

# **Raja N. L. Khan Women's College (Autonomous)**



## **Curriculum for M.Sc. in Zoology**

**[Choice Based Credit System]**

## COURSE STRUCTURE OF M.Sc. IN ZOOLOGY

SEM-ESTER	PAPER CODE	CONTENT	Marks	Credit	
I	ZOO-101	Non- Chordates& Chordates	50	4	
	ZOO-102	Histochemistry& Animal Physiology	50	4	
	ZOO-103	Immunology and Methods in Biology	50	4	
	ZOO-104	Cell Biology &Cytogenetics	50	4	
	ZOO-195	Non- Chordates, Chordates, Histochemistry& Animal Physiology (Practical)	50	4	
	ZOO-196	Immunology, Methods in Biology, Cell Biology &Cytogenetics (Practical)	50	4	
	<b>TOTAL</b>			<b>300</b>	<b>24</b>
II	ZOO-201	Biosystematics & Ecological principles	50	4	
	ZOO-202	Biophysics &Biochemistry	50	4	
	ZOO-203	Molecular Biology &Parasitology	50	4	
	<b>C-ZOO</b>	<i>Wildlife &amp; Eco-Management and Aqua informatics</i>	50	4	
	ZOO-295	Ecological principles, Biochemistry & Field Study)	50	4	
	ZOO-296	Biosystematics, Molecular Biology, Parasitology & Biophysics	50	4	
	<b>TOTAL</b>			<b>300</b>	<b>24</b>
III	ZOO-301	Basic & applied Entomology and Ecotoxicology	50	4	
	ZOO-302	Molecular Evolution and Microbiology	50	4	
	<b>SPECIAL PAPER (A: Fishery; B: Ecology)</b>				
	ZOO-303A	Fish Taxonomy & Biology and Oceanography	50	4	
	ZOO-303B	Biodiversity and Conservation Ecology & Aquatic Ecology			
	<b>C-ZOO-304</b>	Biological Oceanography & Applied Biology, Ecological Principles	50		
	ZOO-395	Entomology, Ecotoxicology, Molecular Evolution and Microbiology	50	4	
	<b>SPECIAL PAPER BASED PRACTICAL</b>				
	ZOO-396A	FISHERY PRACTICAL –I & Field trip	50		
ZOO-	ECOLOGY PRACTICAL –I & Field trip		4		

	396B			
	<b>TOTAL</b>		<b>300</b>	<b>4</b>
IV	ZOO-401	Environmental pollution & management and Biostatistics	50	4
	ZOO-402	Developmental Biology and Neuro-endocrinology	50	4
	<b>SPECIAL PAPER (A: Fishery; B: Ecology)</b>			
	ZOO-403A	Aquaculture & Inland and Marine Fisheries	50	4
	ZOO-403B	Systems Ecology & Human Ecology		
	ZOO-494	Environmental Management, Biostatistics, Developmental	50	4
		Biology & Neuro-endocrinology		
	<b>SPECIAL PAPER BASED PRACTICAL</b>		50	4
	ZOO-495A	FISHERY PRACTICAL –II		
	ZOO-495B	ECOLOGY PRACTICAL –II		
	<b>SPECIAL PAPER BASED PROJECT/DISSERTATION</b>			
	ZOO 496A	FISHERY SPECIAL Pr.	50	4
	ZOO 496B	ECOLOGY SPECIAL Pr.		
		<b>TOTAL</b>	300	24
	<b>GRAND TOTAL</b>	<b>1200</b>	<b>96</b>	

## M.Sc. ZOOLOGY SEMESTER MARKS DISTRIBUTION

<b>SEM</b>	<b>Theory</b>	<b>Practical</b>
I	200	100
II	200	100
III	200	100
IV	150	150
<b>Total</b>	<b>750</b>	<b>450</b>

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

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

<b>ZOO-395</b>	<b>Marks (Total=50)</b>
Entomology	10
Ecotoxicology	13
Microbiology	17
Internal assessment- (Viva & LNB)	10
<b>ZOO-396</b>	<b>Marks (Total=50)</b>
Special paper	
ZOO-396A Fishery	30
ZOO-396B Ecology	30
Field trip/Institute /Lab visit	10
Internal assessment- (Viva & LNB)	(10) for each special paper

<b>ZOO-494</b>	<b>Marks (Total=50)</b>
Biodiversity and Environmental stress	05
Biostatistics	15
Developmental biology	12
Neuroendocrinology	8
Internal assessment- (Viva & LNB)	10
<b>ZOO-495</b>	<b>Marks (Total=50)</b>
Special paper	
ZOO-495A Fishery	40
ZOO-495B Ecology	40
Internal assessment- (Viva & LNB)	10

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

## **SEMESTER-I**

### **Paper ZOO101**

#### **(Non- Chordate & Chordates)**

##### **Group A: Non-Chordates**

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

##### **Reference Books/ Journal Article:**

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

## **Group B: Chordates**

### **1. Origin of Chordates:**

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

### **2. Protochordates:**

Endostyle and Iodine binding capacity in Protochordates.

### **3. Fishes:**

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

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

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

### **5. Excretory System and Osmoregulation:**

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

### **6. Echolocation:**

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

### **Reference Books/ Journal Article:**

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

## **Paper ZOO102**

### **Histochemistry & Animal Physiology**

#### **Group A: Histochemistry**

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

#### **Reference Books/ Journal Article:**

1. Bancroft, JD (1975) Histochemical Techniques (Second Edition), Butterworth-Heinemann.
2. Kirenan, JA (1981) Histological and Histochemical Methods, Theory and Practice (Third Edition).
3. Suvarna, SK, Layton, C, Bancroft, JD (1977) Bancroft's Theory and Practice of Histological Techniques. Churchill Livingstone.

#### **Group B: Animal Physiology**

##### **1. Blood, Circulation and Respiration:**

- Haemopoiesis, haemoglobin, blood groups, haemodynamics.
- Regulation of blood volume and blood pressure, haemostasis.
- Respiratory response to extreme conditions like hypoxia & diving.
- Body oxygen stores –blood, muscle and pulmonary.
- Oxyhaemoglobin and Myoglobin; Oxygen dissociation curve.
- Cardiovascular System:
- Cardiac cycle,
- Electrical and mechanical properties of myogenic and neurogenic hearts;
- Heart as a pump; regulation of heart pumping;
- Neural and chemical regulation of excitation & conduction in heart;
- Frank-Starling mechanism;
- Principle of ECG.

##### **2. Stress physiology:**



- Homeostasis, Feedback control systems
- Oxidative stress. Cellular response. Free radicals and anti-oxidants.

### **3. Thermoregulation:**

- Body temperature and determinants of body heat – production and loss.
- Physiological events for thermoregulation; counter-current system.
- Thermal biology of ectotherms, heterotherms and endotherms.

### **Reference Books/ Journal Article:**

1. Textbook of Medical Physiology - Arthur C. Guyton & John Edward Hall. 13<sup>th</sup> Ed.
2. Ganong's Review of Medical Physiology- Kim E. Barrett, Susan M. Barman, Scott Boitano, Heddwen Brooks. 25th Ed.
3. Biochemistry - Debajyoti Das, 1978.
4. A Textbook of Practical Physiology- C. L. Ghai. 2012.

## Paper ZOO103

### (Immunology and Methods in Biology)

#### Group A: Immunology

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

#### Reference Books/ Journal Article:

1. Abbas, A. K., Lichtman, A. H. and Pillai, S. (2006). *Cellular and molecular Immunology*. 6<sup>th</sup> ed. Saunders.
2. Abbas, A. K. and Lichtman, A. H. (2006). *Basic Immunology*. 2<sup>nd</sup> ed. Elsevier.
3. Coico R, Sunshine, G., Benjamini, E. (2003). *Immunology: A short Course*. 5<sup>th</sup> 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*. 7<sup>th</sup> 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*. 6<sup>th</sup> ed. W.H. Freeman and Co.
8. Male, D., Brostoff, J., Roth, D. and Roitt, I. (2006). *Immunology*. 7<sup>th</sup> 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*.

10<sup>th</sup> ed. BlackwellScience Ltd.

## **Group B: Methods in Biology**

### **1. Molecular Biotechnology**

- a) Recombinant DNA technology
- b) Restriction Endonuclease
- c) Production of recombinant DNA molecule
- d) Cloning Vector
- e) Amplification by PCR
- f) DNA finger printing and its application

### **2. Environmental Biotechnology**

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

### **3. Techniques and Bioinstrumentation**

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

### **Reference Books/ Journal Article:**

1. Principle and techniques of biochemistry and Molecular Biology by K. Wilson and J. Walker 7<sup>th</sup> Edn, Cambridge low price edn.
2. Physical biochemistry- Principles and Applications by David Sheehan, 2<sup>nd</sup> edn.

**Paper ZOO104**  
**(Cell Biology & Cytogenetics)**

**Group A: Cell biology**

**1. Biomembrane Structure**

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

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

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

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

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

**4. Signal Transduction**

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

**5. Cytoskeleton & Cellular Motility**

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

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

**7. Interactions between Cells and Their Environment:**

- i. Overview of major cell-cell and cell-matrix adhesive interactions, Cell-Cell and Cell–Extracellular Junctions and Their Adhesion Molecules, The Extracellular Matrix: The Basal Lamina and Connective tissue

**Reference Books/ Journal Article:**

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

**Group A: Cytogenetics****1. Genetic Fine structure :**

- a. The CIS-TRANS or complementation test for functional allelism, Fine structure of the phage T4 rII locus, Complementation mapping and deletion mapping.

**2. Recombination in Bacteria:**

- a. F factor, episomes, Hfr, integration of F factor, Interrupted mating Experiment, conjugation mapping, transformation and transduction

**3. Tumor Inducing Viruses – Viral Oncogenes**

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

**4. Genetic structure of Populations-**

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

**Reference Books/ Journal Article:**

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

## **Practical Paper**

### **Paper ZOO-195**

- 1) Non- Chordates:
  - i) Identification of common Invertebrate and Vertebrate taxa
  - ii) Minor Dissection:
    - (1) Grasshopper - Reproductive system/ Nervous system
    - (2) Cockroach – Stomatogastric Nervous system
    - (3) Achatina – Reproductive system & Nervous system
- 2) Chordates:
  - i) Major Dissection
  - ii) Bony fish - Vth, VIIth cranial nerves
- 3) Histochemistry
  - a. Microtechniques and tissue identification from chordates
  - b. Enzyme histochemistry
  - c. Staining for nucleic acid/ connective tissue
  - d. Demonstration of research article.
  - e. General idea about modern tools of histological techniques.
- 4) Animal Physiology
  - i) Estimation of pH and its impact on plankton.
  - ii) Observation of gut movement in frog/rat/fish under hypoxia using Dale's apparatus

## **Practical Paper**

### **Paper ZOO-196**

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

## SEMESTER II

### Paper ZOO201

#### (Biosystematics & Ecological principles)

##### Group A. Biosystematics

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

##### Reference Books/ Journal Article:

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



## **Group B: Ecological principles**

### **1. Basics of Ecology**

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

### **2. Population Ecology**

Survivorship; Life table, fertility schedule. Reproductive strategies; 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 species extinction, habitat destruction and fragmentation, introduction of exotic species.

### **3. Community and Ecosystem**

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

### **4. Habitat Ecology**

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

### **5. Evolutionary Ecology**

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

### **Reference books:**

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

**Paper ZOO202**  
**(Biophysics & Biochemistry)**

**Group A: Biophysics**

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

**Reference books:**

1. Cotterill, R. (2005) Biophysics: An Introduction. Jhon Wiley & Sons.
2. Bialek, W. Biophysics: Searching for Principles.
3. Cleri, F. (2016) The Physics of Living System. Springer.

**Group B: Biochemistry**

1. **Stablizing** interactions (Van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction)
2. **Protein Conformation:** Primary, secondary, tertiary and quaternary structures; Ramachandran plot; domains; motif and folds.
3. **Enzymes:** Enzyme kinetics, Michaelis-Menton equation, hyperbolic and Lineweaver-Burke plot; co-enzymes and Cofactor; competitive and non-competitive inhibitor and their effects on enzyme kinetics; Active site of an enzyme; Enzyme regulation, allosteric modification, its kinetics, covalently modulated enzymes.
4. **Biological Oxidation:** Redox potential, mitochondrial electron carriers, the respiratory chain (electron transport chain); Mitchell's chemiosmotic theory of oxidative phosphorylation; FoF, ATPase
5. **Lipid Metabolism:** denovo synthesis of fatty acids, microsomal fatty acid elongase&desaturase systems; oxidation of saturated fatty acids and unsaturated fatty acids.
6. **Protein metabolism:** deamination, transamination, ammonotelism, ureotelism, uricotelesim, formation of urea, formation of specialized products from amino acids: catecholamine, serotonin, melatonin, glutathione, T<sub>3</sub>, T<sub>4</sub>.
7. **Carbohydrate metabolism:** anabolic role of TCA cycle, integration of carbohydrate, fat and protein metabolism. Regulation of Glucolysis TCA cycle, Gluconeogenesis, Pentose phosphate pathway, Glycogenesis, glycogenolysis with special reference to rate limiting steps.

**Reference books / Journal articles:**

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

**Paper ZOO202**  
**(Molecular Biology & Parasitology)**

**Group A: Molecular Biology**

**1. DNA Replication:**

The chemistry of DNA synthesis, the mechanism of DNA polymerase, the replication fork, the specialization of DNA polymerase, finishing replication

**2. The Transcription Process –**

Role of RNA polymerase in prokaryotes, initiation of transcription at Promoters, elongation and termination of an RNA in prokaryotes, Initiation, elongation, DNA methylation and control of transcription in eukaryotes

**3. Protein Synthesis**

Charging tRNA, initiation of translation; role of initiation factors, Elongation: binding of Aminoacyl-tRNA, peptide bond formation and translocation. Termination of translocation.

**4. Regulation of Gene Expression in Prokaryotes:**

The Operon Model; lac, an inducible Operon, Positive Control of the lac Operon by CAP and Cyclic AMP. Repressible operon, Gene organization of the Tryptophan biosynthesis

**Reference books / Journal articles:**

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

**Group B: Parasitology**

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

**Reference books:**

1. Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.
2. Chandler, A. C. and Read. C. P. (1961). *Introduction to Parasitology*, 10th ed. John Wiley 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.

## **C-ZOO-204**

### **Theory (CBCS)**

#### **(Wildlife & Eco-management and Aqua informatics)**

#### **Group A: Wildlife & Eco-Management**

- a) Wildlife diversity and distribution in India – Mammals, Avifauna and Reptiles; IUCN threatened categories.
- b) Threatened wildlife in India with special reference to Eastern India.
- c) Root causes of depletion of wildlife wealth.
- d) Wildlife conservation strategies-  
Protected areas-National Parks, Sanctuaries, Biosphere Reserve; Cores and Buffer; Nodes and Corridor.
- e) Management of wildlife-Taxonomic Status, Distribution, Habitat Utilization Patterns, Threats and conservation of Mask Deer; Vultures; Olive Ridley turtle.
- f) Tools and Techniques-  
PRA methods ; Molecular Techniques; Tele satellite images; Radio coloring ; Peoples Participation; Ground truth Assessment-Pugmarks, Call counts, Capture-Recapture. Wild life trades, Crimes, Laws & Ethics.
- g) Environment –different relevant terminology.
- h) Environmental Management-Basic steps Sustainability, Ecomonitoring Impact Assessment.
- i) Pollution-Types: Mode of action and Environmental Consequences; Global Scenario.
- j) Conservation Biology –different concepts and approaches.

#### **Group B: Aqua informatics:**

1. Spatial database development through different survey information analysis, Decision base support system formation.
2. Climate change and policy research design on Aquatic resources from beginning to end. Role of Information Communication Technology (ICT) in Aquaculture sector.
3. Recent approaches in Aquatic floral -faunal conservation/ assessment through Web based system.
4. Technology Innovation and Integrated Information Management System (software Program) in Aquaculture.

**Paper ZOO-295**  
**(Practical Paper)**

1. Biosystematics
  - i) Preparation of taxonomic key
2. Ecological principles
  - a. Estimation of primary productivity in aquatic ecosystems
  - b. Estimation of transparency of water
  - c. Measurement of intensity of light – using Lux meter.
  - d. Determination of the minimum size and number of quadrat – Species area curve method.
  - e. Study of density, diversity, frequency and abundance of plant community.
3. Biophysics
  - a. Membrane biology dynamics
  - b. USIC/ SIF visit for Lab Demonstration
  - c. Demonstration of Scientific Techniques using local Species as an experimental tool
4. Biochemistry
  - a) Quantitative estimation of protein- Lowry method or by FolinCiocalteu reagent.
  - b) Estimation of Glucose by Dinitrosalicylic (DNS) acid reagent.
  - c) Estimation of Fructose by Resorcinol reagent.
  - d) Estimation of DNA by Diphenylamine reagent.
  - e) Detection of reducing sugars by Benedict's, Barfoed's& Fehling's reagents.
  - f) Detection of amino acids by Ninhydrin reaction.
  - g) Determination of Km & Vmax of enzymes Amylase and/or Alkaline phosphatase.  
Preparation of Progress Curve of the above mentioned enzymes.

**Paper ZOO-296**

1. Parasitology
  - a) Smear preparation and staining of rectal content of Bufo sp./Cockroach
  - b) Preparation and staining of blood parasite from pigeon blood.
  - c) Identification:  
*Plasmodium sp., Leishmania sp., Ascaris sp., Fasciola sp., Paramphistomum sp., Anopheles sp., Culex sp., Aedes sp. Columbicola sp., Pediculus sp., Cimex sp.*
2. Molecular Biology
  - a) Isolation & purification of DNA from tissue.
  - b) Principle & method of Agarose Gel Electrophoresis
3. Field report & viva

## SEMESTER III

### ZOO-301

#### (Basic & applied Entomology and Ecotoxicology)

##### Group A: Basic & applied Entomology

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

##### Reference books / Journal articles:

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

##### Group B. Ecotoxicology

###### 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.

###### 2. Toxicity test & bioassay

LC<sub>50</sub>, LD<sub>50</sub>, Dose response curve; Biotransformation, Bioaccumulation & Biomagnification of Xenobiotics in food chain; Hazardous heavy metals and their toxicity and probable antidotes; Elementary idea on Chelation therapy.

### **3. Aquatic Toxicology**

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

### **4. Immunotoxicology**

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

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

### **Reference books / Journal articles:**

1. Newman, M. C. and W. H. Clements (2007). Ecotoxicology: A Comprehensive Treatment, CRC Press. CRC Press, 2007.
2. Jorgensen, E. (2010). Ecotoxicology, Elsevier Science. Academic Press, 2010.
3. Walker, C. H., R. M. Sibly, et al. (2016). Principles of Ecotoxicology, 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.

## **PaperZOO-302**

### **(Molecular Evolution and Microbiology)**

#### **Group A. Molecular Evolution**

##### **1. Neo-Darwinism**

- a. Hardy-Weinberg law of genetic equilibrium
- b. A detailed account of destabilizing forces: (i) Natural selection (ii) Mutation (iii) Genetic drift (iv) Migration

##### **2. Molecular phylogenies**

- a. Construction of phylogenetic trees
- b. Phylogenetic Inference-Distance methods, parsimony methods, maximum likelihood method
- c. Immunological techniques
- d. Amino acid sequences and phylogeny
- e. Nucleic acid phylogeny, DNA-DNA hybridizations, restriction enzyme sites, nucleotide sequence comparisons and homologies

**Reference Books/ Journal Article:**

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

**Group B: Microbiology**

1. Outline classification of microorganisms: 5-kingdom, 8-kingdom system, Bergey's manual.
2. Classification & morphology of Bacteria
3. General accounts of Algae, Protists, Fungi & Virus.
4. Microbial Physiology:
  - i. Growth in Bacteria: normal growth curve; methods of measuring growth.
  - ii. Yield and characteristics, strategies of cell division.
  - iii. Bacterial chemotaxis and quorum sensing.
5. Nutrition of microbes
  - i. Principles behind formulating culture media
  - ii. Culture techniques; pure cultures.
6. Microbes in soil ecology: fertility, petroleum formation; Role of soil microbial community as a key component of the soil ecosystem.
7. Microbial fermentation: manufacture of industrially important products.

**Reference books:**

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

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

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

**Reference books / Journal articles:**

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



Taylor & Francis. CRC Press, 1991

### **Group B: Oceanography**

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

#### **Reference books / Journal articles:**

1. Trujillo, AP., Thurman, HV. (1983) Essentials of Oceanography. (ISBN-13: 978-0134073545)
2. Garrison, T., Ellis, R. Oceanography: An Invitation to Marine Science. (9<sup>th</sup>Eds).
3. Knauss, JA. Introduction to Physical Oceanography. (2<sup>nd</sup>Eds).

### **Paper: ZOO-303B: ECOLOGY SPECIAL**

#### **(Biodiversity & Conservation Ecology and Aquatic Ecology)**

#### **Group A: Biodiversity & Conservation Ecology**

- **Biodiversity** - Utility and concept. CBD, Megadiversity countries, Biodiversity hotspots. Estimating biodiversity, biodiversity indices. IUCN Red List Category Version 3.1; IUCN categories of Protected Areas- National Parks, Sanctuaries, Biosphere Reserve. Biodiversity convention, criteria for measuring conservation value of areas. Types of conservation: (i) Exsituconservation of animals; captive breeding; species reintroduction, species translocation; population reinforcement; (ii) In-situ conservation- conserving ecosystem function and management. Bioindicators for biodiversity monitoring.
- **Wildlife Ecology**: Evolution of Approaches in Wildlife Conservation. Diversity, ecology, threats & conservation strategies of major Wildlife in West Bengal. Wildlife Habitat management for conservation. Wildlife crime. Social forestry: Joint Forest management- Arabari concept. Biodiversity profile of Ganga River and restoration activities.
- **Conservation of biodiversity**– Conservation process; Enhancing & conserving environmental resources. World Heritage Sites. Red datasheet for India. Critically Endangered Vertebrates of India with special reference to West Bengal. Distribution, habitat utilization, threats to survival of Endangered fauna (Tiger, Wild Elephant), and conservation strategies. Climate change and its effect on wildlife (amphibians & reptiles) and their habitat (eg. alpine vegetation). Human-animal conflict with special reference to elephant migration.
- **Endemic Avifauna of India**– IBAs of West Bengal. Distribution, habitat preference, migration, biology, threats to survival, conservation strategy of Vulture and Great Indian Bustard. Wetland and forest as complementary habitats for the conservation of Avifauna.
- **Tools and techniques for wildlife census and survey**. Technologies for Wildlife Research and Management. Molecular techniques for wildlife biology; DNA fingerprinting in wildlife forensics. Remote sensing: basic idea of GIS and GPS and their application in habitat & wildlife conservation.

#### **Reference books:**

- Conserving Forest Biodiversity: A Comprehensive Multiscaled Approach- David B. Lindenmayer, Jerry F. Franklin. 2013.
- Valuation and Conservation of Biodiversity: Interdisciplinary Perspectives... Michael

Markussen, Ralph Buse, Heiko Garrelts, María Manéz Costa, Susanne Menzel, Rainer Marggraf. 2005.

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

### **Group B: Aquatic Ecology**

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

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

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

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

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

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

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

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

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

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

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

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

#### **Reference books:**

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

**Paper ZOO-395  
Practical**

- 1) Entomology
  - a) Method of collection and preservation of insects
  - b) Study of the behavioural modification of legs in honey bee.
  - c) Entomological comments on common Pests, Aquatic insects, Insects of medical and economical importance. Galls & Seed cocoon
  - d) Mounting of sting apparatus & coupling device of Honey bee.
- 2) Ecotoxicology
  - a) Dose response curve
  - b) Lethal dose estimation
  - c) MATC in a fish species
  - d) Lethal dose 50 mortality curve
- 3) Molecular Evolution
- 4) Microbiology
  - a. Staining and identification of bacteria, endospores, etc. from a culture media.
  - b. Different methods of staining: Gram staining, Negative and differential staining.
  - c. Preparation of different culture media with Sterilization techniques.
  - d. Inoculation of microbes to respective culture media through proper culture methods.
  - e. Enumeration of Coliform bacteria using multiple tube fermentation method.

**Special paper Practical**

**ZOO-396A Fishery**

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

**ZOO-396B Ecology**

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

## Biological Oceanography: Paper- 304(A) KM

1. Classification of the marine environment and marine organisms.
2. Physio-chemical factors affecting marine life -- light, temperature, salinity, pressure, nutrients, dissolved gases; adaptation and biological processes.
3. Primary and secondary production; factors controlling phytoplankton and zooplankton abundance and diversity; nekton and fisheries oceanography; benthic organisms; coastal marine communities and community ecology – estuaries, coral reefs and mangrove communities.
4. Energy flow and mineral cycling – energy transfer and transfer efficiencies through different trophic levels; food webs including the microbial loop.
5. Human impacts on marine communities; impacts of climate change on marine biodiversity. Impact of pollution on marine environments including fisheries.

### Reference books / Journal articles:

1. Trujillo, AP., Thurman, HV. (1983) Essentials of Oceanography. (ISBN-13: 978-0134073545)
2. Garrison, T., Ellis, R. Oceanography: An Invitation to Marine Science. (9thEds).
3. Knauss, JA. Introduction to Physical Oceanography. (2ndEds).

## APPLIED BIOLOGY & ECOLOGICAL PRINCIPLES

Paper- 304(B)

AD

1. Bioremediation and phytoremediation.
2. Biogeography: Major terrestrial biomes; theory of island biogeography; biogeographical zones of India.
3. Habitat and Niche: Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
4. Population Ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.

### Reference Books/ Journal Article:

1. Principle and techniques of biochemistry and Molecular Biology by K. Wilson and J. Walker 7th Edn, Cambridge low price edn.
2. Physical biochemistry- Principles and Applications by David Sheehan, 2 ndedn.
3. Fundamentals of Ecology- Eugene P. Odum, 2005.
4. Biological Science – Scott Freeman. 2018.
5. Ecology- Robert E. Ricklefs, Gary Leon Miller. 2000.

## SEMESTER IV

### Paper ZOO-401

#### (Environmental pollution & management and Biostatistics)

##### Group A: Environmental pollution & management

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

##### Reference books:

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

##### Group B: Biostatistics

1. **Concepts of Biostatistics:** Data, population, sample and sampling, frequency distribution, graphical representation of data, parametric and nonparametric statistics
2. **Measures of Central Tendency:** Mean, median and Mode
3. **Measures of Dispersion:** Range, quartile deviation, mean deviation and standard deviation, standard error, variance and covariance
4. **Probability distribution:** Normal distributions, Properties and uses of binomial distributions and Poisson's distributions
5. **Set theory and probability**
6. **Testing of Hypothesis:** Null Hypothesis. Level of significance. Error of interference and degrees of freedom.
7. **Analysis of frequencies:** Chi-square test for goodness of fit.
8. **Student 't' distribution**
9. **Z test and Fisher's F test**

**10. Correlation and regression:** Properties and types of correlation. Pearson's product-moment correlation coefficient- properties, assumptions, computation from ungrouped data and significance test. Partial and multiple correlations. Rank correlation Regressions- types and models, simple linear regression – assumption, properties and computation. Multiple regression.

**11. Analysis of Variances:** Types and models of analysis of variances. Assumption for ANOVA. One-way ANOVA- computation and interpretation of F ratio, multiple comparison t-test, Scheffe's multiple comparison f-test.

**12. Nonparametric Test**

**Reference books:**

1. Fundamentals of biostatistics.-7 th ed./Bernard Rosner
2. Principles of Biostatistics/Marcello Pagano/Duxbury press 1993
3. Statistics in scientific investigation its basis, application and interpretation/Glen McPherson/Springer Verlag 1990
4. Introduction to Biostatistics/Robert R Sokal and F James Rohlf/Dover Publication
5. Biostatistical Analysis, 5th Edition, Jerrold H. Zar
6. Biostatistics by D Das

**Paper ZOO-402**

**Developmental Biology & Neuroendocrinology**

**Group A: Developmental Biology**

**1. Early development and molecular mechanism of Amphibian axis formation:**

Inductive interactions,organisation of a secondary axis,dorsal and ventral signal of the organizer,functions of the organizer, epidermal induction.

**2. Regeneration:**Regeneration of animals with special emphasis on the process of regeneration in Hydra and Amphibia.

**3. Beginning a new organism:** Fertilization in sea urchin and Mammals, the chemoattraction of sperm and egg,species specific binding of acrosomal process, the fast and slow block of polyspermy,role of calcium and egg activation in sea urchin. egg, Translocation and Capacitation in mammals,recognition at zonapellucida,mouse acrosome reaction and gamete fusion

**Reference books:**

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

**Group B: Neuro-Immuno Endocrinology**

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

**Reference books:**

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

## ZOO-403A FISHERY SPECIAL

### Aquaculture & Fish Technology and Inland & Marine fisheries

#### Group A: Aquaculture & Fish Technology

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

#### Reference books:

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

#### Group B. Inland and Marine fisheries

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

#### Reference books:

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

## ZOO-403B ECOLOGY SPECIAL

### Systems Ecology & Human Ecology

#### Group A: Systems Ecology

- 1. Community Ecology:** Biotic community: Abundance, Frequency, Relative Abundance, Dominance and Dominance index, Species Diversity and Evenness indices.  $\alpha$ ,  $\beta$ ,  $\gamma$  diversity. Species diversity hypotheses, Species diversity in ecological gradient. Metacommunity concept: Metapopulation structure. Fragmentation of habitat. Metacommunity dynamics: empirical examples.
- 2. Restoration Ecology:** Definition, Philosophy and rationale for ecorestoration, Ecological restoration and sustainability, Process of ecorestoration – in the context of landscape to species level.
- 3. Ecotourism:** Definition, sustainable development and ecotourism, Foundation of ecotourism, Economics and management issues, merits and demerits.
4. Ecosystem services and human wellbeing. Ecological Economics.
- 5. Mathematical Ecology:** Basic concept of ecological modeling; Deterministic and Stochastic models; Theoretical model and analytical solution. - Patterns of Spatial distribution - Random, contagious and regular, coefficient of dispersion. Index of



similarity and index of association.

#### **6. System structure and function:**

a. Aquatic system: Physiography of freshwater ecosystems, stratification, distributions and mixing patterns. Dynamics of light, oxygen and nutrient content.

b. Terrestrial system: Soils of West Bengal. Ecological processes in Tropical forest ecosystem - Vertical stratification of plants and animals. Production and nutrient cycling. Leaf litter decomposition. Assessment of health of forests / vegetation.

#### **Reference books:**

- Elements of Ecology- Thomas Michael Smith, Robert Leo Smith – 2015.
- Ecology: Global Insights and Investigations- Peter Stiling – 2011.
- Issues and Perspectives in Landscape Ecology- John A. Wiens, Michael R. Moss. 2005.
- Handbook of Ecological Restoration – Vol. 2. - Martin R. Perrow, Anthony J. Davy. 2002.

### **Group B: Human Ecology**

**1. Global Environmental Issues; Global warming** – climate change; Acid rain; Stratospheric

ozone layer destruction; Thermal Inversion – Smog, Point and Non-point pollution – fertilizers and pesticides. Carbon sequestration and landscape change.

**2. Solid waste recycling:** Agriculture, Municipal, Biomedical Wastes – nature, source, environmental impact and management. Wastes in ecosystems and management-urban waste, industrial waste, agricultural waste, radioactive waste, medical waste- effects and control.

**3. Environmental Management and Acts:** Environmental Impact Assessment: Definition; Types of EIA, EIA process and methodologies – scoping, prediction, evaluation, mitigation and monitoring; Socioeconomic impact assessment; EIA Notification. Environmental Management System, Ecomark.

**4. Urbanization:** Urban environment – criteria and its present global status, major environmental problems of cities. Urban impact on air and water environment, on biodiversity, agriculture; Indoor Pollution – characteristic of indoor environment, common indoor pollutants, their sources and mode of action; Effect of urbanization on biodiversity.

**5. Wasteland and watershed management:** Concept – integrated process and mechanism of wasteland restoration and watershed management; Soil erosion – types and factors.

**6. Bioinvasion:** Related terminologies; Underlying operating principles; Ecological Consequences—Case Studies.

### **Paper ZOO-494**

#### **Practical**

1. Biodiversity and Environmental stress

i. Qualitative and quantitative estimation of soil and aquatic biodiversity.

ii. Basic principles for the estimation of heavy metals.

iii. BOD and COD estimation.

2. Biostatistics

i. Chi square test for goodness of fit with a Mendelian frequency distribution.

ii. Computation and significance test of product – moment  $r$  between two continuous measurement variables.

iii. Computation of simple linear regression.

iv. Computation of variance ratio (F) and multiple comparison of Scheffe's F

test for one-way anova and their interpretation.

v. Significance of observed sex ratios using binomial distribution.

### **3. Developmental biology**

i. Extraction and identification of different stages of chick embryos (24 hours, 48 hours and 72 hours)

ii. Histological sectioning and staining of different stages of chick embryo.

### **4. Neuro-Immuno Endocrinology**

i. Neuroendocrine structure demonstration in invertebrates

ii. Endocrine structure in fish

iii. Auto-micrograph of neurosecretory elements.

iv. Neurohistological techniques

## **ZOO-495A Fishery**

### **Practical**

1. Identification of Shellfish, macrophytes and aquatic insects.

2. Physicochemical characteristics of water – salinity, organic carbon, nitrogen, potassium, phosphorus, turbidity and pH.

3. Calculation of - Length weight relationship, 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 fin-fish and shell fish. ARO System of fish.

9. Biochemical parameter demonstration: pH, Dissolve Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, turbidity, etc.

## **ZOO-495B Ecology**

### **Practical**

1. Estimation of the degree of faunal similarity and association between species.

2. Computation of microdistribution pattern for spatial distribution.

3. Estimation of alpha, beta and gamma diversity.

4. Analysis of the structure of biotic community: Abundance, Relative abundance, Frequency, Species diversity and Dominance indices; Shannon-Weiner diversity index and Importance Value Index.

5. Estimation of textural composition and Water Holding Capacity of soil.

6. Evaluation of Restoration sites; Study of forest/vegetation health- Estimation of tree height, DBH, stand density, canopy density and tree biomass

7. Vermitechnology and related matter: Analysis of biota from urban waste materials & identification of suitable specimen for vermicomposting.

8. Air pollution monitoring: demonstration of Air sampler

9. Submission of Laboratory notebook.

10. Viva-voce

## **PROJECT/DISSERTATION**

### **Special Paper**

#### **Dissertation/ project**

#### **ZOO-496A: Fishery**

#### **ZOO-496B: Ecology**

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