RAJA NARENDRALAL KHAN WOMEN'S COLLEGE (AUTONOMOUS)

MIDNAPORE -721 102, WEST BENGAL, INDIA

Faculty of Science

Department of Zoology

The Syllabus for the POST-GRADUATE Programme

in

Zoology

Under Choice Based Credit System (CBCS)

w.e.f. 2022-2023

PROGRAMME OUTCOME

The course curriculum of the department has been designed and developed, giving due importance to both classical components of the subject Zoology and its different ramifications in tune with the modern scientific development across the world. The classical aspects of Zoology include essential structural-functional organization of the Non-Chordates and Chordates, Taxonomy, Biosystematics, Histology, Animal physiology, Evolution and Adaptation. In contrast, the modern dimension of the course curriculum has attached the most significant aspects of Molecular biology, Genetics, Biotechnology, Bioinformatics, Biochemistry, Biostatistics, Immunology, and Parasitology. The effort appears to be very fruitful to the results and academic performance of the existing and former students, reflected in their success in different national and state-level competitions. The department offers two special papers (Fishery & Ecology) which also enabled rural-based students of the College to get proper recognition regionally, nationally and internationally in different subject-based services. Moreover, the outreach and extension program involving the students in their practical curriculum has contributed significantly to the livelihood generation of the region's marginalized people. All the courses in the program are carefully designed to equip the students for competitive examinations like CSIR NET, SET, GET etc., and to write research proposals for grants.

COURSE STRUCTURE OF M.Sc. IN ZOOLOGY

SEM-ESTER	PAPER CODE	CONTENT		Marks	Credit
I	ZOO 101	Non- Chordate Biology and Chordate Biology			
		ZOO 101.1	Non- Chordate Biology	25	2
		ZOO 101.2	Chordate Biology	25	2
	ZOO 102	Histochemistry and Animal Physiology			
		ZOO 102.1	Histochemistry	25	2
		ZOO 102.2	Animal Physiology	25	2
	ZOO 103	Immunology and Methods in Biology			
		ZOO 103.1	Immunology	25	2
		ZOO 103.2	Methods in Biology	25	2
	ZOO 104	Cell Biology and Cytogenetics			
		ZOO 104.1	Cell Biology	25	2
		ZOO 104.2	Cytogenetics	25	2
	ZOO 195	Non- Chordate Biology, Chordate Biology, 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 and Ecological Principles			
		ZOO 201.1	Biosystematics	25	2
		ZOO 201.2	Ecological Principles	25	2
	ZOO 202	Biophysics & Biochemistry			
		ZOO 202.1	Biophysics	25	2
		ZOO 202.2	Biochemistry	25	2
	ZOO 203	Molecular Biology and Parasitology			
		ZOO 203.1	Molecular Biology	25	2
		ZOO 203.2	Parasitology	25	2
	C-ZOO 204	***Wildlife and Eco-Management and Aquaculture***			
		C-ZOO 204.1	***Wildlife and Eco-Management***	25	2
		C-ZOO 204.2	***Aquaculture***	25	2
	ZOO 295	Biosystematics, Ecological principles, Biophysics & Biochemistry (Practical)		50	4
	ZOO 296	Molecular Biology, Parasitology & Field Study (Practical)		50	4
	TOTAL			**300**	**24**
III	ZOO 301	Entomology and Ecotoxicology			
		ZOO 301.1	Entomology	25	2
		ZOO 301.2	Ecotoxicology	25	2
	ZOO 302	Molecular Evolution and Microbiology			
		ZOO 302.1	Molecular Evolution	25	2
		ZOO 302.2	Microbiology	25	2
	SPECIAL PAPER (A:Fishery; B:Ecology)				

	ZOO 303A	Fish Taxonomy, Anatomy and Biology and Fish Health Management			
		ZOO 303A.1	Fish Taxonomy, Anatomy and Biology	25	2
		ZOO 303A.2	Fish Health Management	25	2
	ZOO303B	Biodiversity and Conservation Ecology and Aquatic Ecology			
		ZOO 303B.1	Biodiversity and Conservation Ecology	25	2
		ZOO 303B.2	Aquatic Ecology	25	2
	C-ZOO 304	***Genetics and Basic and Applied Immunology (CBCS)***			
		C-ZOO 304.1	***Genetics***	25	2
		C-ZOO 304.2	***Basic and Applied Immunology***	25	2
	ZOO 395	Entomology, Ecotoxicology, Molecular Evolution and Microbiology		50	4
	SPECIAL PAPER BASED PRACTICAL				
	ZOO 396A	Fishery Practical - I			
	ZOO396B	Ecology Practical - I		50	4
	TOTAL			**300**	24
IV	ZOO 401	Environmental Pollution , Management and Biodiversity and Biostatistics		50	4
		ZOO 401.1	Environmental Pollution , Management and Biodiversity		
		ZOO 401.2	Biostatistics		
	ZOO 402	Developmental Biology and Neuroendocrinology		50	4
		ZOO 402.1	Developmental Biology		
		ZOO 402.2	Neuroendocrinology		
	SPECIAL PAPER (A: Fishery; B:Ecology)				
	ZOO 403A	Aquaculture and Fish Technology and Limnology and Oceanography			
		ZOO 403A.1	Aquaculture and Fish Technology	25	2
		ZOO 403A.2	Limnology and Oceanography	25	2
	ZOO 403B	System Ecology & Human Ecology			
		ZOO 403B.1	System Ecology	25	2
		ZOO 403B.2	Human Ecology	25	2
	SPECIAL PAPER BASED PRACTICAL				

	ZOO 495A	Fishery Practical - II	50	4
	ZOO 495B	Ecology Practical - II		
	SPECIAL PAPER BASED PROJECT/DISSERTATION			
	ZOO 496A	Fishery	50	4
	ZOO 496B	Ecology		
	TOTAL		**300**	24
GRAND TOTAL			**1200**	**96**

M.Sc. ZOOLOGY SEMESTER MARKS DISTRIBUTION

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

Marks Distribution of Practical Papers	
ZOO-195	**Marks (Total=50)**
Non- Chordate Biology	10
Chordate Biology	10
Histochemistry	05
Animal Physiology	15
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	12
Parasitology	18
Field Study	10
Internal Assessment- (Viva & LNB)	10

ZOO-395	**Marks (Total=50)**
Entomology	10
Ecotoxicology	8
Molecular Evolution	7
Microbiology	15
Internal Assessment- (Viva & LNB)	10
ZOO-396 (Special paper)	**Marks (Total=50)**
ZOO-396A Fishery	40
ZOO-396B Ecology	40
Internal assessment-(Viva & LNB)	(10) for each special paper

ZOO-494	**Marks (Total=50)**
Environmental Pollution , Management and Biodiversity	05
Biostatistics	15
Developmental Biology	15
Neuroendocrinology	05
Internal Assessment- (Viva & LNB)	10
ZOO-495 (Special paper)	**Marks (Total=50)**
ZOO-495A Fishery	40
ZOO-495B Ecology	40
Internal Assessment- (Viva & LNB)	10

ZOO-496 (PROJECT/DISSERTATION)	**Marks (Total=50)**
Special paper	
ZOO-496A Fishery	50
ZOO-496B Ecology	50

1st YEAR

SEMESTER- I

Course No: ZOO 101: Non-Chordate Biology and Chordate Biology

(50 Marks, 4 credit)

UNIT I: ZOO 101.1: Non-Chordate Biology

Expected course outcome:

The students will be acquainted with non-chordate biology at the end of the course. Students will be able to identify the invertebrates and classify them. Non-chordates (Metazoa), representing the largest group of the animal kingdom, are characterized by several unique features and display various phenomena (Cyclomorphosis, filter feeding, hydrostatic skeleton, metamorphosis etc.), based on which an array of theories, hypotheses, 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 hypotheses explaining non-chordate, especially metazoans origin and evolution; 2) Phylogenetic relationships among metazoans based on superphyletic concepts; 3) some unique biological phenomena with functional roles and 3) Conservation strategies of metazoans for the ecological and economic benefits.

Syllabus:

1. Origin and evolution of Metazoa; phylogenetic overview of major invertebrate phyla.; Phylogenetic relationship among Protozoa, Parazoa, Mesozoa, and Metazoa; evolutionary significance; Concepts and evidence about Super Phyla	4L
2. Foraminifera– characteristics, origin, distribution, biology, and ecological and economic significance of foraminifera.	3L
3. Comparative account of different larval forms of coelomate non-chordates.	3L
4. Biology of free living nematodes – feeding mechanism and roles of nematodes in ecosystem.	3L
5. Lophophorate relationships; Bryozoa (Ectoprocta and Entoprocta) – anatomical peculiarities feeding mechanisms and phylogenetic relationship.	3L

6. Rotifera – general organization, mastax, reproduction, and cyclomorphosis.	3L
7. Foraminifera– characteristics, origin, distribution, biology, and ecological role of foraminifera.	3L
8. Conservation strategies of invertebrates: invertebrate diversity, importance, and threats; alternative approaches to species-focused conservation; conservation status evaluation for invertebrate species.	3L

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. Invertebrate Zoology: Anderson
10. Invertebrate Zoology: Meglitsch and Schram
11. Pat Willmer: Invertebrates Relationships

UNIT II: ZOO 101.2: Chordate Biology

Expected course outcome:

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

Syllabus:

1. **Origin of Chordates:** Hemichordata, Cephalochordata, Urochordata, the origin of craniates, the evolution of primateswith special reference to *Homo sapiens sapiens.*	5L
2. **Protochordates:** Endostyle and iodine binding capacity in Protochordates.	3L
3. **Respiratory system & gas bladder:** Function and requirements of the respiratory system; ventilation of internal gills; Agnatha, cartilaginous fishes, bony fishes, larval gills; arial respiration in lung fishes; swimbladder and the origin of lungs and other ducts.	5L
4. **Excretory System and osmoregulation:** Evolution of kidneys among vertebrates, kidney structure in relation to osmoregulation; basic pattern and the Archinephros,	5L

Pronephros, Mesonephros, Metanephros: External salt excretion, osmoregulation in freshwater and marinefishes, association with the urinary system.	
5. **Echolocation:** Structure and function of organs of hearing balance and echolocation; morphological adaptation for echolocation; bat echolocation.	5L
6. **Integumentary system:** Cellular association and glandular System	2L

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 No: ZOO102: Histochemistry and Animal Physiology

(50 Marks, 4 credit)

UNIT I: ZOO102.1: Histochemistry

Expected course outcome:

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

Syllabus:

1. Introduction to Micro-technique: Microtomy: Parts of a rotary microtome and their functions; Alcohol as an ideal dehydrating agent; Paraffin as an ideal embedding medium; Mayer's albumin; Natural and synthetic mounting media. Routine histopathology: Fixation, dehydration, clearing, infiltration, embedding and block preparation of tissue samples; section cutting and stretching over slides.	5L
2. Fixation: Objectives of fixation; Preservatives vs. fixatives; Additive and non-additive fixatives; Coagulant vs. non-coagulant fixatives; Action of alcohol, formalin, mercuric chloride, and picric acid on cells; Applications of fixation: Composition, merit and demerit, use of Bouin's fluid, aceto-alcohol and Carnoy's fixative; Fixation artifact; Fixation for electron microscopy (with glutaraldehyde and osmium tetroxide).	5L
3. Dyes: Stain vs. dye; Properties of dye molecules; Acid and basic dyes; Chemical	3L

classification of dyes; Dyes of plant and animal origins; Vital dyes; Amphoteric dyes.	
4. Histological staining: Orthochromatic vs. metachromatic staining; Mordants and mordanting (single-bath and double-bath methods); Applications of staining: single, double, and triple staining of tissues using toluidine blue, hematoxylin-eosin, and Mallory's trichrome staining.	4L
5. Enzyme histochemistry: (i) Gomori's reaction for alkaline phosphatase: Working principle; Applications in cell biology, cancer biology, ecotoxicology, and developmental biology. (ii) Benzidine reaction for myeloperoxidase in blood smears Working principle; Applications in the detection of myeloid and lymphoid leukemia, and congenital myeloperoxidase deficiency.	4L
6. Immunohistochemistry: Primary and secondary antibodies; Reporter enzyme and chromogenic substrate; Working principles of direct and indirect immunohistochemistry; Applications of immunohistochemistry in the detection of different types of cancer.	4L

Reference Books/ Journal Article:

1. Baker, J. R. (1958). Principles of Biological Micro-technique. Methuen, London.
2. Buchwalow, I. B. and Böcker, W. (2010). Immunohistochemistry: Basics and Methods. Springer.
3. Stoward, P. J. and Pearse, A. G. (1992). Histochemistry: Theoretical and Applied (Vol. 3: Enzyme Histochemistry) (4th ed.).Churchill Livingstone.
4. Suvarna, K. S., Layton, C. and Bancroft, J. D. (2018). Bancroft's Theory and Practice of Histological Techniques (8th ed.). Elsevier.

UNIT II: ZOO 102.2: Animal Physiology

Expected course outcome:

The course will provide detailed knowledge of the various physiological organ systems and the importance of the integrative functions of the human body. To have enhanced knowledge and appreciation of mammalian physiology; to understand the processes of critical physiological systems, including the cardio-respiratory, renal, reproductive, and metabolic systems; to know 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.

Syllabus:

1. Blood, Circulation and Respiration:	
i. Haemopoiesis & haemostasis	1L
ii. Blood volume, blood pressure and their regulation	1L
iii. Acclimatization to extreme conditions like hypoxia & diving	2L
iv. Body oxygen stores: Haemoglobin, Oxyhaemoglobin and Myoglobin	2L
v. Oxygen dissociation curve; Bohr's effect; Haldane effect.	1L
2. Cardiovascular System:	
i. Neurogenic hearts	1L
ii. Myogenic heart, heart as a pump; regulation of heart pumping; specialized junctional tissue	2L
iii. Cardiac cycle	1L
iv. Neural and chemical regulation of excitation & conduction in the heart	1L
v. ECG – principle, measurement and significance.	1L
3. Stress Physiology:	
i. Homeostasis, Comfort zone, feedback control systems	3L
ii. Oxidative stress; Cellular response; Free radicals and antioxidants	3L
4. Thermoregulation:	
i. Body temperature and determinants of body heat – production and loss	3L
ii. Physiological events for thermoregulation-physical, chemical, neural; counter-current system.	3L

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.

Course No: ZOO 103: Immunology and Methods in Biology

(50 Marks, 4 credit)

UNIT I: ZOO 103.1: Immunology

Expected 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 comprehend the roles of the lymphoid organ, immune system cells, antigens, antibodies, MHC, antigen presentation and immunity to infectious diseases.

Syllabus:

1. Cells and organs involved in the immune system, types of immunity	2L
2. a) Antigenicity and immunogenicity b) Concept of the epitope, paratope, agretope, hapten and adjuvants	1L 2L
3. T-cell and B-cell biology a) Origin and maturation of T and B lymphocyte b) Mechanism of humoral and cell-mediated Immune Response c) T-cell subpopulation	 2L 2L 2L
4. a) Antigen processing and presentation b) Major Histocompatibility Complex (MHC): Mechanism of immune response and generation of immunological diversity	2L 2L
5. The Complement System: The Major Pathways of Complement Activation, the Regulation of Complement Activity, Complement Deficiencies	4L
6. a) Structure and function of Immunoglobulin (Ig) and its Isotypes. b) Enzymatic activity on Ig molecule.	3L 1L
7. Applied Immunology:-ELISA, RIA, Immunoblotting, and Immunohistochemistry.	2L

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.

UNIT II: ZOO 103.2: Methods in Biology

Expected course outcome:

Upon completing this course, students will be able to address a research problem in biotechnology, Provide examples of current applications of biotechnology and advances in different areas like medical, microbial, environmental, and bioremediation. After getting theoretical knowledge, students would be acquainted with some modern instruments and methods indispensable to pursuing advanced research in the biotechnology field.

Syllabus:

1. Molecular Biotechnology	
a) Recombinant DNA technology	2L
b) Restriction & modifying enzymes	2L
c) Production of recombinant DNA molecule	2L
d) Cloning Vector	1L
e) Amplification of DNA by PCR	1L
2. Environmental Biotechnology	
a) Bioremediation	
i. *In situ* bioremediation	1L
ii. *Ex situ* bioremediation	1L
b) Bioremediation of Xenobiotic components and hydrocarbons	2L
c) Phytoremediation	2L
d) Integration of different rural biotechnological tools and Cryopreservation	1L

3. Techniques and Bioinstrumentation a) Principle and applications of different types of chromatography, LC-MS. b) Basic Principles of Electrophoresis; Agarose Gel Electrophoresis; SDS-PAGE; Cell fractionation; Ultracentrifugation; Southern Blotting Hybridization. c) Flow Cytometry, 2D Gel Electrophoresis, and FISH.	4L 4L 2L

Reference Books/ Journal Article:

1. Principle and techniques of biochemistry and Molecular Biology by K.Wilson and J. Walker 7th Ed, Cambridge
2. Physical biochemistry- Principles and Applications by David Sheehan, 2nd Ed.

Course No: ZOO 104: Cell Biology and Cytogenetics

(50 Marks, 4 credit)

UNIT I: ZOO 104.1: Cell Biology

Expected course outcome:

Students will be well informed about the membrane structure and composition, transport and trafficking of protein, the cytoskeleton, cell movement, and extra cellular matrix. The mechanism of cell division and its regulation through different checkpoints will be thoroughly understood. Cell cycle, apoptosis, signal transduction, and cancer biology are vital parts of the course.

Syllabus:

1. Biomembrane Structure The Lipid Bilayer: Composition and Structural Organization; Membrane Proteins: Structure and Basic Functions, Membrane lipids: Phospholipids, Sphingolipids, and Cholesterol and Intracellular Movement	2L
2. Transmembrane Transport of Ions and Small Molecules Overview of Transmembrane Transport, ATP-Powered Pumps and the Intracellular Ionic Environment, Overview of Trans-cellular Transport	2L
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	4L

4. Signal Transduction The 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 pathway	6L
5. Cytoskeleton & Cellular Motility Microtubule Dynamics and regulation, Microtubular motor proteins: Kinesins & Dyneins and Cellular motility	3L
6. Cell cycle regulation: Phases of Eukaryotic cell cycle, cyclin and cyclin-dependent kinase, Regulation of CDK-cyclin complexes, Protein kinases in cell cycle, Regulation by ubiquitin ligase, Exit from mitosis, DNA replication and DNA damage checkpoints, chromosome–microtubule attachment	5L
7. Interactions between Cells and Their Environment: Overview of major cell-cell and cell-matrix adhesive interactions, Cell-Cell and Cell–Extracellular Junctions and their adhesion molecules; the extracellular matrix: The basal lamina and connective tissue; Integrin	3L

Reference Books/ Journal Article:

1. Cell and Molecular Biology by Gerald Karp, 7th Ed. 2013.
2. Lewin's Cells by Gorge Plopper, David Sharp, 3rd Ed. 2015.
3. Molecular Cell Biology by Harvey Lodish, 9th Ed. 2021.
4. Molecular Biology the Cell by Bruce Alberts, 6th Ed. 2015.
5. Molecular Biology by Robert F. Weaver, 5th Ed. 2012.

UNIT II: ZOO 104.2: Cytogenetics

Expected course outcome:

The course will provide an understanding of genetic analysis at the gene, genome and

population levels. Understanding Drosophila genetics. Evaluation of the various aspects of structural, functional and comparative genomics. Designing and development of experiments using Drosophila and their assessment through genetic analysis and interpretations

Syllabus:

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.	5L
2. **Recombination in Bacteria:** F factor, episomes, Hfr, integration of F factor, Interrupted mating Experiment, conjugation mapping, transformation and transduction	5L
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, regulation of gene expression and signal transduction Cancer induction by Retroviruses, tumor suppressor gene and their function.	8L
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 of the Hardy-Weinberg Law.	7L

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 No: ZOO195 (Practical):

Non-Chordate Biology, Chordate Biology, Histochemistry and Animal Physiology

(50 Marks, 4 credit)

Syllabus:

1. Non- Chordate Biology:
    i) Identification of common Invertebrate and Vertebrate taxa
    ii) Minor Dissection:
        a. Grasshopper - Reproductive system/ Nervous system
        b. Cockroach – Stomatogastric Nervous system
        c. Achatina – Reproductive system & Nervous system
2. Chordate Biology:
    i) Major Dissection: Vth, VIIth cranial nerves of bony fish
    ii) Minor Dissection: Fish scale and pecten of bird
3. Histochemistry
    i) Preparation of laboratory fixative mixtures
    ii) Microtechnique for routine histological study
    iii) Histological study of different vertebrate organs
4. Animal Physiology
    i) Demonstration of blood haemoglobin estimation in the animal model
    ii) Estimation of pH and its impact on any aquatic animal.
    iii) Observation of gut movement in an animal under hypoxia using Dale's apparatus
    iv) Estimation of Blood Pressure and Heart Rate
    v) Determination of Breath-Holding Time (BHT) in humans

Course No: ZOO 196 (Practical):

Immunology, Methods in Biology, Cell Biology and Cytogenetics

(50 Marks, 4 credit)

Syllabus:

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
    c. Cell isolation and cell counting
4. Cytogenetics:
    a. The life cycle of *Drosoplila*.
    b. Analysis and interpretation of genetic crosses with special reference to *Drosophila*
    c. Study of the polytene chromosome of *Drosophila*.

1st YEAR

SEMESTER- II

Course No: ZOO 201: Biosystematics and Ecological Principles

(50 Marks, 4 credit)

UNIT I: ZOO 201.1: Biosystematics

Expected course outcome:

This course will describe the importance of taxonomy in biology, the historical resume of systematics and the 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.

Syllabus:

1. **Microtaxonomy:** Phenon, Taxon, Category, type; stages of taxonomy; Aims and tasks of Taxonomists; Importance of taxonomy in Biology.	3L
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 classification.	4L
3. **Concept of Species:** Typological species concept, Nominalistic species concept, Biological species concept, Evolutionary species concept; other species; Polytypic species, Subspecies, Infraspecies and Superspecies.	4L
4. **Neo Systematics:** Morphological approach, Immature stages and Embryological approach, Ecological approach, Behavioural approach, Ecological approach, Cytological approach, Biochemical approach, Numerical systematics, Differential systematics.	4L
5. **Molecular Systematics:** Immunological aspect, chromatographic aspect, Electrophoresis, Infrared spectrophotometry, Histochemical studies, genetic complement, DNA hybridization, Karyological studies.	4L
6. **Macromolecular & Micromolecular Systematics:** based on DNA, RNA, Protein, amino acids, fatty acids and phenols.	2L

7. **Role of Systematics in applied Biology:**Agriculture& Forestry, Biological control, wild life management, National Defense, Environmental problems, soil fertility, Mineral prospecting, Quarantine measure, Commercial application.	3L
8. **Systematics and Public Health Management**	1L

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. Publisher Alpha 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.

UNIT II: ZOO 201.2: Ecological principles

Expected 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). To understand the applicability of this subject, the students must have an acquaintance with the different definitions, terminologies, scientific principles, hypotheses, theories, etc., with proper examples. The contents of this syllabus have been identified 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.

Syllabus:

1. Basics of Ecology Biosphere and Ecosphere; Types of the 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 redundancy of components; resistance and resilience stability, Gaia hypothesis.	5L

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 extinction, habitat destruction and fragmentation, and the introduction of exotic species.	5L
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 concerning size, shape and fragmentation of habitat. Organismic and individualistic concepts of community. Leibig's Law of tolerance.	5L
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.	5L
5. Evolutionary Ecology Definition; different approaches, Bet-Hedging strategies, Hamilton's role and limitations of the inclusive fitness model.	2L
6. Ecology and organism: **i) Aquatic Ecology**: Types and zonation's of aquatic bodies, lotic and lentic biotic communities and limiting factors, **ii) Terrestrial Ecology**: Bio-geography of Indian terrestrial landscape with special reference to soil subsystem and forests with respective biotic community	3L

Reference books:

1. Fundamentals of Ecology- Eugene P. Odum, 2005.
2. Biological Science – Scott Freeman. 2018.
3. Ecology- Robert E. Ricklefs, Gary Leon Miller. 2000.
4. Riverine Ecology. Volume 1 (Chapter 3) (Published by Springer Nature): Chakraborty Susanta Kumar

Course No: ZOO 202: Biophysics and Biochemistry

(50 Marks, 4 credit)

UNIT I: ZOO 202.1: Biophysics

Expected course outcome:

At the end of the course, the student will be able to understand fundamental concepts in biophysics that underlie biological processes through knowledge of membrane biophysics and thermodynamics laws. The system would be dealt with the principle of thermodynamics, electromagnetic and ionizing radiation, and principles of biophysical chemistry.

Syllabus:

1. Biophysical principles: (i) pH and buffer – Meaning, range and calculation of pH; Mechanism of action of buffers; Significance of pH in the biological system; Buffers of extra- and intracellular fluids. (ii) Osmotic pressure: Laws of osmotic pressure; Isosmotic vs. isotonic solutions; Effect of hypotonic treatment on animal and plant cells; Survival of freshwater teleost fishes in hypotonic lotic water; Survival of marine teleost and elasmobranch fishes in hypertonic sea water. (iii) Membrane transport: Diffusion; Osmosis; Active transport and its types; Ion channels vs. membrane pumps; Facilitated diffusion vs. active transport; Reverse osmosis and its application.	8L
2. Thermodynamics: Different types of thermodynamic systems; Laws of thermodynamics; Applicability of thermodynamic principles in living beings.	2L
3. Colloidal system: Crystalloid vs. colloid particles; Classification of colloids; Lyophilic sol and lyophobic sol – properties and preparation; Brownian movement and Tyndall effect; Dialysis and its clinical importance; Electrodialysis and its application in the production of drinking water.	4L
2. **Microscopy in biology and medicine:** (i) Fluorescence microscopy – Auto-fluorescence and hetero-fluorescence; Working principle of fluorescence microscope; Application in the detection of chronic myeloid leukemia, tuberculosis infection and catecholamine hormones; Principle of immunofluorescence. (ii) Transmission electron microscopy – Comparison of working principles of light microscope and TEM; Biological application with reference to the diagnosis of viral infection and other diseases.	5L
3. **Biophysics of membrane:** Fluid mosaic model; Intrinsic and Peripheral membrane proteins; Asymmetric distribution of proteins, lipids and carbohydrates in bio-membranes; Movement of membrane lipids and proteins with reference to cell fusion study and fluorescence recovery after photobleaching (FRAP).	3L
4. **Dynamics of circulation:** Laminar and turbulent blood flow; Reynold number; Basic	3L

concept of blood pressure and blood volume; Factors influencing blood pressure and blood volume.	

Reference books:

1. Das, D. (1982). Biophysics and Biophysical Chemistry. Academic Publishers, Kolkata.
2. De Robertis, E. D. P. and De Robertis, E. M. P. Jr. (2017). Cell and Molecular Biology (8th Ed.). Lea &Febiger, U.S.
3. Hayat, M. A. (2000). Principles and Techniques of Electron Microscopy: Biological Applications (4th Ed.). Cambridge University Press, U.K.
4. Palit, S. R. (1975). Elementary Physical Chemistry (2nd Ed.). Science Book Agency, Kolkata.

UNIT II: ZOO 202.2: Biochemistry

Expected course outcome:

The course will provide an understanding of fundamental biochemical principles such as biomolecules, metabolic pathways, and regulation of the biological process. Upon completion of the course, students can: Understand the agencies responsible for producing various products using biochemistry. Understand the term pH, Buffer. Understand the structure and function of carbohydrates, amino acids, proteins, and lipids. The students will understand the fundamental energetic biochemical processes and metabolic pathways' chemical logic. The course also integrates metabolic processes in cellular systems and organizes cellular pathways.

Syllabus:

1. **Stabilizing interactions** (Vander Waals, electrostatic, hydrogen bonding, hydrophobic interaction)	2L
2. **Protein Conformation**: Primary, secondary, tertiary and quaternary structures; Ramachandran plot; domains; motif and folds.	5L
3. **Protein Purification:** Salting out, Dialysis, Gel-filtration chromatography, Ion-exchange chromatography, Affinity chromatography, High-pressure liquid chromatography, Gel electrophoresis, Isoelectric focusing, Two-dimensional electrophoresis.	3L
4. **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.	3L

5. **Biological Oxidation:** Redox potential, mitochondrial electron carriers, the respiratory chain (electron transport chain); Mitchell's chemiosmotic theory of oxidative phosphorylation; FoF, ATPase, and Q cycle.	4L
6. **Lipid Metabolism**: denovo synthesis of fatty acids, microsomal fatty acid elongase & desaturase systems; oxidation of saturated fatty acids and unsaturated fatty acids.	3L
7. **Protein metabolism**: Deamination, transamination, formation of urea, formation of specialized products from amino acids: catecholamine, serotonin, melatonin, glutathione, T_3, and T_4.	2L
8. **Carbohydrate metabolism**: Anabolic role of TCA cycle, integration of carbohydrate, fat and protein metabolism. Regulation of Glycolysis and TCA cycle, Gluconeogenesis, Pentose phosphate pathway, Glycogenesis, glycogenolysis with special reference to rate-limiting steps.	3L

Reference books / Journal articles:

1. Biochemistry by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 7th Ed. 2012.
2. Biochemistry by D Voet and J G. Voet, 4th Ed. 2011.
3. Biochemistry by Mary K. Campbell, Shawn O. Fa, 6th Ed. 2009.
4. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, 6th Ed. 2011.
5. Biochemistry by David E. Metzler, 2nd Ed. 2003.

Course No: ZOO 203: Molecular Biology and Parasitology

(50 Marks, 4 credit)

UNIT I: ZOO 203.1: Molecular Biology

Expected course outcome:

The course will explain the fundamentals of genetics and the Mendelian laws, the concept of alleles, and the idea of linkage and crossing over of genes. The course will open an avenue to become familiar with various types of genetic data (genotyping, expression, and sequence data), chromosomal mapping, the genetic composition of the biological population, and evolutionary factors that explain the variation. In-depth knowledge of chemical and molecular processes between cells, including the central dogma, will be assured at the end of this course.

Syllabus:

1. **DNA Replication:** The chemistry of DNA synthesis, the mechanism of DNA polymerase, the replication fork, the specialization of DNA polymerase, Sliding DNA clamp loading, Initiation of DNA replication in prokaryotes and eukaryotes, helicase loading and activation, elongation and termination of replication.	6L
2. **The Transcription Process:** Role of RNA polymerase in prokaryotes, initiation of transcription at Promoters, elongation and termination of an RNA in prokaryotes, Different types of RNA ploymerases in eukaryotes Initiation, elongation, and termination of transcription in eukaryotes, Post-transcriptional control of gene expression by Micro RNAs and RNA interference.	7L
3. **Protein Synthesis** Genetic codes, Ribosome, Charging tRNA, initiation of translation; the role of initiation factors, Elongation: binding of Aminoacyl tRNA, peptide bond formation and translocation; Termination of translation.	6L
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.	6L

Reference books / Journal articles:

1. Molecular Biology of the Gene by James D. Watson
2. Genes XII 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

UNIT II: ZOO 203.2: Parasitology

Expected course outcome:

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

Syllabus:

1. a) Types of Parasites and hosts. b) The basic concept of Parasitism, symbiosis, phoresis, commensalisms and mutualism.	2L 2L
2. Molecular, cellular and physiological basis of host-parasite interactions.	2L
3. Life cycle and immunology of *Plasmodium falciparum*.	3L
4. Epidemiology and transmission of parasitic diseases. Malaria, Kalaazar.	4L
5. a) Zoonosis and Zoonotic diseases with special reference to Balantidiasis, Giardiasis Filariasis and Paragonimiasis. b) Life cycle and biology of *Leishmania sp. Schistosom sp.*.	3L 4L
6. Structure and composition of helminth cuticle.	2L
7. Vector biology with special reference to mosquito, sand fly, and ticks.	3L

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 and Sons 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.

CBCS

Course No: *C-ZOO 204: Wildlife and Eco-management and Aquaculture (CBCS)*

(50 Marks, 4 credit)

UNIT I: C-ZOO 204.1: Wildlife and Eco-Management

Expected 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 fundamental elements 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 in the students across the disciplines so that they can become a part of wildlife and biodiversity conservation.

Syllabus:

1. Wildlife diversity and distribution in India – Mammals, Avifauna and Reptiles; IUCN threatened categories.	2L
2. Threatened wildlife in India with special reference to Eastern India.	2L
3. Root causes of depletion of wildlife wealth.	2L
4. Wildlife conservation strategies-Protected areas-National Parks, Sanctuaries, Biosphere Reserve; Core and Buffer; Nodes and Corridors.	2L
5. Management of wildlife-Taxonomic Status, Distribution, Habitat Utilization Patterns, Threats and conservation of Musk Deer; Vultures; Olive Ridley turtle.	4L
6. Tools and Techniques- PRA methods; Molecular Techniques; Tele satellite images; Radio collaring; Peoples Participation; Ground truth Assessment-Pugmarks, Call counts, Capture-Recapture.	3L
7. Wild life trades, Crimes, Laws & Ethics.	2L
8. Environment –different relevant terminology.	2L
9. Environmental Management-Basic steps Sustainability, Ecomonitoring Impact Assessment.	2L
10. Pollution-Types: Mode of action and Environmental Consequences; Global Scenario.	2L
11. Conservation Biology –different concepts and approaches.	2L

Reference books / Journal articles:

1. An Introduction to Disturbance Ecology-A road map for Wildlife Management and Conservation (Springer)
2. Wildlife in India: B Bsaharaia
3. A manual for wildlife Radio Tagging by Robert E Kenward
4. Conservation of Expoited species (Edted by John D. Renolds, Georgina M. 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
11. Riverine Ecology Volume 2 (Chapter 4; Wildlife) (Published by Springer Nature)

UNIT II: C-ZOO 204.2: Aquaculture

Expected 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.

Syllabus:

1. Principles of aquaculture:	
a) Definition, basics, scope and history of aquaculture, current national and global scenario	3L
b) Major candidate species for aquaculture in fresh, brackish and marine waters	2L

2. Freshwater aquaculture: a) Basics of Pond culture (IMC culture: from pond preparation to fish harvesting), pen culture, cage culture, running water culture system, waste water fishery. b) Basics of monoculture, polyculture and integrated culture system. c) Water quality management for aquaculture d) Common live fish food organisms	2L 2L 2L 2L
3. Coastal and marine aquaculture: a) Cultivable brakish water fin fishes and shellfishes: Traits of important cultivable fish and shellfishes, Major and minor carps, tiger shrimp, white shrimp, mud crab, mussel, clam, oysters (edible & pearl), lobsters, sea weeds, seed resources from Indian coast b) Mariculture practices: Methods of shellfish culture in/on rafts, racks, cages, poles and ropes, introduction to seaweed culture, pearl culture	5L 4L
4. Impact of climate change on fishes	3L
5. Best practices for sustainable aquaculture	2L

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 No: ZOO 295 (Practical):

Biosystematics, Ecological principles, Biophysics, and Biochemistry

(50 Marks, 4 credit)

Syllabus:

1. **Biosystematics**
    a) Preparation of taxonomic key
2. **Ecological principles**
    a) Estimation of primary productivity in aquatic ecosystems
    b) Estimation of transparency of water
    c) Measurement of the 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 the plant community.
3. **Biophysics**
    a) Demonstration of osmosis (Potato osmoscope)
    b) Microscopic study of hypotonic and hypertonic treatment of mammalian erythrocytes
    c) Estimation of pH of solutions by pH meter.
    d) Demonstration of phase-contrast and fluorescence microscopy (Live and virtual)
4. **Biochemistry**
    a) Quantitative estimation of protein- Lowry method / Bradford method.
    b) Protein denaturation and renaturation assay
    c) Estimation of Glucose, cholesterol, total protein and urea
    d) Estimation of DNA by Diphenylamine reagent.
    e) Detection of amino acids by Ninhydrin reaction.
    f) Determination of Km &Vmax of enzymes Amylase / Alkaline phosphatase.

Course No: ZOO 296 (Practical):

Molecular Biology, Parasitology and Field Study

(50 Marks, 4 credit)

Syllabus:

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 study

2nd YEAR

SEMESTER- III

Course No: ZOO 301: Entomology and Ecotoxicology

(50 Marks, 4 credit)

UNIT I: ZOO 301.1: Entomology

Expected course outcome:

The subject of entomology deal with the study of different aspects of insects, the largest animal taxa of the world has been included in the general syllabus of Zoology for the third semester mainly to give the students an understanding on three different aspects of entomology— morphology and classifications, some relevant aspects of 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 also can undertake measures for the conservation of beneficial insects and control of the harmful ones.

Syllabus:

1. **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.	4L
2. **General characters and classification of Insects (up to order) -** Insect's head, capsule, antennae, legs, wings, the digestive system with special emphasis to the midgut, filter chamber and peritrophic membrane; integument, Insects' neuro-endocrine system and Hormonal regulation – components, the chemical structure of hormones and functions; molting and metamorphosis, insects' egg-type, hatching, growth, development, diapause and aestivation.	5L
3. **Biology, nature of damage and control of insect pests -** Jute, cashew, betel vine and stored grains; Integrated approach to pest management (Dynamics of Economic Injury Level (EIL); Economic Threshold Level); Biological control of pests: Challenges and success.	4L
4. **Aquatic insects** – Diversity of freshwater and marine insects, Adaptation – water balance; Importance for environmental monitoring.	3L

5. **Insect behavior -** 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.	4L
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.	3L
7. Insect's Perception of the environment: Pheromones, allelochemicals, semiochemicals, etc.; Intra-specific and inter-specific chemical and mechanical communications in insects.	2L

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, Ananatha Krishnan & 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: Tristram D.Wyatt (Oxford University Press)

UNIT II: ZOO 301.2: Ecotoxicology

Expected course outcome:

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

Syllabus:

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.	5L
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 possible antidotes; Elementary idea on Chelation therapy.	6L
3. Aquatic Toxicology Aquatic environment, Factors affecting the Environmental Contraction of Chemicals, Toxicological concepts and Principles, Factors that influence Toxicity, Toxic agents and their effects, concentration – Response Relationships, toxicity testing, Biomonitoring Toxicity data and Environmental regulation.	6L
4. Immunotoxicology Immunology – Defensive responses, Immunological methodology; Immunotoxicology – Effects of classes of Toxicants.	3L
5. **Environmental Genotoxicology** Basic mechanism of DNA damage, Analytical techniques, In situ Environmental Genotoxicity studies with Aquatic species, and potential value of Environmental genotoxicity.	5L

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, Fourth Edition, 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 No: ZOO 302: Molecular Evolution and Microbiology

(50 Marks, 4 credit)

UNIT I: ZOO 302.1: Molecular Evolution

Expected 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 the same or diverse group. By nearest neighbor analysis and by the principle of parsimony, a gene tree could be made. PG students are benefitted from the study of genome analysis and by finding the sequences, they may be able to find out the molecular systematic position.

Syllabus:

1. Neo-Darwinism	
a. Hardy-Weinberg law of genetic equilibrium	2L
b. A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration	3L
2. Molecular phylogenies	
a. Construction of phylogenetic trees	4L
b. Phylogenetic Inference-Distance methods, parsimony methods, maximum likelihood method	4L
c. Immunological techniques	4L
d. Amino acid sequences and phylogeny	4L
e. Nucleic acid phylogeny, DNA-DNA hybridizations, restriction enzyme sites, nucleotide sequence comparisons and homology	4L

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

UNIT II: ZOO 302.2: Microbiology

Expected course outcome

To gain knowledge on the 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, and Genetic Engineering. With this exposure, students can be employed in testing/pathology laboratories alternatively.

Syllabus:

1. Resolving powers of different microscopes.	1L
2. Microbial classification: various systems and their basis, Bergey's manual.	2L
3. Categorization of Bacteria: based on Gram-staining, spores, temperature, pH, oxygen; detailed morphology of Bacteria.	3L
4. General attributes of Algae, Protista, Fungi & Virus: classification, structural uniqueness, reproduction, medical importance.	2L
5. Microbial Physiology: i. Growth in Bacteria: normal growth curve; methods of measuring growth- direct and indirect count (cell number and cell mass). ii. Calculation of Growth rate & Generation time; strategies of cell division.	5L
6. Microbial identification: colony characteristics and biochemical identification (benchtop tests).	2L
7. Microbial Nutrition: i. Culture media – types, purpose and examples. ii. Culture techniques; pure cultures.	3L
8. Microbial ecology: Biofilm; Role of soil microbial community	2L
9. Bacterial Communication: Chemotaxis and quorum sensing- significance and mechanism.	2L
10. Microbial fermentation: manufacture of industrially important products.	3L

Reference books:

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

SPECIAL PAPER: FISHERY

Course No: ZOO 303A: Ichthyotaxonomy & Biology and Limnology & Oceanography

(50 Marks, 4 credit)

UNIT I: ZOO 303A.1: Ichthyotaxonomy & Biology

Expected 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. Overfishing, ineffective management practices, industrial development and agricultural pollution have reduced fish stocks.

Syllabus:

1. Classification of fishes (up to order) and shell fishes. History and Introduction to ray fin fisheries	3L
2. Fish nutrition and growth: Fish feed type 1. Floating 2. Sinking 3. Dust; Formulation ingredient: Conventional and Non-conventional; Factors concern with fish growth, Live Fish food organism.	3L
3. Fish reproduction and development: Type of reproduction, egg type, embryonic development and life cycle stages; gonado-somatic index, ponderal index, fecundity.	4L
4. Endocrine regulation of fish reproduction, Endocrine glands , pituitary, thyroid, thymus, types of hormones and their functions.	3L
5. Temperature sensitivity and Thermoregulation in fishes.	3L
6.Fish migration and behaviour ;types cause and significances	3L
7. Digestion and absorption in fishes, quantitative and qualitative analysis of stomach content	3L
8. Age and growth determination in fish by direct and indirect methods.	3L

Reference books / Journal articles:

1. Fundamentals of Fish Taxonomy: K. C. Jayaram
2. Textbook of Fish Biology & Fisheries 3rd Edition: S Skhanna H R Singh
3. The Physiology of Fishes: 5th Edition: Suzanne Currie, David H. Evans.
4. Fish Diseases and Medicine: 1st Edition: Stephen A. Smith
5. Fish Anatomy – by Shagufta
6. Anatomy of fishes: Wilhelm Harder

UNIT I: ZOO 303A.2: Limnology and Oceanography

Expected course outcome:

Habitat diversity, complexity and stability provide the diversity in fishery resources. Proper scientific management of the habitats and resources offers sustainable development in aquaculture.

Syllabus

1. Lentic & Lotic system – structure & function.	2L
2. Lakes – Types, structure, function & fishery resources	3L
3. Reservoir fishery in India.	3L
4. Wastewater fishery, wastewater nature, wastewater as a resource.	3L
5. Oceanic and deep-sea fishery, important faunal resources.	3L
6. Estuary – structure, function & fishery resources.	3L
7. Marine fisheries	2L
8. Aquatic pollution –Riverine pollution & marine pollution: causes and impact	3L
9. Application of remote sensing & GIS in the fishery.	3L

Reference books:

1. Limnology: Lake and River Ecosystems by Robert G. Wetzel.
2. Oceanography : An Invitation to Marine Science Garrison, T., Ellis, R. 9th Edition.

SPECIAL PAPER: ECOLOGY

Course No: ZOO303B: Biodiversity and Conservation Ecology and Aquatic Ecology

(50 Marks, 4 credit)

Expected course outcome:

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

UNIT I: ZOO 303B.1: Biodiversity and Conservation Ecology

Syllabus:

1. Benefits of biodiversity; CBD, Megadiversity countries.	2L
2. Biodiversity: status, monitoring (surveys) and documentation; levels of biodiversity measurement; mapping of Biodiversity hotspots.	3L
3. Threats to Biodiversity; Causes and Consequences of Biodiversity Declines; Biodiversity and Ecosystem Stability.	2L
4. Major approaches to Biodiversity management and Wildlife Conservation.	2L
5. Necessity and Objectives of Conservation; IUCN Red List Category Version 3.1; Categories of endangered animals; Red Data Book; Red datasheet for India. IUCN categories of Protected Areas- National Parks, Sanctuaries, Biosphere Reserves. World Heritage Sites.	3L
6. Globally Threatened Species- Invertebrates and vertebrates; Trends in the Status of Threatened Species; Causes of threat; Ethics of Wildlife Management and Conservation.	2L
7. Critically Endangered Vertebrates of India with special reference to West Bengal; Endemic Avifauna of India– IBAs of West Bengal.	2L

8. Indian case studies on conservation/management strategy; Social forestry: Joint Forest management- Arabari concept.	2L
9. Wildlife crime; CITES.	2L
10. Types of conservation: (i) Ex-situ conservation: captive breeding; species reintroduction, species translocation; population reinforcement; (ii) In-situ conservation.	2L
11. Technologies for Wildlife Research and Management. Tools and techniques for wildlife census and survey. Remote sensing: the basic idea of GIS and GPS and their application in habitat & wildlife conservation.	3L

Reference books:

1. Biological Science 5th Ed; Pearson publication- Freeman, Quillin& Allison
2. Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach- David B. Lindenmayer, Jerry F. Franklin. 2013.
3. Valuation and Conservation of Biodiversity: Interdisciplinary Perspectives… Michael Markussen, Ralph Buse, HeikoGarrelts, MaríaManez Costa, Susanne Menzel, Rainer Marggraf. 2005.
4. Practical Approaches to the Conservation of Biological Diversity- Richard KenithBaydack, Henry Campa, Jonathan B. Haufler. 1999.
5. https://www.nature.com/scitable/knowledge/library/causes-and-consequences-of-biodiversity-declines-16132475/
6. 2004 IUCN Red List of Threatened Species™. A Global Species Assessment. Edited by-Jonathan E.M. Baillie, Craig Hilton-Taylor and Simon N. Stuart. 2004
7. https://www.cms.int/sites/default/files/fact_sheet_wildlife_crime.pdf
8. https://www.traffic.org/what-we-do/projects-and-approaches/wildlife-conservation-technology/wildlife-sniffer-dogs/

UNIT II: ZOO 303B.2: Aquatic Ecology

Syllabus:

1. Water as a resource - types and distribution; past changes and present status; Hydrological cycles – different phases, factors contributing to the 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 the river, floodplains, lakes, freshwater wetlands, salt marsh and coastal dunes – in respect of climate change.

b) **Marine Ecosystem:** Origin, Extent and zonation of the sea, physical properties and physical processes, chemical composition, behavior 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, specially 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. Waste water management – types, source, physical-chemical properties, recycling and bioremediations.

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

5. Aquatic biodiversity: Potential threats and conservation in Indian perspectives

Reference books:

1. Limnology: Lake and River Ecosystems - Robert G. Wetzel. 2001. Third Edition.
2. Freshwater Ecology: Concepts and Environmental Applications of Limnology - Walter K. Dodds, Matt R Whiles. 2010.
3. Riverine Ecology (Volume 1 and 2) (Published by Springer Nature) Chakraborty Susanta Kumar
4. The Biology of Polluted Waters; H.B.N.Hynes and F.T.K.Pentelow ; Liverpool University Press; Page 1-202.

CBCS

Course No: *C-ZOO 304: Genetics and Basic and Applied Immunology (CBCS)*

(50 Marks, 4 credit)

UNIT I: C-ZOO 304.1: Genetics

Expected course outcome

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

Syllabus:

1. Sex-chromosome inheritance	
i) Chromosomal Determination of Sex, X-linked inheritance	2L
ii) Pedigree characteristics of Human, X-linked inheritance	2L
iii) Nondisjunction as proof of the chromosome theory of heredity	1L
iv) Chromosome theory of Heredity	1L
v) Sex Determination in *Drosophila*	1L
2. Probability in the prediction of progeny distributions	
i) Using the binomial distribution in genetics	2L
ii) Testing goodness of fit to a genetic hypothesis, The Chi-Square Method	1L
3. Genetic Linkage and Chromosome Mapping	
i) Linkage and recombination of genes in a chromosome	1L
ii) The Chi-square test for linkage	1L
iii) Each pair of linked genes has a characteristics frequency of recombination	1L
iv) Genetic Mapping, Map distance and frequency of recombination	2L
v) Crossing –over	1L
vi) Recombination between genes results from a physical exchange between chromosomes	1L
4. Genetic Mapping in Three-Point Testcross	
i) Chromosome Interference in double crossovers	2L
ii) Genetic Mapping Functions, Genetic Map Distance and physical distance	2L
5. The central dogma of Life	
i) Overview of Organisation of DNA in chromosome	2L
ii) The basic concept of Replication, transcription and translation	2L

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

UNIT II: C-ZOO 304.2: Basic and Applied Immunology

Expected 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 comprehend the roles of the lymphoid organ, immune system cells, antigens, antibodies, MHC, antigen presentation and immunity to infectious diseases.

Syllabus:

1. Overview of the immune system: Innate and Acquired immune response	3L
2. Cells and tissues of immune system: Hemopoietic tissues: Structure & function [Annelida/ Arthropoda/ Mollusca; Chordata (Class-Fish/mammals)], Blood cells: Structure & function	5L
3. Organs and Immune System Microenvironments: Primary Lymphoid Organs, Secondary Lymphoid Organs	5L
4. Outline for the Humoral and Cell-Mediated (Cellular) Branches of the Immune System	4L
5. Structure and types of Antibody, T- cell receptor, and Major Histocompatibility complex (MHC)	3L
6. Applied Immunology:- ELISA, RIA, Immunohistochemistry, Vaccination	5L

Reference books:

1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2018). *Cellular and Molecular Immunology*. 9th ed. Saunders.
2. Kindt, T., Goldsby, R. Osborne, B. (2013). *Kuby*'s *Immunology*. 7th ed. W.H. Freeman and Co.
3. Kenneth M, Casey W, (2016) Janeway's Immunobiology 9th ed. Garland Science.
4. Wood P. (2006) Understanding immunology. 2nd ed. Pearson.

Course No: ZOO 395: Practical

Entomology, Ecotoxicology, Molecular Evolution and Microbiology

(50 Marks, 4 credit)

Syllabus:

1) **Entomology**
    a) Collection and preservation of insects
    b) Study of the behavioral modification of legs in the honey bee.
    c) Entomological comments on common Pests, Aquatic insects, and Insects of medical and economic 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**
    a. Construction of phylogenetic trees
    b. Hardy-Weinberg law of genetic equilibrium
    c. Estimation of gene frequency
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

Course No: ZOO 396A: Fishery Practical-I

(50 Marks, 4 credit)

Syllabus:

1. Identification of fin fish, ray fish, and shellfish.
2. Qualitative and Quantitative estimation of zooplankton.
3. Identification of fish parasites.
4. ARO in fishes.
5. Identification of shellfishes.
6. Identification of different development stages of prawns and crabs.
7. Visit shrimp, prawn, and biofloc hatcheries.
8. Field study.

Course No: ZOO 396B: Ecology Practical-I

(50 Marks, 4 credit)

Syllabus:

1. Preparation of Climograph
2. Estimation of transparency, TSS, TDS, conductivity, hardness, salinity and alkalinity of water.
3. Estimation of N, P, and K content of water/ soil.
4. Basic principle pertaining to acid digestion for the estimation of heavy metals in the water sample.
5. Ecological comments on major biotic components in the Aquatic system
6. Recording/documentation and submission of terrestrial/aquatic faunal components in and local areas – (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 the landscape.
8. Submission of Laboratory notebook.
9. Field study

2nd YEAR

SEMESTER- IV

Course No: ZOO 401: Environmental Pollution, Management and Biodiversity and Biostatistics

(50 Marks, 4 credit)

UNIT I: ZOO 401.1: Environmental Pollution, Management and Biodiversity

Expected course outcome:

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

Syllabus:

1. Global environmental problems; Bioinvasion-Principles, threats and management	2L
2. **Environmental pollution**: Types, natural versus man-made; Global scenario.	2L
3. **Air pollution**: Composition of air, zonations of the atmosphere; classification, properties/behavior and the fate of air pollutants; properties and role of oxides of nitrogen and sulfur as an air pollutant, greenhouse effect and global warming; photochemical smog, acid rains, the impact of pollutants on human health and plants.	4L
4. **Water pollution**: Classification and behavior of water pollutants, point and non-point pollution, water pollution by agricultural wastes (fertilizers and pesticides); sewage, oil, thermal power plants; and eutrophication.	5L
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.	5L
6. **Environmental management:** Ecodegradation and pollution; sustainable environmental management; indicators of quality of life. Objectives of conservation;	4L

world conservation strategies. Biomonitoring. Green movements; traditional environmental knowledge and people's participation.	
7. **Forests and wildlife in India:** Ecological perspectives, the definition of wildlife	3L

Reference books:

1. Waste Management; David C. Wilson; Clearendon Press oxford 1981; Page 1-509.
2. Coastal Zone Management; Timothy Beatley, David J. Brower, Anna K. Schwab; Island Press, Washington; Page 1-317.
3. Integrated Solid Waste Management: Engineering Principles and Management Issuues; George Tchobanoglous, Hilary Theisen, and S. A. Vigil; McGrowhill; Page 1-957.
4. Ecosystem Management: Application for Sustainable Forest and Wildlife Resources; Mark S. Boyee and Alan Haney; 1-361.
5. Urban Ecology: An International Perspective on the Interaction Between Humans and Nature; John M. Marzluff, Eric Shulenberger. Wilfried Endlicher, Marina Alberti, Gordon Bradley, Clare Ryan, Craig ZumBrunnen, Ute Simon; Springer; Page 1-807.
6. Principles of Water Quality Control; T. H. Y. Tebbutt; Butterworth Heinemann; Page 1-278.
7. An Introduction to Pollution Science: Roy M. Harrison; RSC Publishing; Page 1-330.
8. Soil Erosion and Conservation; R.P.C. Morgan; Longman; Page 1-198.
9. Aquatic Pollution: An introductory Test; Edward A. laws; An Interscience Publication, John Wiley & Sons, INC; Page 1-611.
10.Pollution Control and Waste Management in Developing Countries; Rogers W'O Okot-Uma, Georges E Ekosse, Yvonne Gotlop Bogatsu, Kwesi Darkoh, Otlogetswe Totolo; The Commonwealth Secretariat; Page 1 – 460.

UNIT II: ZOO 401.2: Biostatistics

Expected course outcome

To learn about critical biostatistical concepts and efficient tools for summarizing and plotting data and making decisions in the presence of uncertainty. The student will be acquainted with parametric and nonparametric statistics, samples and data. They will be able to understand t-test, Chi-square, correlation, regression, and Anova.

Syllabus:

1. Concepts of Biostatistics: Data, population, sample and sampling, frequency distribution, graphical representation of data, parametric and nonparametric statistics	2L
2. Measures of Central Tendency: Mean, median and Mode	3L
3. Measures of Dispersion: Range, quartile deviation, mean deviation and standard deviation, standard error, variance and covariance	3L
4. **Probability distribution**: Normal distributions, Properties and uses of binomial distributions and Poisson's distributions	2L
5. **Set theory and probability**	2L
6. **Testing of Hypothesis**: Null Hypothesis. Level of significance. The error of interference and degrees of freedom.	1L
7. **Analysis of frequencies**: Chi-square test for goodness of fit.	1L
8. **Student 't' distribution**	1L
9. **Z test and Fisher's F test**	2L
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 analysis. Multiple regression.	4L
11. **Analysis of Variances**: Types and models of analysis of variances. The assumption for ANOVA. One-way ANOVA- computation and interpretation of F ratio, multiple comparison t-test, Scheffe's multiple comparison f-test.	2L
12. **Nonparametric Tests**	2L

Reference books:

1. Fundamentals of biostatistics. 7th 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 No: ZOO 402: Developmental Biology and Neuroendocrinology

(50 Marks, 4 credit)

UNIT I: ZOO 402.1: Developmental Biology

Expected course outcome:

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

Syllabus:

1. Early development and molecular mechanism of Amphibian axis formation: Inductive interactions, organization of a secondary axis, the dorsal and ventral signal of the organizer, functions of the organizer, epidermal induction.	8L
2. Regeneration: Regeneration of animals with special emphasis on the process of regeneration in Hydra and Amphibia.	8L
3. Beginning a new organism: Fertilization in sea urchins and Mammals, the chemoattraction of sperm and egg, species-specific binding of acrosomal process, the fast and slow block of polyspermy, the role of calcium and egg activation in sea urchins. Translocation and Capacitation in mammals, recognition at zonapellucida, mouse acrosome reaction and gamete fusion	9L

Reference books:

1. Developmental biology, 11th edition 2016 by S. F. Gilbert
2. Principles of Development. 4th edition. Lewis Wolpert

UNIT II: ZOO 402.2: Neuroendocrinology

Expected course outcome

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

Syllabus:

1. Electrical properties of the nerve cell membrane, voltage-gated and ligand-gated ion channels	2L
2. Action potential, local circuit, synapses & synaptic transmission, gap junctions.	3L
3. Ionotropic and metabotropic receptors	2L
4. Neuropeptides, neuromodulation, neuron vs. NSC	2L
5. Hypothalamic releasing and inhibiting hormones	2L
6. Neuroendocrine glands in invertebrates (Insect & crustaceans)	2L
7. Neuroendocrine integration	2L
8. Common neural disorders: Alzheimer's and Parkinson's disease	2L
9. Mechanism of protein and steroid hormone action	2L
10. Hormone and disease: Type-I and Type-II diabetes, Ordinary and Exophthalmic goiter, Addison's disease	4L

Reference books:

1. An Introduction to Neuroendocrinology. Cambridge University Press. Brown RE (1994).
2. Methods in Neuroendocrinology Van De Kar, LD., C R C Press.
3. Clinical Neuroscience - Kelly Lambert, Craig H. Kinsley. 2004.
4. Hall, J. W. (1992). An Introduction to Molecular Neurobiology. Oxford University Press Inc.
5. Melmed, S., Polonsky, K. S., Larsen, P. R, and Kronenberg, H. M. (2015). Williams Textbookof Endocrinology (13th Ed.). Elsevier.
6. Robinson, D. (Editor) (1998). Neurobiology. Springer-Verlag Berlin and Heidelberg GmbH &Co. KG.
7. Sharma, D., Singh, S. and Singh, R. (2021). Textbook of Neurobiology. Dreamtech Press.

SPECIAL PAPER: FISHERY

Course No: ZOO 403A:

Aquaculture and Fish Technology and Inland and Marine fisheries

(50 Marks, 4 credit)

Expected course outcome:

Advanced knowledge regarding aquaculture as well as fishery will accelerate productivity of aquatic resources and that will solve the protein malnutrition of the people of our country. Application of modern technology and scientific approaches in fishery ensure sustainable development in this section. By the application of modern approaches, in fish culture harvesting, processing and marketing will create aquaculture based industrial development and entrepreneurship. Disease associated with fish and different parasites which decrease productivity and proper control / management of these disease and parasites also play an important role in fishery. Application of antibiotics and probiotics is also another modern aspect of fish health management. In near future, all ex-situ commercial culture practice will depend on such antibiotics and probiotics. These modern aspects of fishery will create a global demand for antibiotics and probiotics in fishery sector.

UNIT I: ZOO 403A.1: Aquaculture &Fish Technology

Syllabus:

1. Aquaculture - definition types and scope.	1L
2. System of aquaculture - pond culture, pen culture, cage culture, biofloc culturesystem.	2L
3. Extensive, semi-intensive, intensive and super intensive aquaculture.	2L
4. Monoculture, Polyculture and Integrated culture system.	2L
5. Shell Fish Fishery – Prawn fishery, Crab fishery, Molluscan Fishery.	2L
6. Weed fish, predatory fish and aquatic insect	2L
7. Water and soil quality related to Fishery, physical, chemical and biological factors affecting the productivity of ponds.	2L
8. Application of Biotechnology in Fishery and Transgenic fish, Fish Immunology – Application of Probiotics and Immuno stimulants	4L
9. Fisheries Planning, Economics and Extension.	2L
10. Fish Harvesting & Processing.	2L
11. Fish by-products	1L
12. Fish disease and its management: 1. Infectious diseases - Protozoan, Trichomoniasis, Myxosporidian, Helminth, Acanthocephalan, Black spot disease, Arthropodans and Epizootic ulcerative syndrome. 2. Non Infectious disease – Gas bubble disease, Gill disease, Algal toxicosis. 3. Antibiotics in aquaculture.	6L

Reference books:

1. Textbook Of Fish Genetics And Biotechnology by Salve Balasaheb Shankarrao .
2. Fish Biotechnology by Ranga MM.
3. Textbook of Aquaculture by A. Patel (Author), S. N. Pathak.
4. Aquaculture: Farming Aquatic Animals and Plants: Lucas John S.
5. A Text Book of Aquaculture: M Srinivasulu Reddy, K.R.S Sambrasiva Rao.

UNIT II: ZOO 403A.2: Inland and Marine Fisheries

Expected course outcome:
Knowledge about the freshwater fishery resources, estuarine resources and marine resources and their wise and valuable utilization for mankind. Further the trainee will be acquainted with the modern aspects in marine fisheries like RS-GIS and waste-water treatment and management.

Syllabus:

1. Freshwater resources / marine water resources and their biology.	2L
2. Trends in aquaculture.	4L
3. Estuarine fishery in Bengal.	6L
4. Reservoir fishery in India and its Merits and Demerits, cage and pen culture.	6L
5. Waste water management: treatment process, merits and demerits in fishery.	2L
6. RS – GIS in aquaculture: Working principle and its application in fishery.	3L
7. Fishery traits: site selection, fish selection, culture and trading.	2L

Reference books / Journal articles:

1. Jhirngan, 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 No: ZOO 403B: System Ecology and Human Ecology

(50 Marks, 4 credit)

UNIT I: ZOO 403B.1: System Ecology

Expected course outcome:

Both theory and practical learning processes are to acquaint students with both the essential traditional/conventional components of 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 the south West Bengal. The entire syllabus has four dimensions- Systems Ecology, Human Ecology, and Aquatic Ecology & Wildlife Ecology. The major emphasis was laid on developing the syllabus to cover not only traditional aspects of Ecological but also modern developments in the sphere of ecological sciences: system, mathematical, molecular, urban, restoration and aquatic ecology.

Syllabus:

1. Community Ecology: a) Nature of communities; Characterizing Communities; community structure and attributes; b) Levels of species diversity and its measurement; c) Species diversity hypotheses; edges and ecotones. d) Metacommunity concept: Metapopulation structure; Fragmentation; Metacommunity dynamics.	 1L 1L 1L 2L
2. Ecological Restoration: a) Philosophy and types of eco-restoration (ER); Restoration Ecology vs. Conservation Ecology; ER and sustainability; Process of ER; Trajectory; case studies.	4L
3. Ecotourism: a) Foundation of ecotourism, Sustainable development and ecotourism, management issues, merits and demerits.	4L
4. Ecosystem services (ES) and human wellbeing: a) Significance; Categories of ES; Ecological Economics.	2L

5. Mathematical Ecology: a) Basic concept of ecological modeling; Deterministic and Stochastic models; b) Patterns of Spatial distribution - Random, clumped and uniform coefficient of dispersion. c) Index of similarity and index of association.	 2L 2L 1L
6. System structure and function of some Indian ecosystems: a) Terrestrial system (forest): Ecological processes in Tropical forest ecosystem - Vertical stratification of plants and animals. Production and nutrient cycling. Leaf litter decomposition. Assessment of vegetation health. b) Aquatic system (freshwater). Physiography of freshwater ecosystems, stratification, distributions and mixing patterns. Ecology of Wetland Ecosystems: Water, Substrate, and Life.	 3L 2L

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.
- https://www.nature.com/scitable/knowledge/library/characterizing-communities-13241173/

UNIT II: ZOO 403B.2: Human Ecology

Syllabus:

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.	4L
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.	4L
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	4L

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, biodiversity, agriculture; Indoor Pollution – characteristic of the indoor environment, common indoor pollutants, their sources and mode of action; Effect of urbanization on biodiversity.	4L
5. Wasteland and watershed management: Concept – integrated process and mechanism of wasteland restoration and watershed management; Soil erosion – types and factors.	4L
6. Sustainable environmental management: Roles of traditional knowledge and people's participation.	2L
7. Bioinvasion: Related terminologies; Underlying operating principles; Ecological Consequences—Case Studies.	3L

Reference books:

1. Conservation and Biodiversity; Andrew P. Dobson; Scientific American Library, New York; Page 1-264.

2. Environmental Biotechnology: A Biosystems Approach; Daniel A. Vallero; Elsevier; Page 1-742.

3. Global Marine Diversity: A Srategy for Building Conservation into Decision Making; Island Press, Washington D.C.; Page 1-383.

4. Climate Change and Biodiversity; Thomas E. Lovejoy and Lee Hannah; Yale University Press, New Haven and London; Page 1-416.

5. Conservation Biology; Andrew S. Pullin; Cambridge University Press; Page 1-342.

6.Biodiversity and Global Change; O.T. Solbrig, H.M. Van Emden and P.G.W.J. Van Oordt; Cab International, International Union of Biological Sciences; Page 1-223.

7.The International Business Environment: Global and local marketplaces in changing World; Janet Morrison; Palgrave Macmillan; Pages 1-516.

8. Biofertilizers for Sustainable Agriculture; Arun K. Sharma; Agrobios(India); Page 1-407.

9.Introduction to Population Biology; Dick Neal; Cambridge University Press; Page 1-393.

10. Handbook of Ecological Restoration volume1 and 2; Martin R. Perrow and Anthony J. Davy.
11. Perspectives and Issues in Environmental Studies; Ananda Deb Mukhopadhyay; Vidyasagar University.
12. Urban Environmental Management: Environmental change and Urban Design; Rodney R. White; John Wiley and Sons, New Work.
13. Global Action for Biodiversity: An International Framework for Implementing the Conservation on Biological Diversity; Timothy Swanson; Earthscan Publications Ltd. London.

Course No: ZOO 494 (Practical):

Environmental Management, Biostatistics, Developmental Biology & Neuro-endocrinology

(50 Marks, 4 credit)

Syllabus:

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. Estimation of B.O.D and C.O.D
2. Biostatistics
    i. Computation of column statistics
    ii. Testing of hypothesis: t-test, Z-test, and F test
    iii. Computation and significance test of product-moment (r) between two continuous measurement variables.
    iv. Computation of simple linear regression.
    v. One-way Anova and their interpretation.
3. Developmental biology
    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 the chick embryo.
4. Neuro-Endocrinology

i. Neuroendocrine structure in invertebrates

ii. Endocrine structure in vertebrates

iii. Photomicrograph of neurosecretory elements.

iv. Neurohistological techniques

- Electrical properties of membranes
- Single neuron recording, patch-clamp recording, EEG, brain activity recording, lesion and stimulation of the brain, pharmacological testing, PET, MRI, CAT
- Demonstration of modern neurodiagnostic tools & techniques (EEG, CT-Scan, MRI)

SPECIAL PAPER PRACTICAL

Course No: ZOO 495A: Fishery Practical-II

(50 Marks, 4 credit)

Syllabus:

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 finfish and shellfish. ARO System of fish.
9. Biochemical parameter demonstration: pH, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, turbidity, etc.

Course No: ZOO 495B: Ecology Practical-II

(50 Marks, 4 credit)

Syllabus:

1. Estimation of the degree of faunal similarity and association between species.
2. Computation of micro-distribution 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 matters: Analysis of biota from urban waste materials and identification of suitable specimen for vermicomposting.
8. Air pollution monitoring: demonstration of the operating principles High Volume Sampler
9. Submission of Laboratory notebook.
10. Viva-voce

PROJECT/DISSERTATION

Expected course outcome:

The project report should include an introduction, methodology, techniques, results, discussion and bibliography. Institutional and study tour reports emphasizing theoretical aspects should be included. Evaluation of the project report and viva-voce will be open defense through PowerPoint presentation and evaluated by the external examiners.

Syllabus:

Special Paper	Dissertation/ project
ZOO 496A	**Fishery**
ZOO 496B	**Ecology**