

***RAJA NARENDRALAL KHAN WOMEN'S
COLLEGE (AUTONOMOUS)***



MIDNAPORE-721102, WESTBENGAL, 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			
		ZOO101.1	Non-Chordate Biology	25	2
		ZOO101.2	Chordate Biology	25	2
	ZOO 102	Histochemistry and Animal Physiology			
		ZOO102.1	Histochemistry	25	2
		ZOO102.2	Animal Physiology	25	2
	ZOO 103	Immunology and Methods in Biology			
		ZOO103.1	Immunology	25	2
		ZOO103.2	Methods in Biology	25	2
	ZOO 104	Cell Biology and Cytogenetics			
		ZOO104.1	Cell Biology	25	2
		ZOO104.2	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			
		ZOO201.1	Biosystematics	25	2
		ZOO201.2	Ecological Principles	25	2
	ZOO 202	Biophysics & Biochemistry			
		ZOO202.1	Biophysics	25	2
		ZOO202.2	Biochemistry	25	2
	ZOO 203	Molecular Biology and Parasitology			
		ZOO203.1	Molecular Biology	25	2
		ZOO203.2	Parasitology	25	2
	<i>C-ZOO204</i>	<i>Wildlife and Eco-Management and Aquaculture</i>			
		C-ZOO 204.1	<i>Wildlife and Eco-Management</i>	25	2
		C-ZOO 204.2	<i>Aquaculture</i>	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			
		ZOO301.1	Entomology	25	2
		ZOO301.2	Ecotoxicology	25	2
	ZOO 302	Molecular Evolution and Microbiology			
		ZOO302.1	Molecular Evolution	25	2
		ZOO302.2	Microbiology	25	2
SPECIAL PAPER (A: Fishery; B: Ecology)					

	ZOO303A	FishTaxonomy,AnatomyandBiologyand FishHealth Management				
		ZOO303A.1	FishTaxonomy,AnatomyandBiology		25	2
		ZOO303A.2	FishHealthManagement		25	2
	ZOO303B	BiodiversityandConservationEcologyandAquaticEcology				
		ZOO 303B.1	BiodiversityandConservationEcology		25	2
		ZOO 303B.2	AquaticEcology		25	2
	C-ZOO304	Genetics and BasicandAppliedImmunology(CBCS)				
		C-ZOO 304.1	Genetics		25	2
		C-ZOO 304.2	Basicand Applied Immunology		25	2
	ZOO 395	Entomology,Ecotoxicology,MolecularEvolutionand Microbiology			50	4
	SPECIALPAPERBASEDPRACTICAL					
ZOO396A	FisheryPractical-I			50	4	
ZOO396B	EcologyPractical-I					
TOTAL				300	24	
IV	ZOO 401	EnvironmentalPollution, Management andBiodiversityand Biostatistics			50	4
		ZOO401.1	EnvironmentalPollution,Managementand Biodiversity			
		ZOO401.2	Biostatistics			
	ZOO 402	DevelopmentalBiologyandNeuroendocrinology			50	4
		ZOO402.1	DevelopmentalBiology			
		ZOO402.2	Neuroendocrinology			
	SPECIALPAPER(A:Fishery;B:Ecology)					
	ZOO403A	AquacultureandFishTechnologyand Limnologyand Oceanography				
		ZOO403A.1	AquacultureandFishTechnology		25	2
		ZOO403A.2	LimnologyandOceanography		25	2
	ZOO403B	SystemEcology&HumanEcology				
ZOO 403B.1		SystemEcology		25	2	
ZOO 403B.2		HumanEcology		25	2	
SPECIALPAPERBASEDPRACTICAL						

ZOO495A	FisheryPractical-II	50	4
ZOO495B	EcologyPractical-II		
SPECIALPAPERBASEDPROJECT/DISSERTATION			
ZOO496A	Fishery	50	4
ZOO496B	Ecology		
TOTAL		300	24
GRANDTOTAL		1200	96

M.Sc.ZOOLOGYSEMESTERMARKSDISTRIBUTION

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

MarksDistributionofPractical Papers	
ZOO-195	
Marks(Total=50)	
Non- ChordateBiology	10
ChordateBiology	10
Histochemistry	05
AnimalPhysiology	15
Internalassessment- (Viva& LNB)	10
ZOO-196	
Marks(Total=50)	
Immunology	10
MethodsInBiology	05
Cytogenetics	15
CellBiology	10
Internalassessment- (Viva& LNB)	10

ZOO-295	Marks(Total=50)
Biosystematics	05
Ecologicalprinciples	15
Biophysics	05
Biochemistry	15
Internalassessment- (Viva& LNB)	10
ZOO-296	Marks(Total=50)
MolecularBiology	12
Parasitology	18
FieldStudy	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(Specialpaper)	Marks(Total=50)
ZOO-396AFishery	40
ZOO-396BEcology	40
Internalassessment-(Viva&LNB)	(10)foreachspecialpaper

ZOO-494	Marks(Total=50)
EnvironmentalPollution,Managementand Biodiversity	05
Biostatistics	15
DevelopmentalBiology	15
Neuroendocrinology	05
Internal Assessment- (Viva& LNB)	10
ZOO-495(Specialpaper)	Marks(Total=50)
ZOO-495AFishery	40
ZOO-495BEcology	40
Internal Assessment- (Viva& LNB)	10

ZOO-496(PROJECT/DISSERTATION)	Marks(Total=50)
Specialpaper	
ZOO-496AFishery	50
ZOO-496BEcology	50

1st YEAR

SEMESTER- I

CourseNo:ZOO101:Non-ChordateBiologyandChordateBiology

(50Marks,4credit)

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 SuperPhyla	4L
2. Foraminifera – characteristics, origin, distribution, biology, and ecological and economic significance of foraminifera.	3L
3. Comparative account of different larval forms of coelomates in 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 primates with special reference to <i>Homo sapiens sapiens</i> .	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; aerial respiration in lungfishes; swim bladder 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 marine fishes, 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 E

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.

CourseNo: ZOO103:Immunologyand MethodsinBiology

(50Marks,4credit)

UNIT I: ZOO 103.1:

ImmunologyExpected 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	1L
b) Concept of the epitope, paratope, agetope, hapten and adjuvants	2L
3. T-cell and B-cell biology	
a) Origin and maturation of T and B lymphocyte	2L
b) Mechanism of humoral and cell-mediated Immune Response	2L
c) T-cell subpopulation	2L
4. a) Antigen processing and presentation	2L
b) Major Histocompatibility Complex (MHC): Mechanism of immune response and generation of immunological diversity	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.	3L
b) Enzymatic activity on Ig molecule.	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., Brostoff, 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. <i>In situ</i> bioremediation	1L
ii. <i>Ex situ</i> 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.	4L
b) Basic Principles of Electrophoresis; Agarose Gel Electrophoresis; SDS-PAGE; Cell fractionation; Ultracentrifugation; Southern Blotting Hybridization.	4L
c) Flow Cytometry, 2D Gel Electrophoresis, and FISH.	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: ZOO104: Cell Biology and Cytogenetics

(50 Marks, 4 credit)

UNIT: ZOO104.1: Cell Biology Ex

pected course outcome:

Students will be well informed about the membrane structure and composition, transport and trafficking of protein, the cytoskeleton, cell movement, and extracellular 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

<p>4. Signal Transduction</p> <p>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, MAPK pathway</p>	6L
<p>5. Cytoskeleton & Cellular Motility</p> <p>Microtubule Dynamics and regulation, Microtubular motor proteins: Kinesins & Dyneins and Cellular motility</p>	3L
<p>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</p>	5L
<p>7. Interactions between Cells and Their Environment:</p> <p>Overview of major cell-cell and cell-matrix adhesive interactions, Cell-Cell and Cell–Extracellular Junctions and their adhesion molecules; the extracellular matrix: The basement membrane and connective tissue; Integrin</p>	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

CourseNo:ZOO195(Practical):

Non-ChordateBiology,ChordateBiology,HistochemistryandAnimalPhysiology

(50Marks,4credit)

Syllabus:

1. Non-ChordateBiology:
 - i) IdentificationofcommonInvertebrate andVertebratetaxa
 - ii) MinorDissection:
 - a. Grasshopper -Reproductivesystem/Nervoussystem
 - b. Cockroach– StomatogastricNervoussystem
 - c. Achatina– Reproductivesystem&Nervoussystem
2. ChordateBiology:
 - i) MajorDissection:Vth,VIIthcranialnervesofbonyfish
 - ii) MinorDissection:Fishscaleandpectenofbird
3. Histochemistry
 - i) Preparationoflaboratoryfixativemixtures
 - ii) Microtechniqueforroutinehistologicalstudy
 - iii) Histologicalstudyofdifferentvertebrateorgans
4. AnimalPhysiology
 - i) Demonstrationofbloodhaemoglobinestimationintheanimalmodel
 - ii) EstimationofpHanditsimpactonanyaquaticanimal.
 - iii) ObservationofgutmovementinananimalunderhypoxiausingDale'sapparatus
 - iv) EstimationofBloodPressureandHeartRate
 - v) DeterminationofBreath-HoldingTime(BHT)inhumans

CourseNo:ZOO196 (Practical):

Immunology,Methods inBiology,CellBiologyandCytogenetics

(50Marks,4credit)

Syllabus:

1. Immunology:
 - a. Studyofmacrophage.
 - b. Studyofphagocytosis.
 - c. Determinationofhumanbloodgroup
2. Methods inBiology
 - a. CharacterizationofmacromoleculethroughGelectrophoresis
3. CellBiology
 - a. Identificationofdifferentstagesofcelldivisionandcellorganelle.
 - b. MitochondrialStaining
 - c. Cellisolationandcellcounting
4. Cytogenetics:
 - a. Thelifecycleof*Drosoplila*.
 - b. Analysisandinterpretationofgeneticcrosseswithspecialreferenceto*Drosophila*
 - c. Studyofthe polytene chromosome of*Drosophila*.

1st YEAR

SEMESTER- II

CourseNo:ZOO201:BiosystematicsandEcologicalPrinciples

(50Marks,4credit)

UNIT I: ZOO 201.1:

BiosystematicsExpected 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, Intraspecies and Superspecies.	4L
4. NeoSystematics: 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,wildlifemanagement,NationalDefense,Environmentalproblems,soilfertility,Mineralprospecting,Quarantinemeasure,Commercialapplication.	3L
8. SystematicsandPublicHealthManagement	1L

ReferenceBooks/JournalArticle:

1. Mertens,T.R. andJ.L.Lines(1978).Principlesofbiosystematics,EducationalMethods.
2. Daniel,M.(2009).Taxonomy:EvolutionatWork,AlphaScienceInternational.PublisherAlphaScience International,2009
3. Mayr,E.andP.D.Ashlock(1991).Principlesofsystematiczoology,McGraw-Hill.PublisherMcGraw-Hill,1991
4. Hickman,C.P.,S.L.Keen,etal.(2016).IntegratedPrinciplesofZoology,McGraw-HillEducation.17thEds.

UNIT II: ZOO 201.2: Ecological

principlesExpected 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, habitatecology, 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
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<p>2. Population Ecology</p> <p>Survivorship; Lifetable, fertility schedule. Reproductive strategies; semelparity, 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.</p>	5L
<p>3. Community and Ecosystem</p> <p>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.</p>	5L
<p>4. Habitat Ecology</p> <p>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.</p>	5L
<p>5. Evolutionary Ecology</p> <p>Definition; different approaches, Bet-Hedging strategies, Hamilton's role and limitations of the inclusive fitness model.</p>	2L
<p>6. Ecology and organism:</p> <p>i) Aquatic Ecology: Types and zonation's of aquatic bodies, lotic and lentic biotic communities and limiting factors,</p> <p>ii) Terrestrial Ecology: Biogeography of Indian terrestrial landscape with special reference to soil subsystem and forests with respective biotic community</p>	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

CourseNo:ZOO202:BiophysicsandBiochemistry

(50Marks,4credit)

UNIT I: ZOO 202.1:

BiophysicsExpected course

outcome:

At the end of the course,the student will be able to understand fundamental concepts inbiophysics that underlie biological processes through knowledge of membrane biophysics andthermodynamiclaws.Thesystemwouldbedealtwiththeprincipleofthermodynamics,electroma gnetic andionizingradiation,andprinciplesofbiophysicalchemistry.

Syllabus:

<p>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; Buffersof extra- and intracellular fluids. (ii) Osmotic pressure: Laws of osmotic pressure;Isosmotic vs. isotonic solutions; Effect of hypotonic treatment on animal and plantcells; Survival of freshwater teleost fishes in hypotonic lotic water; Survival of marineteleost and elasmobranch fishes in hypertonic sea water. (iii) Membrane transport:Diffusion; Osmosis; Active transport and its types; Ion channels vs. membrane pumps;Facilitateddiffusion vs.activetransport;Reverseosmosisanditsapplication.</p>	8L
<p>2. Thermodynamics: Different types of thermodynamic systems; Laws ofthermodynamics; Applicabilityofthermodynamicprinciplesin living beings.</p>	2L
<p>3.Colloidalsystem:Crystalloidvs.colloidparticles;Classificationofcolloids;Lyophilicand lyophobicsol–propertiesandpreparation;BrownianmovementandTyndall effect; Dialysis and its clinical importance; Electrodialysis and its applicationintheproductionofdrinkingwater.</p>	4L
<p>2.Microscopyinbiologyandmedicine:(i)Fluorescencemicroscopy–Auto-fluorescence and hetero-fluorescence; Working principle of fluorescence microscope;Application in the detection of chronic myeloid leukemia, tuberculosis infection andcatecholamine hormones; Principle of immunofluorescence. (ii) Transmission electronmicroscopy– ComparisonofworkingprinciplesoflightmicroscopeandTEM;Biological application with reference to the diagnosis of viral infection and otherdiseases.</p>	5L
<p>3.Biophysics of membrane: Fluid mosaic model; Intrinsic and Peripheral membraneproteins;Asymmetricdistributionofproteins,lipidsandcarbohydratesinbio- membranes; Movement of membrane lipids and proteins with reference to cell fusionstudyandfluorescence recoveryafterphotobleaching(FRAP).</p>	3L
<p>4.Dynamicsofcirculation:Laminarandturbulentbloodflow;Reynoldnumber;Basic</p>	3L

concept of blood pressure and blood volume; Factors influencing blood pressure and blood volume.	
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Reference books:

1. Das, D. (1982). Biophysics and Biophysical Chemistry. Academic Publishers, Kolkata.
2. DeRobertis, E. D. P. and DeRobertis, 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 III: ZOO 202.2: Biochemistry E

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, Gelelectrophoresis, 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 ₁ , ATPase, and Q cycle.	4L
6. Lipid Metabolism: de novo 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: ZOO203: 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 polymerases 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.	2L
b) The basic concept of Parasitism, symbiosis, phoresis, commensalism and mutualism.	2L
2. Molecular, cellular and physiological basis of host-parasite interactions.	2L
3. Lifecycle and immunology of <i>Plasmodium falciparum</i> .	3L
4. Epidemiology and transmission of parasitic diseases. Malaria, Kalaazar.	4L
5. a)	3L
Zoonosis and Zoonotic diseases with special reference to Balantidiasis, Giardiasis Filariasis and Paragonimiasis.	4L
b) Lifecycle and biology of <i>Leishmania sp.</i> <i>Schistosom sp.</i>	
6. Structure and composition of helminth cuticle.	2L
7. Vector biology with special reference to mosquito, sandfly, 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-ZOO204: Wildlife and Eco-management and Aquaculture (CBCS)

(50 Marks, 4 credit)

UNIT I: C-ZOO204.1: 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 - PRAM methods; Molecular Techniques; Telesatellite images; Radiocollaring; Peoples Participation; Ground truth Assessment - Pugmarks, Call counts, Capture-Recapture.	3L
7. Wildlife trades, Crimes, Laws & Ethics.	2L
8. Environment – different relevant terminology.	2L
9. Environmental Management - Basic steps Sustainability, Eco monitoring Impact Assessment.	2L
10. Pollution - Types: Mode of action and Environmental Consequences; Global Scenario.	2L
11. Conservation Biology – different concepts and approaches.	2L

Referencebooks/Journalarticles:

1. AnIntroductiontoDisturbanceEcology-Aroadmapfor WildlifeManagementandConservation(Springer)
2. WildlifeinIndia:BSaharaia
3. AmanualforwildlifeRadioTaggingbyRobertEKenward
4. Conservation of Exploited species (Edted by John D. Renolds, Georgina M. Mace, Kent H.RedfordandJohnG.Robinson)(CambridgeUniversityPress)
5. EcologicalCensustechniques:Sutherland
6. WildlifeBiology:RFDasnan
7. Amanualofwildlife conservation: RDTeague
8. AnimalBehavior: Asynthesisofethologyand comparativepsychology: RAHinde
9. Animalbehavior:Dugarikin
10. Animalbehavior:Alcock
11. RiverineEcologyVolume2(Chapter4;Wildlife)(PublishedbySpringerNature)

UNITII:C-ZOO204.2: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. Freshwateraquaculture:	
a) BasicsofPondculture(IMCculture:from pondpreparationtofishharvesting),penculture,cageculture,runningwaterculture system,wastewaterfishery.	2L
b) Basicsofmonoculture,polycultureandintegratedculturesystem.	2L
c) Waterqualitymanagementforaquaculture	2L
d) Commonlivefishfoodorganisms	2L
3. Coastalandmarineaquaculture:	
a) Cultivable brakish water fin fishes and shellfishes: Traits of important cultivable fishandshellfishes,Majorandminorcarps,tigershrimp,whiteshrimp,mudcrab,mussel, clam, oysters (edible & pearl), lobsters, sea weeds, seed resources fromIndiancoast	5L
b) Mariculture practices:Methods of shellfish culturein/on rafts, racks, cages, polesandropes,introductiontoseaweedculture,pearlculture	4L
4.Impact ofclimate changeonfishes	3L
5.Bestpracticesforsustainableaquaculture	2L

Referencebooks/Journalarticles:

1. Roy,A.K.andN.Sarang(2008).AppliedBioinformatics,Statistics&EconomicsinFisheriesResearch,New IndiaPub.Agency.
2. Burnell, G. and G. L. Allan (2009). New Technologies in Aquaculture: Improving ProductionEfficiency,QualityandEnvironmentalManagement,CRCPress.
3. Food and A. O. o. t. U. Nations (1964). FAO Fisheries Technical Paper, Food and AgricultureOrganizationofthe UnitedNations (ISBN 9251055548,9789251055540).
4. Zazueta, F. S. (2006). Computers in Agriculture andNatural Resources: Proceedings of the4thWorldCongress:Orlando,Florida,USA,July24-26,2006,AmericanSocietyofAgriculturalandBiologicalEngineers.
5. Bank, T. W. (2012). Agricultural Innovation Systems: An Investment Sourcebook, WorldBankPublication.(ISBN 0821389440,9780821389447).Length680pages.

CourseNo:ZOO295(Practical):

Biosystematics, Ecological principles, Biophysics, and Biochemistry

(50Marks,4credit)

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 K_m & V_{max} of enzymes Amylase / Alkaline phosphatase.

CourseNo:ZOO296(Practical):

MolecularBiology,ParasitologyandFieldStudy

(50Marks, 4credit)

Syllabus:

1. Parasitology

- a) SmearpreparationandstainingofrectalcontentofBufosp./Cockroach
- b) Preparationandstaining ofbloodparasitefrompigeonblood.
- c) Identification:

Plasmodiumsp., Leishmaniasp.,Ascarissp.,

*Fasciolasp.,Paramphistomumsp.,Anophelessp.,Culexsp.,Aedessp.Columbicola
sp.,Pediculussp.,Cimex sp.*

2. MolecularBiology

- a) Isolation&purificationofDNA fromtissue.
- b) Principle&methodofAgaroseGelElectrophoresis

3. Fieldstudy

2nd YEAR

SEMESTER-III

CourseNo:ZOO301:EntomologyandEcotoxicology

(50Marks,4credit)

UNIT I: ZOO

301.1:EntomologyExpected 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 phenomenon in the insect life such as bioluminescence, pheromones, secondary adaptation aquatic insects, insects-plants interactions, integrated management of insect pests 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 tract 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 flight production, Control and significance of flight 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. Principles of Insect Morphology R E Snodgrass
2. Imm's 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 K Nayar, 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 Gillet
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 III: ZOO301.2: Ecotoxicology E

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 Xenobiotics 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 Xenobiotics 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 Concentration 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.

CourseNo: ZOO302:MolecularEvolutionandMicrobiology

(50Marks,4credit)

UNITI:ZOO302.1:MolecularEvolutionEx

pected 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

UNITII:ZOO302.2:MicrobiologyE

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 interesting/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 (biochemical 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: ZOO303A: 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 shellfishes. 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. S. Khanna & 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

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: ZOO303B.1: Biodiversity and Conservation Ecology Syllabus:**abus:**

1. Benefits of biodiversity; CBD, Megadiversity countries.	2L
2. Biodiversity: status, monitoring (surveys) and documentation; level 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 data sheet 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-Arabi 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, Heiko Garrelts, María Manez Costa, Susanne Menzel, Rainer Marggraf. 2005.
4. Practical Approaches to the Conservation of Biological Diversity- Richard Kenith Baydack, 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/>

UNITII:ZOO303B.2:AquaticEcologySy

llabus:

<p>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, transmissivity, and storativity.</p>
<p>2. Structure and function of aquatic ecosystems and their management:-</p> <ul style="list-style-type: none">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.
<p>3. Wastewater management – types, source, physical-chemical properties, recycling and bioremediations.</p>
<p>4. Aquatic biota, types and trophic interactions – Macrophytes, phytoplankton, zooplankton, periphyton, benthos and nekton.</p>
<p>5. Aquatic biodiversity: Potential threats and conservation in Indian perspectives</p>

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-ZOO304: Genetics and Basic and Applied Immunology (CBCS)

(50 Marks, 4 credit)

UNIT I: C-ZOO304.1: 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 ii) Pedigree characteristics of Human, X-linked inheritance iii) Nondisjunction as proof of the chromosome theory of heredity iv) Chromosome theory of Heredity v) Sex Determination in <i>Drosophila</i>	2L 2L 1L 1L 1L
2. Probability in the prediction of progeny distributions i) Using the binomial distribution in genetics ii) Testing goodness of fit to a genetic hypothesis, The Chi-Square Method	2L 1L
3. Genetic Linkage and Chromosome Mapping i) Linkage and recombination of genes in a chromosome ii) The Chi-square test for linkage iii) Each pair of linked genes has a characteristic frequency of recombination iv) Genetic Mapping, Map distance and frequency of recombination v) Crossing-over vi) Recombination between genes results from a physical exchange between chromosomes	1L 1L 1L 2L 1L 1L
4. Genetic Mapping in Three-Point Testcross i) Chromosome Interference in double crossovers ii) Genetic Mapping Functions, Genetic Map Distance and physical distance	2L 2L
5. The central dogma of Life i) Overview of Organisation of DNA in chromosome ii) The basic concept of Replication, transcription and translation	2L 2L

Referencebooks:

1. IntroductiontoGenetic AnalysisbyJ.F.Griffiths
2. Genesviii byBenjaminLewin
3. Genetic:AnalysisandPrinciplesbyRobertJ.Brooker
4. AnIntroductiontotheGeneticAnalysisbyDavidT.Suzuki
5. Genetics:AConceptualApproachbyBenjaminA.Pierce
6. iGenetics:AMolecularApproachbyPeter J.Russell
7. PrincipleofGeneticsbyPeterSnustad

UNITIII:C-ZOO304.2:BasicandAppliedImmunologyExpected

course outcome

Thiscoursewilldescribetheimmunesystemsofvertebratesthatenablethemtorecognizeand respond specifically to foreign substances. The students will be able to comprehend the roles of thelymphoidorgan,immunesystemcells,antigens,antibodies,MHC,antigenpresentationandimmunity toinfectious diseases.

Syllabus:

1. Overviewoftheimmunesystem:InnateandAcquiredimmuneresponse	3L
2.Cellsandtissuesof immunesystem:Hemopoietictissues:Structure& function[Annelida/Arthropoda/Mollusca;Chordata(Class-Fish/mammals)],Bloodcells:Structure &function	5L
3. OrgansandImmuneSystemMicroenvironments:PrimaryLymphoidOrgans,SecondaryLymphoidOrgans	5L
4. OutlinefortheHumoralandCell-Mediated(Cellular)BranchesoftheImmuneSystem	4L
5. StructureandtypesofAntibody,T-cell receptor,andMajorHistocompatibilitycomplex(MHC)	3L
6. AppliedImmunology:-ELISA,RIA,Immunohistochemistry,Vaccination	5L

Referencebooks:

1. Abbas,A.K.,Lichtman,A.H.andPillai,S.(2018).*CellularandMolecularImmunology*.9thed.Saunders.
2. Kindt,T.,Goldsby,R.Osborne,B.(2013).*Kuby'sImmunology*.7thed.W.H.FreemanandCo.
3. KennethM, CaseyW, (2016)Janeway'sImmunobiology9thed. GarlandScience.
4. WoodP.(2006)Understandingimmunology. 2nded.Pearson.

CourseNo:ZOO395: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 honeybee.
- c) Entomological comments on common Pests, Aquatic insects, and Insects of medical and economic importance. Galls & Seed cocoon
- d) Mounting of stinging apparatus & coupling device of Honeybee.

2) Ecotoxicology

- a) Dose-response curve
- b) Lethal dose estimation
- c) MATC in fish species
- d) Lethal dose 50 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: ZOO396A: 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: ZOO396B: 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

CourseNo:ZOO401:EnvironmentalPollution,ManagementandBiodiversityandBiostatistics

(50Marks,4credit)U

NITI:ZOO401.1:EnvironmentalPollution, ManagementandBiodiversity

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, zonation 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 Issues; George Tchobanoglous, Hilary Theisen, and S.A. Vigil; McGraw-Hill; Page 1-957.
4. Ecosystem Management: Application for Sustainable Forest and Wildlife Resources; Mark S. Boye 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 Text; Edward A. Laws; An Interscience Publication, John Wiley & Sons, INC; Page 1-611.
10. Pollution Control and Waste Management in Developing Countries; Rogers W'Okot-Uma, Georges E. Ekosse, Yvonne Gotlop Bogatsu, Kwesi Darkoh, Otlogetswe Totolo; The Commonwealth Secretariat; Page 1-460.

UNIT II: ZOO401.2: 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

Referencebooks:

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 S Sokal and F James Rohlf/Dover Publication
5. Biostatistical Analysis, 5th Edition, Jerrold H. Zar
6. Biostatistics by D Das

Course No: ZOO402: Developmental Biology and Neuroendocrinology**(50 Marks, 4 credit)****UNIT I: ZOO402.1:****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:

<p>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.</p>	8L
<p>2. Regeneration: Regeneration of animals with special emphasis on the process of regeneration in Hydra and Amphibia.</p>	8L
<p>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 zona pellucida, mouse acrosome reaction and gamete fusion</p>	9L

Referencebooks:

1. Developmentalbiology,11thedition2016byS.F.Gilbert
2. PrinciplesofDevelopment. 4thedition.LewisWolpert

UNITIII:**ZOO402.2:Neuroendocrinology**Expected

course outcome

The course will provide an understanding of basic concept of the neural system. Students would beacquaintedwithelectricalsignalingandmechanism.Thecoursewillcovertheevolutionaryperspective nervoussystem,functionalorganizationofthe CNSand endocrine disorder

Syllabus:

1.Electricalpropertiesofthenervecellmembrane,voltage-gated andligand-gated ionchannels	2L
2.Actionpotential,localcircuit,synapses&synaptictransmission,gapjunctions.	3L
3.Ionotropicandmetabotropicreceptors	2L
4.Neuropeptides, neuromodulation, neuronvs.NSC	2L
5.Hypothalamicreleasingandinhibitinghormones	2L
6.Neuroendocrineglands ininvertebrates(Insect&crustaceans)	2L
7.Neuroendocrineintegration	2L
8.Commonneuraldisorders:Alzheimer'sandParkinson'sdisease	2L
9.Mechanismofproteinandsteroid hormone action	2L
10.Hormoneanddisease:Type-IandType-II diabetes, OrdinaryandExophthalmicgoiter,Addison'sdisease	4L

Referencebooks:

1. AnIntroductiontoNeuroendocrinology.CambridgeUniversityPress.BrownRE(1994).
2. MethodsinNeuroendocrinologyVanDeKar,LD.,CRCPress.
3. ClinicalNeuroscience- KellyLambert,CraigH. Kinsley. 2004.
4. Hall,J.W.(1992).AnIntroductiontoMolecularNeurobiology.OxfordUniversityPressInc.
5. Melmed,S., Polonsky,K.S.,Larsen,P.R,andKronenberg,H.M.(2015).WilliamsTextbookofEndocrinology(13thEd.).Elsevier.
6. Robinson,D.(Editor)(1998).Neurobiology.Springer-VerlagBerlinandHeidelbergGmbH &Co.KG.
7. Sharma, D.,Singh,S. andSingh,R. (2021).TextbookofNeurobiology. DreamtechPress.

SPECIALPAPER:FISHERY

CourseNo: ZOO403A:

AquacultureandFish Technologyand InlandandMarine fisheries

(50Marks,4credit)

Expected course outcome:

Advancedknowledge 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 ensures 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: ZOO403A.1: Aquaculture & Fish Technology

Syllabus:

1. Aquaculture-definition types and scope.	1L
2. System of aquaculture-pond culture, pen culture, cage culture, biofloc culture system.	2L
3. Extensive, semi-intensive, intensive and superintensive aquaculture.	2L
4. Monoculture, Polyculture and Integrated culture system.	2L
5. Shellfish 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 Immunostimulants	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 Sambrasila Rao.

UNIT II: ZOO403A.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

Referencebooks/Journalarticles:

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.

CourseNo: ZOO403B: System Ecology and Human Ecology

(50 Marks, 4 credit)

UNIT I: ZOO403B.1: System Ecology Ex

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;	2L
b) Patterns of Spatial distribution - Random, clumped and uniform coefficient of dispersion.	2L
c) Index of similarity and index of association.	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.	3L
b) Aquatic system (freshwater). Physiography of freshwater ecosystems, stratification, distributions and mixing patterns. Ecology of Wetland Ecosystems: Water, Substrate, and Life.	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 Sy

llabus:

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.EnvironmentalManagementSystem,Ecomark.	
4.Urbanization: Urban environment – criteria and its present global status, majorenvironmental problems of cities. Urban impact on air and water environment,biodiversity,agriculture;IndoorPollution–characteristicoftheindoorenvironment, common indoor pollutants, their sources and mode of action; Effectofurbanizationonbiodiversity.	4L
5.Wastelandandwatershedmanagement: Concept–integratedprocessandmechanism of wasteland restoration and watershed management; Soil erosion –typesandfactors.	4L
6. Sustainableenvironmentalmanagement:Rolesoftraditionalknowledgeandpeople'sp articipation.	2L
7. Bioinvasion: Related terminologies; Underlyingoperatingprinciples; EcologicalConsequences—Case Studies.	3L

Referencebooks:

1. ConservationandBiodiversity;AndrewP.Dobson;Scientific AmericanLibrary,NewYork;Page1-264.
2. EnvironmentalBiotechnology: ABiosystemsApproach;DanielA.Vallero;Elsevier;Page1-742.
3. GlobalMarineDiversity:ASrategyforBuildingConservationintoDecisionMaking;IslandPress, WashingtonD.C.;Page1-383.
4. ClimateChangeandBiodiversity;ThomasE.LovejoyandLeeHannah;YaleUniversityPress, NewHavenandLondon;Page 1-416.
5. Conservation Biology; Andrew S. Pullin; Cambridge University Press; Page 1-342.
6. Biodiversityand GlobalChange;O.T.Solbrig,H.M. VanEmdenandP.G.W.J. VanOordt;CabInternational,Internat ionalUnionofBiologicalSciences;Page1-223.
7. TheInternationalBusinessEnvironment:Globaland localmarketplacesinchanging World;JanetMorrison;PalgraveMacmillan;Pages1-516.
8. BiofertilizersforSustainableAgriculture;ArunK.Sharma;Agrobios(India);Page1-407.
9. Introductionto PopulationBiology;DickNeal;CambridgeUniversityPress;Page1-393.

10. Handbook of Ecological Restoration volume 1 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 York.
13. Global Action for Biodiversity: An International Framework for Implementing
the Conservation of Biological Diversity; Timothy Swanson; Earthscan Publications Ltd. London.

CourseNo:ZOO494(Practical):

Environmental Management, Biostatistics, Developmental Biology & Neuro-endocrinology

(50Marks,4credit)

Syllabus:

1. BiodiversityandEnvironmentalstress
 - i. Qualitativeandquantitativeestimationofsoilandaquatic biodiversity.
 - ii. Basicprinciplesfortheestimationofheavymetals.
 - iii. EstimationofB.O.DandC.O.D
2. Biostatistics
 - i. Computationofcolumnstatistics
 - ii. Testingofhypothesis:t-test,Z-test,andFtest
 - iii. Computationandsignificancetestofproduct-moment(r)betweentwocontinuousmeasurementvariables.
 - iv. Computationofsimple linearregression.
 - v. One-wayAnovaandtheirinterpretation.
3. Developmentalbiology
 - i. Extraction and identification of different stages of chick embryos (24 hours,48 hours and72hours)
 - ii. Histologicalsectioningandstainingofdifferentstagesofthechickembryo.
4. Neuro-Endocrinology

- i. Neuroendocrine structure in invertebrates
- ii. Endocrine structure in invertebrates
- 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: ZOO495A: 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, gastro-somatic 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.

CourseNo:ZOO495B:EcologyPractical-II

(50Marks,4credit)

Syllabus:

1. Estimationofthedegree offaunalsimilarityand associationbetweenspecies.
2. Computationofmicro-distributionpatternfor spatialdistribution.
3. Estimationofalpha, betaandgammadiversity.
4. Analysis of the structure of biotic community: Abundance, Relative abundance,Frequency,SpeciesdiversityandDominanceindices;Shannon-WeinerdiversityindexandImportanceValueIndex.
5. EstimationoftexturalcompositionandWaterHolding Capacityofsoil.
6. Evaluation of Restoration sites; Study of forest/vegetation health- Estimation of treeheight,DBH,standdensity,canopydensityandtreebiomass
7. Vermitechnologyand relatedmatters:
Analysisofbiotafrommurbanwastematerialsandidentificationofsuitablespecimenforvermicomposting.
8. Airpollutionmonitoring:demonstrationoftheoperatingprinciplesHighVolumeSampler
9. SubmissionofLaboratorynotebook.
10. Viva-voce

PROJECT/DISSERTATION

Expected course outcome:

The project report should include an introduction, methodology, techniques, results, discussionand bibliography.Institutional and study tour reports emphasizing theoreticalaspects shouldbeincluded. Evaluation of theprojectreport andviva-vocewillbe opendefensethroughPowerPointpresentationandevaluatedbythe externalexaminers.

Syllabus:

SpecialPaper	Dissertation/project
ZOO496A	Fishery

ZOO496B	Ecology
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