development and ecotourism, Foundation of ecotourism, Economics and management issues, merits and demerits.
4. Ecosystem services and human wellbeing. Ecological Economics.
5. **Mathematical Ecology**: Basic concept of ecological modeling; Deterministic and Stochastic models; Theoretical model and analytical solution. - Patterns of Spatial distribution - Random, contagious and regular, coefficient of dispersion. Index of similarity and index of association.
6. **System structure and function:**
    a. Aquatic system: Physiography of freshwater ecosystems, stratification, distributions and mixing patterns. Dynamics of light, oxygen and nutrient content.
    b. Terrestrial system: Soils of West Bengal. Ecological processes in Tropical forest ecosystem - Vertical stratification of plants and animals. Production and nutrient cycling. Leaf litter decomposition. Assessment of health of forests / vegetation.

Reference books:

- Elements of Ecology- Thomas Michael Smith, Robert Leo Smith – 2015.

- Ecology: Global Insights and Investigations- Peter Stiling – 2011.
- Issues and Perspectives in Landscape Ecology- John A. Wiens, Michael R. Moss. 2005.
- Handbook of Ecological Restoration – Vol. 2. - Martin R. Perrow, Anthony J. Davy. 2002.

Group B: Human Ecology

1. **Global Environmental Issues; Global warming** – climate change; Acid rain; Stratospheric ozone layer destruction; Thermal Inversion – Smog, Point and Non-point pollution – fertilizers and pesticides. Carbon sequestration and landscape change.
2. **Solid waste recycling:** Agriculture, Municipal, Biomedical Wastes – nature, source, environmental impact and management.Wastes in ecosystems and management-urban waste, industrial waste, agricultural waste, radioactive waste, medical waste- effects and control.
3. **Environmental Management and Acts:** Environmental Impact Assessment: Definition; Types of EIA, EIA process and methodologies – scoping, prediction, evaluation, mitigation and monitoring; Socioeconomic impact assessment; EIA Notification. Environmental Management System, Ecomark.
4. **Urbanization:** Urban environment – criteria and its present global status, major environmental problems of cities. Urban impact on air and water environment, on biodiversity, agriculture; Indoor Pollution – characteristic of indoor environment, common indoor pollutants, their sources and mode of action; Effect of urbanization on biodiversity.
5. **Wasteland and watershed management:** Concept – integrated process and mechanism of wasteland restoration and watershed management; Soil erosion – types and factors.
6. **Bioinvasion:** Related terminologies; Underlying operating principles; Ecological Consequences—Case Studies.

Reference books:

Course outcome: Both theory and practical learning process are to acquaint students with both the basic traditional/conventional components of the ecological science in order to develop proper knowledge base to tackle the ongoing ecological changes in and around human settlements with special emphasis to the landscapes & ecosystems of south West Bengal. The

entire syllabus has four dimensions- Systems Ecology, Human Ecology, and Aquatic Ecology & Wildlife Ecology. The major emphasis was laid in developing the syllabus to cover not only on traditional aspects of Ecological but also on modern developments in the sphere of ecological sciences: system, mathematical, molecular, urban, restoration and aquatic ecology.

ZOO-403C GENETICS & MOL. BIOLOGY SPECIAL

(Genetic diseases &Molecular Analysis & Applied Genetics)

Group A: Genetic diseases & Molecular Analysis

1. **Molecular & Biochemical basis of**
   a) **Autosomal Disorders:** Cystic fibrosis, Thalassemia
   b) **X-linked Disorders:** Hemophilia A, Muscular dystrophy
   c) **Metabolic Disorders:** Phenylketonuria,Alkaptonuria
   d) **Dynamic Mutations:** Huntington disease
   e) **Late onset disorders:**Alzheimer disease
2. **DNA Markers in Genetic Analysis:**
   Restriction Fragment Length Polymorphism (RFLP), Tandem Nucleotide Repeat Marker, PCR based markers, Random Amplified Polymorphic DNA (RAPD), Amplification of DNAs by the polymerase Chain reaction and variations, Real time PCR.
3. **Protein blotting and Fluorescency:**
   Western Blotting techniques for the analysis of Proteins.Mechanism of Fluorescence and Phosphorescence, Fluorescence spectroscopy.In situ localization by FISH.
4. **DNA and RNA Sequencing:**
   Southern Blotting and Analysis of DNAs, Analysis of RNA by Northern Blot; Sanger Dideoxy Sequencing, Second generation sequencing- pyrosequencing.
5. **Recombinant DNA, Plasmid Cloning Vectors:**
   Restriction Endonuclease &Methylases, Recombination of DNA fragments, Plasmid cloning vector and expression vectors; Linker DNA, Homopolymer tailing, Blunt end ligation, Shotgun Cloning, cDNA cloning, cDNA microarray, T-A cloning.

Reference books:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Molecular Biology of the Gene by James D. Watson
3. Genes viii by Benjamin Lewin
4. Genetic: Analysis and Principles by Robert J. Brooker

5. Genetics:A Conceptual Approach by Benjamin A.Pierce
6. iGenetics: A Molecular Approach by Peter J. Russell
7. Principle of Genetics by Peter Snustad
8. Concept of Genetics by William S. klug, Michael R. Cummings
9. Human Molecular Genetics by Tom Strachan
10. Introduction to genetics A Molecular Approach by Terry Brown
11. Gene Cloning and Manipulation by Christopher Howe
12. Principles of Gene Manipulation and Genomics by S.B.Primrose

Group B: Applied Genetics

1. Genetic changes in differentiation of vertebrate immune cell Genetic control of human antibody, Multigene organization of Ig gene, The mechanism of V(D)J recombination, B cell and T cell receptor genes and expression.
2. The Human Genome Initiative: classical tools of positional cloning, identifying genes mutated in Huntington disease by RFLP, vectors for large scale genome project, studying and comparing Genomic sequences,Human genome.

Reference books:

1. Introduction to Genetic Analysis by J.F.Griffiths
2. Molecular Biology of the Gene by James D. Watson
3. Genes viii by Benjamin Lewin
4. Genetic: Analysis and Principles by Robert J. Brooker
5. Genetics:A Conceptual Approach by Benjamin A.Pierce
6. iGenetics: A Molecular Approach by Peter J. Russell
7. Principle of Genetics by Peter Snustad
8. Concept of Genetics by William S. klug, Michael R. Cummings
9. Human Molecular Genetics by Tom Strachan
10. Introduction to genetics A Molecular Approach by Terry Brown
11. Gene Cloning and Manipulation by Christopher Howe
12. Principles of Gene Manipulation and Genomics by S.B.Primrose

Course outcome: The course will acquaint the students to versatile tools and techniques employed in genetic engineering and recombinant DNA technology. A sound knowledge on methodological repertoire allows students to innovatively apply these in basic and applied fields of biological research. Students will introduced to properties, application and limitation of versatile DNA modifying enzymes, gene cloning, sequencing and genetic transformation etc. This course may be deemed as a foundation course serving as a platform for introduction of more advanced cutting-edge technologies that essentially are an amalgamation of basic techniques

combined in diverse forms of modern applications. Understand and apply the principles and techniques of molecular biology which prepares students for further education and/or employment in teaching, basic research, or the health professions.

ZOO-403D PARASITOLOGY SPECIAL

(Vector Biology &Vector borne Parasites and Molecular Diagnosis & Clinical parasitology)

Group- A Vector biology and vector borne parasites

1. General concept about vector- mode of transmission

2. Biology, importance and control of some vectors

2.1 Mosquito (Anopheles, Culex, Aedes)

2.2 Sand fly

2.3 Fleas

2.4 Ticks

2.5 Mites

2.6 Black fly

2.7 Tsetse fly

3. Life cycle, pathogenecity and control of some vector borne parasite

Plasmodium, Leishmania, Wuchereria, Babesia

4. General idea on Zoonosis and Myiasis

5. Lice as vectors of human disease: Typhus, Trench fever, Relapsing fever

6.Dynamics of Filarial transmission

6. Immunology of African Trypanosomiasis

Group- B Molecular diagnosis & clinical parasitology

1. General concept of molecular diagnosis for parasitic infection

1.1Advantages and disadvantages of molecular diagnosis

1.2 Fundamental techniques used in molecular diagnosis of endoparasites

2. Biology, clinical and laboratory diagnosis of *Hymenolepis nana, Clonorchissinensis, Enterobiusvermicularis, Dracunculusmedinensis,Toxoplasmagondii and Trichomonasvaginalis*

3. Clinical features of hookworm anaemia

4. Laboratory diagnosis of Amoebiasis

5. Xenodiagnosis of Parasites

6. Parasites as Therapeutic Organisms

7. Marker molecule based immunodiagnosis of endoparasites

7.1 Immunoassay or serological techniques for laboratory diagnosis of endoparasites on the basis of marker molecules like *G.intestinalis, B. coli, E. histolytica, L. donovani*, Malarial parasite using

a. ELISA , RIA

b. Counter Current Immunoelectrophoresis (CCI)

c. Complement Fixation Test (CFT)

d.PCR, DNA, RNA probe

8. Epidemiology: Classification, landscape epidemiology, methods of epidemiological studies

8.1 Epidemiology of Malaria, Filaria, Kala-azar

9. Antigenic variation in Trypanosomiasis: the perfect camouflage

Reference books:

1. Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.
2. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley andSons Inc.
3. Chandra, G. (2000). *Mosquito*. SreeBhumi Publication Co. Kolkata.
4. Chatterjee, K. D. (1981).*Parasitology (Protozoology and Helminthology*).13th ed. CBS.
5. Cheng, T. C. (1986). *General Parasitology*. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
6. Cox, F. E. G. (1993). *Modern Parasitology*. 2nd ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.
7. Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata.
8. Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.
9. Kettle, D. S. (1995). *Medical and veterinary Entomology*. 2nd Ed. CAB International.
10. Mullen, G. R. and Durden, L.A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.
11. Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of animal Parasites.* 6th ed. Lea and Febiger, Philadelphia.
12. Roberts, L. S., Janovy, J. and Nadler S. (2013) *Gerald D. Schmidt &Lary S. Roberts' Foundation of Parasitology*. 9th ed. McGraw-Hill International.
13. Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd ed. McGraw Hill Publishers.
14. Schmidt, G. D. (1989). *Essentials of Parasitology*. Wm. C. Brown Publishers (Indian print;1990, Universal Book Stall).
15. Smyth, J. D. (1994). *Animal Parasitology*. 3rd ed. Cambridge University Press.
16. Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of domesticated animals.* ELBS and BailliereTindall. London.
17. R Beaglehole , R Bomta and T Kjelstorm (1993) BASIC EPIDEMIOLOGY Orient Longman in collsboration with WHO , Geneva.
18. W. Peters and R. Killick-Kendrick (1897) THE LEISHMAANIASIS in Biology and Medicine. Academic Press (Inc) Ltd
19. Lynne Shore Garcia (2010) Dignostic Medical Parasitology 5th Edn ASM Press , Washington DC
20. John Hyde (1996) Molecular Parasitology Open University Press
21. J Joseph Marr and Miklos Muller (1995) Biochemistry and Molecular Biology of Parasites 2nd Edn Academic Press

Course outcome: The course will acquaint the students to understand host parasite interactions, complement activation, mode of recognition by TLR and its signaling, hypersensitivity with special reference to asthma. The course will enlightened the students regarding different modern diagnostic methods to identify parasitic infections. Vector biology and epidemiology will be another focus to know the propensity of the vector borne diseases and proper formation of vector control.

Paper ZOO-494
Practical

1. Biodiversity and Environmental stress
    i. Qualitative and quantitative estimation of soil and aquatic biodiversity.
    ii. Basic principles for the estimation of heavy metals.
    iii. BOD and COD estimation.

2. Biostatistics
    i. Chi square test for goodness of fit with a Mendelian frequency distribution.
    ii. Computation and significance test of product – moment r between two continuous measurement variables.
    iii. Computation of simple linear regression.
    iv. Computation of variance ratio (F) and multiple comparison of Scheffe's F test for one-way anova and their interpretation.
    v. Significance of observed sex ratios using binomial distribution.

3. Developmentalbiology
    i. Extraction and identification of different stages of chick embryos (24 hours,48 hours and 72 hours)
    ii. Histological sectioning and staining of different stages of chick embryo.

4. Neuro-Immuno Endocrinology

    i. Neuroendocrine structure demonstration in invertebrates
    ii. Endocrine structure in fish
    iii. Auto-micrograph of neurosecretory elements.
    iv. Neurohistological techniques

ZOO-495A Fishery
Practical

1. Identification of Shellfish, macrophytes and aquatic insects.
2. Physicochemical characteristics of water – salinity, organic carbon, nitrogen, potassium, phosphorus, turbidity and pH.
3. Calculation of - Length weight relationship, gastrosomatic index and gonadosomatic index in IMC.
4. Estimation of muscle protein and lipid from IMC.
5. Identification of freshwater fishes
6. Identification of fish food organism/ aquatic weeds/ aquatic insects
7. Morpho-anatomical demonstration of fish
8. Experimental demonstration of anatomy of fin-fish and shell fish. ARO System of fish.
9. Biochemical parameter demonstration: pH, Dissolve Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, turbidity, etc.

ZOO-495B Ecology
Practical

1. Estimation of the degree of faunal similarity and association between species.
2. Computation of microdistribution pattern for spatial distribution.
3. Estimation of alpha, beta and gamma diversity.
4. Analysis of the structure of biotic community: Abundance, Relative abundance, Frequency, Species diversity and Dominance indices; Shannon-Weiner diversity index and Importance Value Index.
5. Estimation of textural composition and Water Holding Capacity of soil.
6. Evaluation of Restoration sites; Study of forest/vegetation health- Estimation of tree height, DBH, stand density, canopy density and tree biomass
7. Vermitechnology and related matter: Analysis of biota from urban waste materials & identification of suitable specimen for vermicomposting.
8. Air pollution monitoring: demonstration of Air sampler
9. Submission of Laboratory notebook.
10. Viva-voce

ZOO-495C Genetics & Mol. Biology
Practical

1. Probability in Mendelian Inheritance
2. Chi-square, degree of freedom, test for Independence (contingency Chi square),
3. Homogeneity Chi-square, Independent Assortment and probability(binomial expansion)
4. Genetic cross
5. Thin layer chromatography.
6. DNA isolation and Gel electrophoresis (from human blood and goat liver tissue)
7. Family pedigree analysis for autosomal /sex linked, dominant /recessive trait.
8. Isolation & purification of protein & characterization through SDS-PAGE
9. PCR

ZOO-495D Parasitology
Practical

1. Localization of DNA by Fuelgen reaction in protozoa
2. Localization of Glycogen by Periodic Acid Schiff's (PAS) reaction in protozoa
3. Stain preparation and identification of blood parasites from fish
4. Preparation of blood film from human for identification of microfilaria
5. Isolation and electrophoretic separation of plasmid DNA
6. Staining of scolex and proglottids of Cestodes
7. Whole mount preparation of mouth parts of mosquito vector
8. Spot identification of parasites
9. Visit to renowned institute (laboratory)
10. Laboratory Note Book
11. Viva-Voce

PROJECT/DISSERTATION
Special Paper

Dissertation/ project

ZOO-496A:Fishery

ZOO-496B:Ecology

ZOO-496C: Genetics and Molecular Biology

ZOO-496D: Parasitology

Course outcome: Project report should include introduction, methodology, techniques, results, discussion and bibliography. Institutional and study tour report emphasizing theoretical aspects should be included. Evaluation of the project report and viva-voce will be open defense type through PowerPoint presentation and evaluated by external examiner.