

**UNIVERSITY OF NORTH BENGAL**

**M.Sc. SYLLABUS IN ZOOLOGY**  
**Choice Based Credit System**  
**(Implemented from Session 2020-21)**

**University of North Bengal**

## PG Syllabus in Zoology

<b>SEMESTER-I</b>												
Sem	Crs	Course	New Course Code (Alpha-Numeric)	Paper Type	Course name	Course Type	Full Marks (External)	Full marks (Practical)	Full Marks (Internal)	Total FM	Credit	Paper sequen ce
1	327	Zoology	ZOOL-CT-101A	T	Functional Biology of Non-Chordates: Maintenance Systems	Core Theory	25		20	70	2.8	1
			ZOOL-CT-101B	T	Functional Biology of Non-Chordates: Support, Control and Development System		25					2
			ZOOL-CT-102A	T	Functional Biology of Chordates:UnitI		25		20	70	2.8	3
			ZOOL-CT-102B	T	Functional Biology of Chordates:UnitII		25					4
			ZOOL-CT-103A	T	Biochemistry: Structure & Function		25		20	70	2.8	5
			ZOOL-CT-103B	T	Biochemistry: Bioenergetics and Metabolism		25					6
			ZOOL-CT-104A	T	Genetics		25		20	70	2.8	7
			ZOOL-CT-104B	T	Cell Biology		25					8
			ZOOL-CP-105	P	Non Chordate & Chordate	Core		50		50	2.0	9

		ZOOL-CP-106	P	Genetics and Cell Biology	Practical		50		50	2.0	10
		ZOOL-CP-107	P	Seminar				20	20	0.8	11
					TOTAL	200	100	100	400	16.0	

SEMESTER-II														
Sem	Crs	Course	New Course Code (Alpha-Numeric)	Paper Type	Course name	Course Type	Full Marks (External)	Full Marks (Practical)	Full Marks (Internal)	Total FM	Credit	Paper Sequence		
2	327	Zoology	ZOOL-CT-201A	T	Immunology: Organization of Immune System	Core Theory	25		20	70	2.8	1		
			ZOOL-CT-201B	T	Immunology: Function of Immune System		25				2			
			ZOOL-CT-202A	T	Ecology		25		20	70	2.8	3		
			ZOOL-CT-202B	T	Aquaculture		25				4			
			ZOOL-CT-203A	T	Insect Biology		25		20	70	2.8	5		
			ZOOL-CT-203B	T	Insect Biology		25				6			
			ZOOL-CT-204A	T	Biotechnology		25		20	70	2.8	7		
			ZOOL-CT-204B	T	Biotechnology		25				8			
			ZOOL-CP-205	P	Biochemistry, Ecology & Aquaculture	Core Practical		50		50	2.0	9		
			ZOOL-CP-206	P	Immunology and Biotechnology			50		50	2.0	10		
			ZOOL-CP-207	P	Review of published article			20		20	0.8	11		
								TOTAL	200	120	80	400	16	

## SEMESTER-III

Sem	Crs	Course	New Course Code (Alpha-Numeric)	Paper Type	Course name	Course Type	Full Marks (External)	Full Marks (Practical)	Full Marks (Internal)	Total FM	Credit	Paper Sequence			
3	327	Zoology	ZOOL-CT-301A	T	Biodiversity	Core Theory	25		20	70	2.80	1			
			ZOOL-CT-301B	T	Wildlife		25					2			
			ZOOL-CT-302A	T	Biophysics		25					3			
			ZOOL-CT-302B	T	Biostatistics		25						4		
			ZOOL-CT-303A	T	Developmental Biology		25						5		
			ZOOL-CT-303B	T	Gamete Biology		25							6	
			ZOOL-ET-304A	T	Cellular Immunology	Elective Theory (choose any one)	37.5						3.80	7	
			ZOOL-ET-304B	T	Molecular Immunology										
			ZOOL-ET-305A	T	Ecology: Organism and Environment										
			ZOOL-ET-305B	T	Ecology: Organism and Environment										
			ZOOL-ET-306A	T	Insect Physiology & Biochemistry										
			ZOOL-ET-306B	T	Industrial Entomology										
			ZOOL-ET-307A	T	Applied Ichthyology		37.5								8
			ZOOL-ET-307B	T	Aquaculture										
ZOOL-ET-308A	T	Molecular Cell Biology													
ZOOL-ET-308B	T	Molecular Cell Biology													
ZOOL-CP-309	P	Developmental Biology & Gamete Biology	Core Practical		40			40	1.60	9					

		ZOOL-CP-310	P	Seminar		25		25	1.00	10
		ZOOL-CP-311	P	Institutional Visit/Field Training		30		30	1.20	11
					TOTAL	<b>225</b>	95	80	400	16.00

### SEMESTER-IV

Sem	Crs	Course	New Course Code (Alpha-Numeric)	Paper Type	Course name	Course Type	Full Marks (External)	Full Marks (Practical)	Full Marks (Internal)	Total FM	Credit	Paper Sequence	
4	327	Zoology	ZOOL-CT-401A	T	Animal Physiology	Core Theory	25		20	70	2.80	1	
			ZOOL-CT-401B	T	Endocrinology	Theory	25						2
			ZOOL-CT-402A	T	Evolution & Population Genetics		25		20	70	2.80		3
			ZOOL-CT-402B	T	Biosystematics		25						4
			ZOOL-ET-403A	T	Clinical Immunology	Elective Theory (Choose any one)	37.5		20	95	3.80	5	
			ZOOL-ET-404A	T	Environmental Biology								
			ZOOL-ET-405A	T	Insect Pests								
			ZOOL-ET-406A	T	Fish Technology								
			ZOOL-ET-407A	T	Molecular Genetics								
			ZOOL-ET-403B	T	Applied Immunology	Elective Theory (Choose any one)	37.5					6	
			ZOOL-ET-404B	T	Environmental Biology								
			ZOOL-ET-405B	T	Insect Pest Management								
			ZOOL-ET-406B	T	Management and Marine Capture Fishery								
			ZOOL-ET-407B	T	Molecular Genetics								
ZOOL-CP-408	P	Animal Physiology & Endocrinology	Core Practical			50		50	2	7			
ZOOL-EP-409	P	Practical Corresponding to Paper 403	Elective Course										
ZOOL-EP-410	P	Practical Corresponding to	Practical										

		Paper 404	(Choose		50		50	2	8
		ZOOL-EP-411	P	Practical Corresponding to Paper 405	one related				
		ZOOL-EP-412	P	Practical Corresponding to Paper 406	to the theory)				
		ZOOL-EP-413	P	Practical Corresponding to Paper 407					
		ZOOL-EP-414	P	Dissertation/Review & viva voce	Elective Practical	40	40	1.6	9
		ZOOL-CP-415	P	Comprehensive viva voce	Core Practical	25	25	1.0	10
					TOTAL	175	165	60	400
								16	



# **M.Sc. Syllabus in Zoology**

## **FIRST SEMESTER**

### **CORE COURSE THEORY**

**ZOOL-CT-101: Functional Biology of Non-chordates**

**Marks 50**

**ZOOL-CT-101A: Functional Biology of Maintenance Systems**

**Marks 25**

1. Nutrition and Digestion:
  - a) Source of nutrition, types and structure of feeding organs
  - b) Feeding patterns in non-chordates
2. Respiration:
  - a) Physical factors, respiratory pigments in non-chordates
  - b) Mechanism of respiration by gills, book lungs and tracheae
3. Excretion:
  - a) Excretory products, structures and mechanisms of excretion in non-chordates
  - b) Osmoregulation in non-chordates

**ZOOL-CT-101B: Functional Biology of Support, Control and Development System**

**Marks 25**

1. Locomotion:
  - a) Locomotory structures; Amoeboid, Flagellar and Ciliary movements; hydrostatic movement in Cnidaria, Annelida and Echinodermata
  - b) Significance of segmentation with reference to locomotion
2. Nervous system:

- a) Primitive and advanced type of Sensory and Nervous system
- b) Trend of neural evolution in Non-chordates
- 3. Non-chordate larva:
  - a) Types, structure and organization of non-chordate larval forms
  - b) Evolutionary significance of larval forms

**ZOOL-CT-102: Functional Biology of Chordates:**

**Marks 50**

**ZOOL-CT-102A: Functional Biology of Chordates: Unit I**

**Marks 25**

1. Basic vertebrate body plan and characteristics
2. Mechanics of body support and movement
3. Ectothermic and Endothermic mode of life
4. Aerodynamics and energetics of flying and gliding
5. Auditory system : Evolutionary changes and adaptive advantage
6. Organs of olfaction and taste

**ZOOL-CT-102B: Functional Biology of Chordates: Unit II**

**Marks 25**

1. Functional and evolutionary significance, cranial kinesis, intracranial mobility in feeding mechanisms; digestion in chordates
2. Respiratory system and its functional requirements; ventilator mechanisms in chordates
3. Heart and circulation in mammals; structure and evolution of portal system
4. Structure and function of kidney in mammals
5. Evolution of cerebrum, functional association of CNS and information processing, role of encephalization in higher brain function.

**ZOOL-CT-103: Biochemistry**

**Marks 50**

**ZOOL-CT-103A: Structure and Function**

**Marks 25**

1. Amino Acids, Protein structure and function

2. Enzymes : Kinetics, function, inhibition and regulation; Ribozymes and Deoxyribozymes
3. Coenzymes and vitamins
4. Carbohydrates : Structure and functions
5. Lipids : Storage lipids, Structural lipids in membranes, Lipids as signals, cofactors and pigments

**ZOOL-CT-103B: Bioenergetics and Metabolism**

**Marks 25**

1. Bioenergetics : Principle of bioenergetics , Glycolysis and its regulation, Citric acid cycle and its regulation,
2. Oxidative Phosphorylation, Electron-transfer reactions in mitochondria.
3. Biosynthesis: Biosynthesis of Carbohydrates, Lipids, Amino Acids and Nucleotides.
4. Amino Acid and Fatty acid catabolism.
5. Bio-transformations: Principle of detoxifications, Detoxifying enzymes, Phase I and Phase II reactions.

**ZOOL-CT-104: Cell Biology and Genetics**

**Marks 50**

**ZOOL-CT-104A: Genetics**

**Marks: 25**

1. Gene Concept: i) Overview of Mendelism ii) One gene one polypeptide hypothesis iii) Concept of Cistron: Benzer's experiment iv) Modern view
2. Recombination: i) Concept of homologous recombination, Gene Conversion ii) Site Specific Recombination: Ser/Tyr recombinases & mechanism of action iii) FLP-FRT and Cre-lox systems and application
3. Microbial genetics: Transformation, Conjugation, Sexduction and Transduction,
4. Gene Regulation: i) Operon and regulon, ii) Trp operon, iii) Lytic and lysogeny in Bacteriophage
5. Mobile genetic elements: i) IS elements, transposons (Prokaryotes and eukaryotes), ii) Retero elements, LINES and SINES, iii) Mechanism of Transposition, iv) Exon – Shuffling Lateral Gene transfer, v) Germ line transformation by P-element, Transposon tagging
6. Gene mapping: i) Three point test cross, ii) Southern hybridization, Northern hybridization, In situ hybridization, FISH, iii) Somatic Cell hybridization and gene mapping, iv) Molecular Marker: RFLP, RAPD, AFLP, SNP
7. Molecular Diagnosis and Genetic Screening: Disorders of hemoglobin synthesis, Sickle-cell anemia, Cystic fibrosis.

**ZOOL-CT-104B: Cell Biology****Marks: 25**

1. Genome Organization: i) Prokaryotes, ii) Chromosomes, Centromere, Telomere, iii) Sequence organization of Non-coding DNA in Eukaryotes, iv) Reassociation kinetics and genome complexity, C-value paradox
2. Cell Cycle: i) Phases and Cell Cycle Control, ii) Check points and DNA Damage Response (Sensor, mediator, Effector, Regulator) and regulation, (iii) Regulations of Meiosis (iv) Cell cycle and Cancer
3. Protein Synthesis: i) Transcription in Eukaryotes: General transcript factor, RNA Polymerases, Mechanism, Splicing, Exon and Intron Definition, Transcription Coupled Repaired & XP ii) Translation in Eukaryotes: tRNA, rRNA and mRNA, tRNA synthetase, Mechanism of Translation
4. Protein folding: Chaperon & Mechanism, Post translational modifications
5. Cell Surface Molecules: i) Ca<sup>2+</sup> dependent cell-adhesion molecule ii) Ca<sup>2+</sup> independent cell-adhesion molecules, iii) ECM, Integrins, iv) Connexins v) Cell Signaling
6. Apoptosis :
  - i) Definition and features of apoptic cells
  - ii) Mechanism and apoptotic pathways: Receptor mediated and Mitochondria mediated pathways, Apoptosis and Disease
7. Extra Cellular organelle: Mitochondrial DNA

**CORE COURSE PRACTICAL****ZOOL-CP-105: Non-Chordate and Chordate****Marks 50****Non-Chordate:**

1. Mounting of :
  - a) Protozoans: i) Gregarine, ii) *Paramoecium*, iii) *Nectotherus*, iv) *Amoeba*, iv) *Opalina*
  - b) Helminthes: i) Soil nematode, ii) Gut nematode of fish / Toad.
  - c) Annelids: i) *Tubifex*, ii) Setae, septal nephridia, Spermatheca of Earthworm.

d) Arthropods: i) *Cyclops*, ii) *Daphnia*, iii) Mosquito mouth parts.

2. Key preparation to different categories (up to order) for following examples:

1. Protista: i) *Plasmodium*, ii) *Haemoproteus*, iii) *Amoeba*, iv) *Entamoeba*, v) *Euglena*, vi) *Trypanosoma*, vii) *Giardia*, viii) *Paramecium*, ix) *Nectotherus*, x) *Trypanosoma*, xi) *Leishmania*, xii) *Eimeria*, xiii) *Monocystis*
2. Porifera: i) *Ascon* ii) *Sycon* iii) *Leucon* (Whole animal & TS/LS of these sponge types.)
3. Cnidaria: i) *Hydra*, ii) *Obelia*, iii) *Porpita* iv) *Siphonophora*, v) *Aurelia*, vi) *Metridium*, vii) *Fungia*, viii) *Madrepora*, ix) *Pennatula* x) *Corallium*
4. Platyhelminthes: i) *Dugesia/Planaria*, ii) *Schistosoma*, iii) *Taenia*, iv) *Fasciola*,
5. Nematoda : i) *Ascaris* ii) *Anchylostoma*, iii) *Wuchereria*
6. Annelida: i) *Pheretima/Metaphire / Eutyphoeus*, ii) *Tubifex*, iii) *Hirudo (Cattle Leech)*, iv) *Terebella*,
7. Arthropoda: i) *Palaemon/ Macrobrachium/Penaeus*, ii) *Hippa*, iii) *Balanus*, iv) *Lepus*, v) *Eupagurus*, *Lacnosterna (dungbeelte)*, *Periplaneta*, *Odontotermis* vi) *Lethocerus*, vii) *Flea* viii) *Pediculus*, ix) *Carcinoscorpius/Tachypleus*, x) *Scorpion*, xi) *Spider*, xii) *Tick*, xiii) *Mite*, xiv) *Cimex*, xv) *Leptocorisa*, xvi) *Aphis*, xvii) *Culex*, *Anopheles*, *Aedes* male and female.
8. Mollusca: i) *Chiton*, ii) *Pila*, iii) *Aplysia/Doris*, iv) *Achatina*, v) *Dentalium*, vi) *Lamellidens*, vii) *Loligo*, viii) *Sepia*, ix) *Octopus*, x) *Nautilus* (or Shell)
9. Echinodermata: i) *Antedon*, ii) *Asterias*, iii) *Ophiocoma / brittle star*, iv) *Holothuria/ Sea cucumber*, v) *Echinus*
10. Minor phyla: i) *Echiurus*, ii) *Lingula*, iii) *Rotifera*, iv) *Bryozoa*.

### **Chordate [Study of internal Morphology/Demonstration]**

1. Location and extraction of pituitary gland of a carp
2. Accessory air-breathing organs of *Anabas/Clarias/Heteropneustes* (market specimen)
3. Gallus Head (market specimen) : 5<sup>th</sup> and 7<sup>th</sup> cranial nerves
4. Rattus/Mice (Laboratory bred): Arterial system and Nerves of the neck region
5. Preparation of key to different categories of Chordate specimens up to orders (preferably considering one typical specimen of each order)

**ZOOL-CP-106: Genetics and Cell Biology**

**Marks 50**

1. Study of mitosis from root tip of *Allium cepa*.
2. Study of meiosis from grasshopper testes.
3. Study of mitosis and meiosis of Rat/mouse by Flame dry method
4. Karyotype preparation (Human)
5. Study of Barr body preparation
6. Study of polytene chromosome from the salivary glands of *Drosophila*
7. Study of common mutants in *Drosophila*, *Drosophila* food preparation.
8. Detection of ABO Blood groups and determination of gene frequencies in human population
9. Genomic DNA extraction. Quantitation of DNA by UV-spectrophotometer
10. Electrophoretic separation of Protein and DNA (Demonstration)

**CONTINUING EVALUATION**

**ZOOL-CT-101 – 104 (Class Test)**

**Marks 20 x 4=80**

**ABILITY ENHANCEMENT COURSE**

**ZOOL-CP-107: Seminar**

**Marks 20**

## **M.Sc. Syllabus in Zoology**

### **SECOND SEMESTER**

#### **CORE COURSE THEORY**

##### **ZOOL-CT-201: Immunology**

**Marks 50**

##### **ZOOL-CT-201A: Organization of Immune System**

**Marks 25**

1. Properties and overview of Immune Responses
2. Cells and Tissues of the Immune System
3. Immunogen characteristics.
4. Antibody: Structural Features of Antibody molecule , Synthesis, assembly and expression of Ig molecules, Antibody diversity.
5. Complement.
6. Concept of Major Histocompatibility Complex of mouse and human, Antigen processing and presentation.

##### **ZOOL-CT-201B: Function of Immune System**

**Marks 25**

1. Lymphocyte activation.
2. Cytotoxicity.
3. Cytokines, Interferons
5. Concept of tolerance and autoimmunity
6. Hypersensitivity.

##### **ZOOL-CT-202: Ecology and Aquaculture**

**Marks 50**

##### **ZOOL-CT-202A: Ecology**

**Marks 25**

1. Community Ecology: Biotic community concept, ecological dominance, Community analysis, species diversity, ecotone and edge effects
2. Population Ecology: Growth patterns, dynamics, life table, survivorship curve Doubling time, natality, mortality, age distribution, intrinsic rate of natural increase, oscillation, regulation, dispersal, concept of metapopulations
3. Freshwater Ecology: Characteristics, limiting factors, nutrient status, classifications of fresh water organisms, fresh water biota, lentic communities, lotic communities, zonation of rivers/ streams and wet lands.
4. Terrestrial Ecology: Terrestrial environment, terrestrial biota, bio-geographic regions, structure of communities, soil subsystem and vegetation subsystem.
5. Wildlife Ecology: Wildlife biology – an overview, food, nutrition and water requirements and cover.
6. Behavioral Ecology: Ethology; Definition, Scope, Importance, Classification, Basic concepts and models of Classical Ethology.

#### **ZOOL-CT-202B: Aquaculture**

**Marks 25**

1. Aquaculture: Definition, scope and importance; Aquaplosion; Aquaranching
2. Concepts of different systems of aquaculture with their prospects: Monoculture; Polyculture/ Composite fish farming; Integrated fish farming; Cage culture; Pen culture; Raceway culture; Water Recirculating System; Extensive, Intensive, Semi-intensive and Traditional systems of fish farming, Ornamental fishes; Air-breathing fishes; Freshwater and Marine prawns
3. Design, criteria (soil & water) and construction of aqua farms.
4. Management aspects of cultivable fish ponds (Nursery, rearing and stocking)
5. Hypophysation technique; Concept of Bundh breeding and Synthetic Hormones (Ovaprim, WOVA-FH, etc.)
6. Basic Concepts of Fish Genetics and Biotechnology: Hybridization , selective breeding, androgenesis, gynogenesis, polyploidy, Cryopreservation, Trangenesis and Sex reversal
7. Common diseases: Viral, bacterial, fungal, protozoan, helminths and crustaceans – their symptoms and control remedies, Ideas on Air-embolism, Sunburn.
8. Limnology – Water quality parameters of significance to fish/prawn health
9. Coldwater/Hill stream fishery , Definition, Characteristics of coldwater/ Hill stream bodies, Adaptations of coldwater/ Hill stream fishes, Major genera of coldwater/ Hill stream fishes.



10. Mariculture – Definition, scope and fisheries (Pearls and Edible Oysters)

**ZOOL-CT-203: Insect Biology**

**Marks 50**

**ZOOL-CT-203A: Insect Biology**

**Marks 25**

1. Insect Classification – Major order with characters and examples
2. Trophic adaptations in insects
3. Reproductive strategies in insects
4. Insect Development and Metamorphosis
5. Insect Predation, Parasitism and Defence

**ZOOL-CT-203B: Insect Biology**

**Marks 25**

1. Concept of pest status and classification of Pesticides
2. Introduction to major pests and vectors of medical, veterinary and agricultural importance from India and their Control
3. Influence of climate and environment change on insect & mite pests
4. Pest Forecasting, Assessing of Crop damage and Protection
5. Methods of insect pest control: Conventional and Non-Conventional  
Concept of Integrated Pest Management (IPM)

**ZOOL-CT-204: Biotechnology**

**Marks 50**

**ZOOL-CT-204A: Biotechnology**

**Marks 25**

1. Recombinant DNA technology : Restriction Endonucleases, Vectors, Cloning strategies, selection of recombinant DNA, DNA sequencing, PCR (basic knowledge), Genomic and cDNA libraries : constructions and screening
2. Expression Vectors and expression of fusion proteins
3. Site directed mutagenesis : strategies and prospects

**ZOOL-CT-204B: Biotechnology****Marks 25**

1. Transgenic Animals : production, prospects, advantages and disadvantages
2. Applications of recombinant DNA technology in human gene therapy, vaccine development, environmental bioremediation and protein engineering
3. Microbial synthesis of commercial products : restriction endonucleases, antibiotics, vitamins, amino acids and industrial dyes

**CORE COURSE PRACTICAL****ZOOL-CP-205: Biochemistry, Ecology and Aquaculture****Marks 50**

1. Estimation of sugars by Somogyi Nelson method.
2. Estimation of proteins by Folin Lowry method.
3. Estimation of saponification Values of Oils and Fats.
4. Electrophoretic study of proteins by SDS – PAGE
5. Water Analysis – Estimation of dissolved oxygen; free carbon dioxide; total alkalinity; total hardness and chloride
6. Soil analysis – Estimation of percentage of calcium carbonate by rapid titration method;
7. Estimation of Organic-carbon by wet oxidation method
8. Estimation of primary productivity of aquatic ecosystems using light and dark bottle method.
9. Qualitative and quantitative estimation of phyto and zooplanktons of fish ponds/streams.
10. Determination of requisite size of quadrat by species area curve.
11. Comments on Ecological specimens and Limnological apparatus.

**ZOOL-CP-206: Immunology and Biotechnology****Marks 50**

1. Collection of plasma and serum
2. Determination of antibody titre by Haemagglutination test
3. Study of lymphoid organs *in situ*

4. Preparation of lymphocytes suspension from solid lymphoid tissues
5. Separation of immune-reactive cell types and viability test, fixation, staining and identification
6. Bacterial Culture: Agar plate, slant, liquid media.
7. Transformation of *E.coli* with plasmid
8. Plasmid isolation: Boiling miniprep only
9. Electrophoretic analyses of uncut and linearized plasmids.
10. Electrophoresis for separation of plasma proteins, Ig classes.

**CONTINUING EVALUATION**

**ZOOL-CC-201 – 204** (Class Test)

**Marks 20 x 4=80**

**ABILITY ENHANCEMENT COURSE**

**ZOOL-CP-207: Review of Published Articles**

**Marks 20**

## M.Sc. Syllabus in Zoology

### THIRD SEMESTER

#### CORE COURSE THEORY

##### **ZOOL-CT-301: Biodiversity and Wildlife**

**Marks 50**

##### **ZOOL-CT-301A: Biodiversity**

**Marks 25**

1. Definition and indices of biodiversity
2. Levels of biodiversity: genetic, species and ecosystem
3. Values and uses of Biodiversity
4. Megadiversity and hotspots of Biodiversity
5. Threats to biodiversity

##### **ZOOL-CT-301B: Wildlife**

**Marks 25**

1. Definition of wildlife & Rationale for wildlife conservation
2. Classification of wildlife according to severity of threats, CITES, WWF, BLI, IUCN, BNHS, IOBP, WLII
3. Models of wildlife management and conservation with special emphasis on Eastern Himalayan & Terai Wildlife
4. *In situ* and *ex situ* conservation: prospects and limitations
5. Socio-economic perspective of wildlife conservation

##### **ZOOL-CT-302: Biophysics and Biostatistics**

**Marks 50**

##### **ZOOL-CT-302A: Biophysics**

**Marks 25**

1. Principles and uses of analytical instruments: Spectrophotometer, Spectrofluorometer, Mass Spectrometry
2. Microscopy: Fluorescence and Confocal Microscopy, GFP, FISH, GISH, FRET

3. Chromatography: Principles, Column chromatography, GLC, HPLC, Ion-exchange chromatography, Gel exclusion chromatography, Affinity chromatography
4. Electrophoresis: Basic principles, PAGE, Agarose gel electrophoresis, 2-D gel electrophoresis
5. Centrifugation: Basic principles of Sedimentation, Differential and Density gradient centrifugation
6. Crystallography and X-ray diffraction, Basic idea of NMR
7. Radioisotope techniques: Radioactivity and half life, radioisotopes, units of radioactivity, G-M counter, solid and liquid scintillation counter, Metabolic labeling, Applications of radioisotopes in Biology.

**ZOOL-CT-302B: Biostatistics**

**Marks 25**

1. Biostatistics/Biometry: Definition and utilization in biological studies
2. Basic concepts of:
  - a. Terminologies used in biostatistics: Variable, Population, Data, Sample, Estimate.
  - b. Measures of Central Tendency
  - c. Measures of Variation
  - d. Graphical representation of data
3. Hypothesis Testing and Students' "t" distribution
4. Probability Distribution – Concept of Probability, Binomial Distribution and Poisson Distribution
5. Simple Linear Regression and Correlation
6. Chi-Square Test
7. Analysis of Variance
8. Models: Definition, Classification, Usefulness.

**ZOOL-CT-303: Development Biology and Gamete Biology**

**Marks 50**

**ZOOL-CT-303A: Development Biology**

**Marks 25**

1. The genetic core of development: Differential gene expression: Differential gene transcription, Methylation pattern and the control of transcription, Transcriptional regulation of an entire chromosome: dosage compensation, Differential RNA processing.
2. Cell-cell communication in development: Induction and competence, Paracrine factors, Cell surface receptors and their signal transduction pathways, Juxtacrine signaling, Cross-talk between pathways.
3. The genetics of axis specification in Drosophila: Early Drosophila development, the origins of Anterior-Posterior Polarity, the generation of Dorsal-Ventral Polarity.
4. Metamorphosis, regeneration, and aging

**ZOOL-CT-303B: Gamete Biology**

**Marks 25**

1. Biochemistry of semen: semen composition and formation, assessment of sperm function.
2. Biology of sex determination and sex differentiation –a comparative account.
3. Multiple ovulation and embryo transfer technology: in vitro oocyte maturation, super ovulation.
4. Hormonal regulation of ovulation, pregnancy and parturition.
5. Cryopreservation of gametes and embryo.
6. Teratological effects of xenobiotics on gametes.
7. Development of gonads.
8. Embryonic stem cells, renewal by stem cells, epidermis.

**ELECTIVE COURSES**

**ZOOL-ET-304: Cellular and Molecular Immunology**

**Marks 75**

**ZOOL-ET-304A: Cellular Immunology**

**Marks 37.5**

1. Innate Immunity: Cell – associated pattern recognition receptors including TLRs of innate immunity, Recognition of microbes of and damaged self by the innate immune system.

2. Differentiation and maturation of B and T cell, positive and negative selection, Generation of receptor diversity.
3. Tolerance & Autoimmunity.
4. Neuro-Immunology: Glial cells, Hypothalamic-Pituitary-Adreno cortical Axis (HPA) immune system interaction.

**ZOOL-ET-304B: Molecular Immunology**

**Marks 37.5**

1. Antigen: Physical and chemical nature, structure, antigenic determinants.
2. Antibody: Three dimensional structure, subclasses, binding forces of antigen and antibody.
3. Complement
4. Cytokines.
5. Organization of MHC in mouse and human, Polymorphism, Antigen presentation and MHC restriction,

**ZOOL-ET-305: Ecology**

**Marks 75**

**ZOOL-ET-305A: Organism and Environment**

**Marks 37.5**

1. Principles pertaining to limiting factors:  
Liebig's law of the minimum, Shelford's Law of tolerance, Law of limiting factors,  
Factor compensation and ecotypes, Combined concept of limiting factors.
2. Concept of habitat and Niche:  
Habitat and microhabitat, Development of Niche concept, Niche width,  
Niche overlap, Diffuse competition, Niche dynamics, Niche – a property of the species or the community, Ecological equivalents, Character displacement  
Sympatry, Allopatry.
3. Soil : Composition, Soil profile, Soil formation, Soil classification and distribution.
4. Radiation ecology: Types of ionizing radiations, Radionuclides of ecological importance, Comparative radio sensitivity, Fate of radionuclides in the environment, Fallout problems, Waste disposal

5. El-nino, La-nina, Southern oscillation and their ecological impact

**ZOOL-ET-305B: Organism and Environment**

**Marks 37.5**

6. Biological rhythms : Periodicity in the environment and in the organisms, Circadian rhythm – Selective advantage, Free-running activity, Temperature compensation, Ontogeny and ageing effect, Genetic control.
7. Ecosystem development: The strategy of ecosystem development, Concept of climax, Theories, Coevolution
8. Human Ecology: Ecological back ground of human origin, Disruptive and directional selection, Brain evolution, Social innovation, Population ecology of man.
9. Wildlife Ecology
10. Community Ecology: Relation between and within species.

**ZOOL-ET-306: Insect Physiology & Biochemistry and Industrial Entomology**

**Marks 75**

**ZOOL-ET-306A: Insect Physiology & Biochemistry**

**Marks 37.5**

1. Insect hormones: Sources, biosynthesis, transport, mode of action and regulation of their titers
2. Haemolymph, Haemocytes and Insect immunity,
3. Intra-specific and inter-specific chemical and mechanical communications in insects
4. Insect flight and migration
5. Mechanism of changes in Insecticide Susceptibility/ Resistance

**ZOOL-ET-306B: Industrial Entomology**

**Marks 37.5**

1. Influence of abiotic factors (environment) on insects development: The Degree–Day Method
2. Genetics of mulberry silk moth in reference to voltinism and moulting. Breeding strategies in Mulberry silkworms & its diseases
3. Honey bee: Role in Pollination and production of honey, propolis and bee-wax; extraction and preservation of honey
4. Insect based drugs, dyes & food for man, fish, poultry and aesthetics



**ZOOL-ET-307: Applied Ichthyology and Aquaculture**

**Marks 75**

**ZOOL-ET-307A: Applied Ichthyology**

**Marks 37.5**

1. Fish Growth: Measurement of growth, patterns of growth (allometric, isometric, relative, absolute); Length – weight relationship; Condition factor or K-factor or Ponderal Index.
2. Fish Age: Methods of age determination; Length – Frequency method (Peterson Method).
3. Knowledge of Maturity, Fecundity and Gonado Somatic Index.
4. Fish Migration and effects of dam on migration.
5. Food and feeding

**ZOOL-ET-307B: Aquaculture**

**Marks 37.5**

1. Basic concepts of different systems of aquaculture (Monoculture, Polyculture, Integrated fish farming, Prawn farming, etc.).
  1. Fish toxicants
  2. Organic farming; Organic manures and Inorganic fertilizers in pond fertilization
  3. Composite fish farming – Principles, Management practices, Supplementary feeding, Intermediate harvesting.
  4. Fish nutrition – Supplementary feeding; Different kinds of processed feeds; Feed ingredients & Feed formulation; Micro-encapsulated diet; FCR and FCE; Dry & Moist feed; Medicated feed; Food energy.
  5. Sewage fed fisheries
  6. Soil and water quality criteria for pond fish culture

**ZOOL-ET-308: Molecular Cell Biology**

**Marks: 75**

**ZOOL-ET-308A: Molecular Cell Biology**

**Marks: 37.5**

1. Cell/Tissue culture techniques: i) Culture media, Properties, and preparation, ii) Primary cell culture, cell lines, Lymphocyte culture, Fibroblast culture, iii) Isolation of clones & Genetic variants, iv) Transformation of cell, v) Cell separation by FACS, Application of Cell culture, Spectral Karyotyping, FISH & its application
2. Replication: Telomere shortening and its replication

3. Transcription: i) Regulatory elements, DNA binding motifs of transcription factors, ii) Activators and Repressors of transcription, RRM iii) degradation of mRNAs, iv) Catalytic RNAs and Regulatory RNAs.
4. Translation: i) Regulation of translation, Post translational modifications ii) Protein degradation iii) Regulation of Translation
5. i) Mitochondrial DNA: Organization, replication and diseases, ii) Prion: replication, TSE, PrPc

**ZOOL-ET-308B: Molecular Cell Biology**

**Marks: 37.5**

1. Gene regulation in Eukaryotes: i) Alternative splicing, (ii) Post transcriptional gene silencing, (iii) Chromatin remodeling in gene regulation
2. Cell-cell signaling: i) Cell surface receptors, ii) G-protein coupled receptors, Signal amplification, iii) Signaling pathways - Cytokine receptor and JAK-STAT pathway, MAP kinase pathway, RTK and RAS Pathway
3. Stem Cell: i) Biology, Genetic regulation of stem cell and its application,
4. Biology of aging: cellular and molecular basis of aging and its genetic control
5. Molecular Virology: i) Biology, entry and replication strategy of DNA & RNA human viruses, ii) Gene expression and Regulation: SV40, HBV, Polyomaviruses, Influenza & HIV, iii) Antiviral strategies

**CORE COURSE PRACTICAL**

**Marks 40**

**ZOOL-CP-309: Developmental Biology and Gamete Biology**

1. After incubation the eggs for different days, take out the embryo and dissect out different organs, dissociate them and observe their characteristics and behavior, fix the cells.
2. Dissecting out of salivary gland and thymus from mouse embryo, making them ready for *in vitro* culture, trypsinization to separate ectoderm and mesoderm.
3. Stages of development up to three layer formation in different vertebrate classes (Desirable: Study in class with fresh fish/frog embryo).
4. Developing organs of chick in histological sections.
5. Identification of regeneration stages in histological preparation (hydra/limb of amphibian).
6. Surgical techniques such as adrenalectomy, thyroidectomy, castration, etc. to be done on rats or mice.
7. Histology of gonads.

8. Biochemical analysis of semen.

**CONTINUING EVALUATION**

**ZOOL-CT-301 – 303 (Class Test)**

**Marks 20 x 3=60**

**ZOOL-ET-304 – 308 (Class Test)**

**Marks 20 x 1=20**

**ZOOL-CP-310: Seminar**

**Marks 25**

**ABILITY ENHANCEMENT COURSE**

**ZOOL-CP-311: Institutional/ Field Training**

**Marks 30**

## M.Sc. Syllabus in Zoology

### FOURTH SEMESTER

#### CORE COURSE THEORY

#### ZOOL-CT-401: Animal Physiology & Endocrinology

Marks 50

#### ZOOL-CT-401A: Animal Physiology

Marks 25

1. Adaptation: i) The nature and levels of adaptation, ii) Fundamental mechanisms of adaptation
2. Respiration: Respiratory pigments; Oxygen dissociation curves; Transport of oxygen and carbondioxide; Bohr effect, Root effect & Haldane effect; Physiology of diving birds and mammals.
3. Circulation of body fluids – Patterns of circulatory systems in animals; Kinds of blood vessels; Conductive tissue systems of heart in mammals; Cardiac cycle; Concepts of Electro Cardio Gram (ECG); Blood pressure; Concepts of haemodynamics.
4. Excretion and Osmoregulation:
  - i) Excretion – Concept of excretory organs in animals; Gross anatomy of kidney in mammals; Glomerular Filtration Rate; Tubular reabsorption and secretion.
  - ii) Osmoregulation – Control of osmoregulation via ADH; Osmorgulation in aquatic and terrestrial animals.
5. Thermoregulation: Concepts of terminologies used (Endotherm, Ectotherm, Homeotherm, Poikilotherm, Heterotherm, etc); Concept of Temperature Coefficient ( $Q_{10}$ ); Adaptations to cold and heat by aquatic & terrestrial animals; Adaptive Hypothermia and Adaptive Hyperthermia; Thermal Neutral Zone; Thermogenesis, Evaporative cooling.
6. Molecular basis of nerve impulse generation and propagation
7. Neurotransmitters: Classification, synthesis, release and functions ; Synaptic transmission and Neuromodulation

#### ZOOL-CT-401B: Endocrinology

Marks 25

1. Mechanism of hormone action
2. Neuro-endocrine integration: Components, orders and feedback regulation
3. Pituitary gland : Hormones and regulations

4. Thyroid gland : Hormones and functions
5. Parathyroid gland : Parathyroid hormone and other regulators of calcium and phosphorus metabolism
6. Adrenal gland : Cortical and medullary hormones and their functions
7. Endocrine pancreas: regulation of blood sugar.
8. Pineal gland and its bioregulators
9. Hormones and reproduction : Male and female hormones and their functions

**ZOOL-CT-402: Evolution, Population Genetics and Biosystematics**

**Marks 50**

**ZOOL-CT-402A: Evolution and Population Genetics**

**Marks 25**

1. Speciation: Biological and Phylogenetic species concept, Patterns and Mechanisms of reproductive isolation; Genetic basis of Reproductive isolation Models of Speciation: Allopatric, Parapatric, Sympatric
2. Molecular Evolution: i) Protein & Gene evolution, Evolution of Multigene Family, ii) Acquisition of new genes: Mechanisms and Exon Theory, Concerted Evolution and Molecular Drive, Emergence of Non-Darwinism: Neutral Hypothesis, Molecular clock, Concept of Evolutionary Developmental Biology, Evolution of Novel Character, Heterochrony, RNA World
3. Origin and Evolution of man, Origin of speech and language
4. Population Genetics: Origin of Genetic variation in the natural population, Hardy-Weinberg law – Assumption, Derivation & application in population genetics, Equilibrium at two or more loci and X-linked loci, Measures of Genetic variation
5. Destabilizing forces influencing allele frequencies: Mutation, Natural Selection: Selection against recessive and recessive lethal, Selection against dominant, Heterozyote advantage, Mutation-Selection Balance, ) Migration and Genetic drift, Mutation – drift balance, Genetic load and Genetic death, Mutational load
6. Inbreeding: Measure of inbreeding, inbreeding depression, Heterosis
7. Quantitative traits: Polygenic concept, Genotype- environment interaction, phenotypic variance, Heritability & its estimation, Quantitative trait loci

**ZOOL-CT-402B: Biosystematics**

**Marks 25**

1. Species and supra- and infra- specific categories,
2. Zoological nomenclature; application of important rules
3. Phenetics and cladistics
4. Determination of genetic distance
5. Molecular Systematics and Phylogeny
6. Application of biosystematics (In war, pest & disease management and resource generation etc)

**ELECTIVE COURSE THEORY**

**Marks 75**

**ZOOL-ET-403: Clinical & Applied Immunology**

**Marks 75**

**ZOOL-ET-403A: Clinical Immunology**

**Marks 37.5**

1. Immunity to infectious diseases.
2. Tumor immunology.
3. HLA and disease association,
4. Immunodeficiency diseases including AIDS
5. Reproductive Immunology, HLA-G, KIR gene
6. Gene therapy

**ZOOL-ET-403B: Applied Immunology**

**Marks 37.5**

1. Monoclonal antibody, and usage
2. vaccines
3. HLA typing.
4. Techniques and technologies for quantitation of immunologically relevant molecules, substances and the cells and their uses for diagnostic purposes. Agglutination reaction, Precipitation reaction, immunodiffusion, immunoelectrophoresis, Radioimmunoassay, ELISA, FACS,MACS, PCR
5. Hybridoma technology

**ZOOL-ET-404: Environmental Biology**

**Marks 75**

**ZOOL-ET-404A: Environmental Biology**

**Marks 37.5**

1. Introduction to Environment:

Segments of Environment (Atmosphere, Lithosphere, Hydrosphere, Biosphere)

General view of climate change and global warming, evolution of atmosphere, temperature inversion, ozone depletion.

Earth System Processes, Major land formations, Geological Hazards (Earthquake, Volcano, Tsunami)

Municipal Solid Waste Management and Properties of leachate.

A general introduction to Environmental Impact Assessment (EIA) & Environmental audit.

2. Concepts of Elementary Environmental Chemistry and Ecotoxicology:

Green Chemistry, Biotransformation and degradation, Effect of pH,  $E_c$ , TDS, Salinity on biota, Dissolved oxygen, BOD (CBOD, NBOD, UBOD), COD, Oxygen sag curve.

Heavy metals, Pesticides, Bioconcentration, Bioaccumulation, Biomagnification, Eutrophication, Biomonitoring, Dose response relationship,  $LC_{50}$ ,  $LD_{50}$ , Bioassay techniques.

3. Endocrine Disruptors:

Endocrine disruption hypothesis, Environmental disruptors, Mechanism of endocrine disruption, Environmental consequences.

**ZOOL-ET-404B: Environmental Biology**

**Marks 37.5**

1. Evolution and Conservation Biology: Major biomes of India and World, Biogeography, Adaptations (High altitude, Desert, Deep Sea), Arms Race, Population growth models, Age pyramid, Restoration, Reclamation, Rehabilitation, Biomanipulation, Acceleration of Succession, Importance of forest and wetlands, Biodiversity, Types and levels of biodiversity, Conservation techniques (in-situ and ex-situ) Concept of Native, Indigenous, Keystone, Endemic, Exotic and Invasive species, Red Data Book, Theory of Reserve design, IUCN Categories, Biodiversity Hotspots with reference to Eastern Himalaya and North Bengal.

2. Applied Environmental Biology and Environmental Biotechnology: Soil biology (including Microbiology and Biochemistry of soil), Genetic Modified Organisms, Quorum Sensing and Quenching, Environmental Biotechnology for management of resources (Reclamation, Bioprospecting, Biomining, Biodiversity Conservation, DNA Barcoding and Alternative fuel) Use of microbes in solid waste management, Vermitechnology.
3. Tools and techniques in Environmental Biology: Techniques for sampling, Water and Soil Health analysis, Introduction to Software, Biodiversity PRO, SPSS.

**ZOOL-ET-405: Insect Pests and Management**

**Marks 75**

**ZOOL-ET-405A: Insect Pests**

**Marks 37.5**

1. Introduction to the important pests of Tea, Timber and stored grains: Symptoms of their attack and crop damage and management
2. Medical, veterinary and Forensic Entomology:
  - a) Vector biology: Mode of transmission of pathogens by vectors to major crop, man and livestock & their Control strategies
  - b) Insects associated with cadavers
  - c) Poisonous insects
  - d) Role of insect as decomposer
  - e) Insect and arthropods causing harm to livestock
3. Aquatic and Ground-dwelling Insects; Insects and Plants: Coevolution and Herbivory

**ZOOL-ET-405B: Insect Pest Management**

**Marks 37.5**

1. Concept of Economic levels:
  - a. Pest surveillance, sampling methods and forecasting
  - b. Economic threshold and injury level
  - c. Determination of EIL & Calculation of economic decision level
  - d. Insecticide Resistance Management (IRM) in Pest and Vectors
2. Techniques of Biological control of pests: Challenges and success



3. Host plant resistance to insects and Molecular biology of insect Biotypes
4. Case histories of successfully implemented IPM
5. Quarantine and legislative measures for preventing spread of pests

**ZOOL-ET-406: Fish Technology and Management**

**Marks 75**

**ZOOL-ET-406A: Fish Technology**

**Marks 37.5**

1. Crafts – Principal types of fishing crafts operated in Inland and Marine Waters of India
2. Gears – Classification of fishing gears; Selection of fishing gears; Types of fishing gears used in Inland and Marine Waters of India; Electro fishing
3. Fish detection methods – Basic principles of acoustic fish detection; Echosounder and Sonar.
4. Fish Preservation – Fundamentals of biochemistry of fish; Principles & methods of processing and preserving fish by Refrigeration, Freezing, Drying, Salt curing, Smoking, Pickling. Use of Refrigerated Sea Water (RSW). Common defects of cured products. Modern techniques employed in fish preservation.
5. Canning Technology – Principles underlying canning process; Can manufacture; Sterilization; Canning process of fish and prawns in India; Common defects of canned fish products.
6. Fish by-products and their economic importance

**ZOOL-ET-406B: Management and Marine Capture Fishery**

**Marks 37.5**

1. Finance – Institutional and Non-institutional loan; Basic aspects of National Fisheries Policy; Funding organizations and their role; Problems of institutional credit.
2. Fisheries Cooperative Society – Definition of Cooperative; Origin, Structure, Aims, Role and Problems of the fishermen's cooperative (Inland & Marine).

3. Biology and Commercial importance of the following marine fishes – Oil sardines; Mackerels; Tunas; Pomfrets; Bombay Duck; Ribbon fishes; Hilsa fisheries, Elasmobranchs; Chunks; Penaeid prawns; Pearls and Edible oysters.
4. Marine Capture Fishery Resources of India and their conservation (Estuarine fishery, Brackish water, Backwaters, Exclusive Economic Zone)

**ZOOL-ET-407: Molecular Genetics**

**Marks: 75**

**ZOOL-ET-407A: Molecular Genetics**

**Marks: 37.5**

1. Patterns of Inheritance: Mendelian inheritance, Family studies, Multiple alleles and Complex traits, Anticipation, Uniparental disomy, Genomic imprinting, Methylation and Eukaryotic gene regulation Multifactorial inheritance – Polygenic theory.
2. Cancer genetics: i) Cancer as a genetic disease, cell cycle and cancer, ii) Mutation – a predisposition to cancer, iii) Oncogenes, tumour suppressor genes, Oncogenic mutations, iv) Two- Hit theory of cancer, Multistep theory of Cancer v) Chromosome instability and environmental factors in cancer, vi) Colorectal and Breast Cancer, vii) Cancer Therapy.
3. Molecular Pathology: Concept, Pathogenic mutation, Loss of function mutations, Gain of function mutation, Gene to disease approach, Disease to gene approach, Chromosomal approach
4. Molecular genetics of Diseases: i) Trinucleotide expansion – HD, Fragile-X Syndrome, ii) Neurodegenerative diseases- Alzheimer, Parkinson, iii) Multifactorial – Schizophrenia: Molecular basis
5. Elementary Idea of Pharmacogenetics and Pharmacogenomics, Ecogenetics, Personalized Medicine.

**ZOOL-ET-407B: Molecular Genetics**

**Marks: 37.5**

1. Genomics and Proteomics: i) Concept of transcriptome and proteome, ii) Global study of Genome activity (Functional Genomics): Analysis of transcriptome by SAGE and DNA Microarray technique, Analysis of proteomes by 2D Gel Electrophoresis, Mass Spectrometry, Yeast two hybrid system, Phage Display, Expression Profiling, Protein-Protein Interaction.
2. Recombinant DNA Techniques and Gene function analysis: i) Recombinant DNA Techniques: PCR, Real Time/ Quantitative PCR, Droplet PCR, DNA sequencing, New generation DNA sequencing (NGS), Shotgun sequencing of whole genome, Foot printing, DNA

mobility shift assay, Western and southwestern blotting, ii) Gene function analysis: Random mutagenesis, site specific mutagenesis, targeted mutagenesis: gene knockout and knock-in method, RNAi and specific gene silencing.

3. Application of Genetic techniques: i) Mapping genome: Linkage analysis in pedigrees in human using DNA markers- RFLP, Microsatellites, SNPs and STS; ii) Detection & Estimation of genetic linkage, iii) Mapping of disease gene: Positional candidate cloning & Functional candidate gene cloning strategy, iv) Mutation detection assays: SSCP, DGGE, HA, CMC, PTT, v) Non-candidate driven approach (GWAS).

### **CORE COURSE PRACTICAL**

**MARKS 50**

#### **ZOOL-CP-408: Animal Physiology and Endocrinology**

1. Comparison of Total RBC and WBC counts in different groups of vertebrates; Estimation of Haemoglobin and Differential count of blood in vertebrates.
2. Determination of oxygen consumption, carbon dioxide liberation and respiratory quotient of a cockroach
3. Study of the changes of blood glucose level in a vertebrate species
4. Estimation of ascorbic acid in an unknown solution
5. Estimation of Amino-N by Sorenson's Formol Titration method
6. *In situ* studies of endocrine organs in mammals
7. Histological and histochemical studies of endocrine glands in mammals
8. Histochemical localization of brain neurosecretory cells of insect

#### **ZOOL-EP-409-413: Elective Course Practical**

**Marks 50**

#### **ZOOL-EP-409: Immunology**

1. Collection of complement and anti-serum
2. Differentiate the primary and secondary antibody response in haemagglutination test by using mercaptoethanol
3. Precipitation and quantitation of immunoglobulins from the immunized rabbit/mouse serum by ammonium sulphate preparation

4. Characterization of purified immunoglobulin preparation by SDS-PAGE
5. a) Preparation of cell suspension from lymphoid organs and solid tumours, staining and identification of cell types  
b) Collection and purification of ascetic tumour cells
6. Separation of cells in Hypaque Ficoll gradient and count of percentage of blasts
7. Raising of antiserum (ALS) and test of specificity of the serum in lysis of target; Ouchterlony Plate Test, Immuno-diffusion and Immunoelectrophoresis
8. Plaque forming cell (PFC) Assay and Rosette forming cell (RFC) assay
9. Test for cell mediated immune response: Measurement of Arthur's rx/CML/GVH/MI response
10. PCR

**ZOOL-EP-410: Environmental Biology:**

1. Frequency, Density, Abundance in terrestrial and aquatic systems.
2. Important value index
3. Species identification with special reference to North Bengal.
4. Functional responses in planktons.
5. Water quality analysis: Dissolved oxygen, BOD, Chloride, Total hardness,  $E_c$ , TDS, Salinity, etc.
6. Soil quality analysis: Organic Carbon, Calcium carbonate, pH,  $E_c$ .
7. Microbiology: Bacteria culture techniques, *E. coli* (EMB media), Coliform test, Gram staining of bacteria.

**ZOOL-EP-411: Entomology**

1. Studies in internal morphology of :  
*Apis*: Digestive and nervous systems  
*Musca*: Male and female reproductive systems  
Cockroach/Grass hopper: Nervous and reproductive systems

2. Mounting:

Wings, mouth parts, antennae, tracheal trunk, spiracle, genitalia of insects; medically important insects

3. Preparation of keys

a) Order level

b) Family level for major orders

c) Collection and preparation of key of pests of major crops of North Bengal (Rice, Jute, Tea, Vegetables)

d) Family level key for timber pests

e) Identification of stored-grain pests

4. a) Quantification of water soluble protein in insect egg

b) Quantitative and qualitative analysis of salivary and gut enzymes

c) Electrophoretic study of haemolymph, ovarian and egg protein

5. a) Host plant/seed preference study

b) Quantitative assay of damage of host leaf/seed caused by pests

c) Estimation of biochemical changes in host plant/seed due to pest attack

6. a) Study of insect population density (any one species)

b) Comparison of variance of populations of a pest species from different locations and or at different time

c) Determination of LD<sub>50</sub>/LC<sub>50</sub> values of pesticides using a pest species

d) Study in species RTU/family level diversity of insect community from crop/forest/grassland/soil habitats

7. a) Study of life cycle of a pest/vector

b) Submission of insects from representative orders (at least from different 10 insect orders) preferably pests.

**ZOOL-EP-412: Fisheries**

1. Collection, identification of benthic organisms (fish ponds/streams)

2. Collection of water samples from different waters to analyse the following;

a) Physico-chemical parameters of water & soil.

- b) Primary productivity
- c) Qualitative and quantitative estimation of phyto-and zooplanktons
- d) Microbial load (Plate count and MPN technique)
- 3. Determination of LC<sub>50</sub> at different hours of polluted river/stream waters
- 4. Determination of Age in fish using scale.
- 5. Collection and identification of commercially important fishes – Inland (including Hill streams) and Marine waters.
- 6. Study of bucco-pharyngeal region, gill-rakers, and the alimentary canal of local fishes to determine their food and feeding habits.
- 7. Survey of aquatic plants; their collection and identification.
- 8. Pituitary gland extraction from head of carps and catfishes and its preservation.
- 9. Determination of Calorific Value of fish muscle by wet – oxidation method.
- 10. Aquarium management; Setting of aquaria; Fabrication; Maintenance; Breeding and rearing of ornamental fishes; Disease control.

### **ZOOL-EP-413: Molecular Cell Biology and Genetics**

- 1. Preparation of mitotic chromosomes from the bone marrow of Mice/ Rat by Air dry/Flame dry method
- 2. Preparation of meiotic chromosome from the testes of Mice by Air/Flame dry method
- 3. Preparation of Synaptonemal Complex by surface spread method from the testes of mice/rat
- 4. Chromosome Banding: C, G banding, NOR
- 5. Micronuclei test
- 6. Drosophila food preparation, Handling of flies and Setting of crosses
- 7. Setting crosses to study sex-linked inheritance, linkage and crossing over in Drosophila
- 8. Three point test cross for gene mapping in Drosophila
- 9. Preparation of polytene chromosomes and Heat shock puffs
- 10. Lymphocyte culture and preparation of mitotic chromosome (Human).
- 11. Construction of Karyotype of Human/Rat
- 12. Genomic DNA isolation from Blood (Human), tissues (Mice) and quantitation

13. Transformation of host bacteria with given plasmid DNA, cloning of DNA
14. Isolation of Plasmid DNA
15. Restriction Digestion of Lambda-DNA/Plasmid/Genomic/Mitochondrial DNA and Electrophoresis, Restriction mapping in plasmid by double digestion
16. Study of Serum protein, Hb, LDH, by PAGE
17. PCR Amplification of known DNA/RAPD
18. Demonstration: Southern blotting and hybridization
19. Pattern of expression of genes in Drosophila by X-gal staining

**CONTINUING EVALUATION**

**ZOOL-CT-401, 402 (Class Test)**

**Marks 20 x 2**

**ZOOL-ET-403,404,405,406,407 (Class Test)**

**Marks 20 x 1**

**ZOOL-EP-414: Dissertation / Review**

**Marks 40**

**COMPREHENSIVE VIVA VOCE**

**ZOOL-CP-415: Comprehensive viva voce**

**Marks 25**

## SUGGESTED READINGS

### Nonchordates & Chordates:

1. Barnes, R.D. 1993 Invertebrate Zoology, W.B. Saunders Co.
2. Brusca, C.R. & Brusca G.J. Invertebrates, Sinauer Associates, Inc. Publishers.
3. Cheng, T.C. Biology of animal parasites, W.B. Saunders Co.
4. Dales, R.P. 1963 Annelids Hutchinson University Library.
5. Hyman, L.H. 1940-67 The Invertebrates vol. I-VI McGraw-Hill.
6. Meglitsch, P.A. 1967 Invertebrate Zoology, Oxford University Press.
7. Marshall, A.J. and Williams, W.D. Text Book of Zoology, Invertebrates, Macmillan Press.
8. Sleigh, M. 1973 The Biology of Protozoa, Edward Arnold.
9. Wigglesworth, V.B. 1966 Insect physiology, John Wiley & Sons.
10. A Test Book of Zoology, Parker & Has well (revised by A.J. Marshall), Vol - II, 7<sup>th</sup> Ed. Macmillan, London (1972).
11. The Life of Vertebrates, J. Z. Young, 3<sup>rd</sup> Ed. Oxford Univ. Press, Oxford (1982).
12. Analysis of Vertebrates Structure, M. Hildebrand. John Wiley & Sons., New York (1974).
13. Biology of Vertebrates, Walter & Sayles. Macmillan, New York (1965).
14. Anatomy of the Chordates, C.K. Weather. McGraw-Hill, New York (1951).
15. Vertebrate life, Pugh, Heifer & McFarland, 4<sup>th</sup> Ed. Prentice-Hall of India, New Delhi (1999).
16. Human Physiology, R.F. Schmidt & Thaws (Eds.), 2<sup>nd</sup> Ed. Springer-Vela, Berlin (1989).
17. Vertebrates: Comparative Anatomy, Functions, Evolution (3<sup>rd</sup> Edn.), K.V. Kardong. Tata McGraw-Hill Pub. Co. Ltd., New Delhi (2002).

### Biochemistry:

1. Elliot, W.H. and D.C. Elliot, Biochemistry and molecular Biology, 2<sup>nd</sup> Ed., Oxford University Press.
2. Devlin, T.M., Text Book of Biochemistry with clinical correlation, Wiley – Liss, New York.
3. Nelson, D.L. and M.M Cox, Lehninger's Principle of Biochemistry, 6<sup>th</sup> Ed., Worth Publishers, New York.
4. Stryer, L., Biochemistry, 7<sup>th</sup> Ed., W.H. Freeman and Company, New York.



### **Cell Biology & Genetics:**

1. Gardner *et al.*, Principle of Genetics, John Wiley & Sons, Inc.
2. Watson *et al.*, Molecular Biology of gene, Benjamin, New York.
3. Griffiths *et al.*, An Introduction to genetic analysis. Freeman
4. Smith-Keary, Molecular Genetics, Macmillan
5. Strickberger, Genetics, Prentice Hall
6. iGenetics-A Molecular approach. Peter J. Russell. Indian Edition (2016). Pearson India Education Services Pvt. Ltd.
7. Lodish *et al.*, Molecular Cell Biology, Scientific American Book, Inc., USA
8. Alberts *et al.*, Molecular Biology of the cell, 4<sup>th</sup> Ed., Garland publishing Inc., New York
9. Snustad & Simmons, Principles of Genetics, 3<sup>rd</sup> Ed. ,John Wiley & Sons
10. Klug & Cummings, 7<sup>th</sup> Ed., Concepts of Genetics, Pearson Education
11. W.M. Becker *et al.*, The World of The Cell, 5<sup>th</sup> Ed., Pearson Education
12. Gerald Karp, Cell & Molecular Biology,5<sup>th</sup> Ed., John Wiley & Sons

### **Biotechnology**

1. Biology and Biotechnology : Science, Applications and Issues. Helen Kreuzer & AdrienneMassey. ASM Press, Washington DC. 2005
2. Handbook of Molecular and Cellular Methods in Biology and Medicine. Second Edition, 2004. Edited by Leland J. Cseke, Peter B. Kaufman, Gopi K. Podila, Chung-Jui Tsai. CRC Press, Boca Raton, London, New York, Washington DC.
3. Molecular Cloning : A Laboratory Manual. Third Edition, 2001. Volumes I, II & III. Joseph Sambrook & David W. Russell. Cold Spring Harbor Laboratory Press, New York.
4. PCR Protocols : A Guide to Methods and Applications. Edited by Michael A. Innis, David H. Gelfand, John J. Sninsky, Thomas J. White. Academic Press, Inc. 1990.
5. Principles of Gene Manipulation and Genomics. Seventh Edition, 2006. S. B. Primrose & R. M. Twyman. Blackwell Publishing

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