



UNIVERSITY OF CALCUTTA

Notification No. CSR/ 50 /14

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 21.10.2014, approved the Revised Syllabus for the 2-year 4-semester M.Sc. course of study in Zoology, under this University as laid down in the accompanying pamphlet.

The above shall take effect from the academic session 2014-2016 and onwards.

SENATE HOUSE
KOLKATA-700073
The 11th November, 2014

A handwritten signature in black ink, appearing to be 'Basab Chaudhuri', with the date '11-11-2014' written below it.

(Prof. Basab Chaudhuri)

Registrar

**Syllabus for a
2-year Semester System
in M.Sc. (Zoology)
(Session - 2014 -2016)**



Department of Zoology, University of Calcutta
35, Ballygunge Circular Road, Kolkata – 700 019.

UNIVERSITY OF CALCUTTA
SYLLABUS STRUCTURE FOR M.Sc. (ZOOLOGY)
SEMESTER COURSE (Session 2014-2016)

Outline of syllabus

<u>1st Semester</u>		MARKS	CREDIT
ZCT 101	Structure & Functions of Nonchordates	50	4
ZCT 102	Ecological theories & Applications	50	4
ZCT 103	Cell & Tissue Biology	50	4
ZCT 104	Genetics and Genetic Engineering	50	4
ZCP 105	Laboratory Course I (2 modules ZCT 101 & 102)	25	1
ZCP 106	Laboratory Course II (2 modules ZCT 103 & 104)	25	1
		250	18
<u>2nd Semester</u>		MARKS	CREDIT
ZCT 207	Structure and Function of Chordates	50	4
ZCT 208	Biochemistry & Molecular Biology	50	4
ZCT 209	Endocrinology & Neurobiology	50	4
ZCT 210	Parasites & Immunity	50	4
ZCP 211	Laboratory Course I (2 modules ZCT 207 & 208)	25	1
ZCP 212	Laboratory Course II (2 modules ZCT 209 & 210)	25	1
		250	18
<u>3rd Semester</u>		MARKS	CREDIT
ZCT 313	Taxonomy & Biodiversity	50	4
ZCT 314	Developmental Biology & Evolution	50	4
ZCT 315	Comparative Animal Physiology	50	4
ZCT 316 -325	Elective paper (Unit I)	50	4
ZCP 326	Laboratory course (3 modules, ZCT 313,314 & 315)	30	1
ZEP 327	Laboratory course on Elective Paper	20	1
		250	18
<p>Optional Elective Subjects (Unit I) : Ecology(316) / Genetics (317)/ Endocrinology(318)/ Entomology(319) / Environmental Biology and Toxicology(320)/ Immunology (321)/ Molecular Cell Biology(322)/ Wildlife & Conservation Biology(323) / Fisheries Science(324)/ Bioresources & Biotechnology (325). For optional elective subjects, the laboratory course work as mentioned in the 4th semester syllabus will be distributed in the 3rd and 4th semester</p>			
<u>4th Semester</u>		MARKS	CREDIT
ZCT 428	Animal Behaviour & Biostatistics	50	4
ZCT 429-438	Elective Paper (Unit II)	50	4
ZEP 439	Laboratory course on Elective Paper	80	6
ZEP 440	Dissertation/Review work	40	2
ZEP 441	Comprehensive Viva-voce	30	2
		250	18
<p>Optional Elective Subjects (Unit II) : Ecology(429) / Genetics (430)/ Endocrinology(431)/ Entomology(432) / Environmental Biology and Toxicology(433)/ Immunology (434)/ Molecular Cell Biology(435)/ Wildlife & Conservation Biology(436) / Fisheries Science(437)/Bioresources& Biotechnology (438). For optional elective subjects, the laboratory course work as mentioned in the 4th semester syllabus will be distributed in the 3rd and 4th semester</p>			

Division of practical marks :

- Practical of 25 marks – 15(practical) + 5 (Internal assessment) + 5 (Viva-voce)
- Practical of 30 marks - 20(practical) + 5 (Internal assessment) + 5 (Viva-voce)
- Practical of 80 marks - 40 (practical) + 20 (Internal assessment) + 10 (Viva-voce) + 10 (submission / laboratory notebook)

The students will submit a Dissertation (40 marks) on their Elective paper opted. Both the Seminar and Dissertation Report will be evaluated by external examiner.

The regulations for the Two-year M. Sc. course in Zoology, University of Calcutta

1. The University of Calcutta shall provide instructions leading towards two year M. Sc. degree in Zoology.
2. A candidate who has passed the three-year B.Sc. Examination with **Honours in Zoology** will be eligible for admission to this course.
3. Procedure for admission will be guided by the University as per notification to be issued for any academic session.
4. The duration of the course shall be two academic years and the examination for the M. Sc. degree in Zoology shall be held over four semesters over a total of 1000 marks. The duration of the semesters shall be as follows:

1st Semester	July – December
2nd Semester	January – June
3rd Semester	July – December
4th Semester	January – June

Course Structure

- A] **Core Subjects** : Compulsory for all
B] **Elective Subjects** : Student will choose any one of the ten Elective subjects being offered

MARKS/CREDIT	MARKS			CREDIT		
	THEORY	PRACTICAL	TOTAL	THEORY	PRACTICAL	TOTAL
1st Semester	200	50	250	16	2	18
2nd Semester	200	50	250	16	2	18
3rd Semester	200	50	250	16	2	18
4th Semester	100	150	250	10	8	18
	Grand total		1000			72

5. The courses shall comprise a total marks of 1000 and credit of 72 evenly distributed over the four semesters. The courses shall be grouped as Core, and Elective and will carry credits according to the number of theoretical classes required, study hours and laboratory hours.
6. A candidate shall be eligible for appearing in the examination provided he/she completes a regular course of studies in Zoology maintaining percentage of attendance as specified by the University.
7. Examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as the final consolidated practical and viva-voce examination of the students on the laboratory course. The marks allotted through internal assessment and assessment of each practical comprising of external examiners, will be as mentioned in the course structure.

Evaluation of the elective practical will be based on continuous assessment, and assessment of the final consolidated practical comprising of external examiners, will be as indicated in course structure.

8. The candidate has to obtain at least 40% marks in each of the theory and practical courses separately to qualify in each semester.
9. If a student gets 'F' in a particular course, he/she shall be deemed to have failed in that course only and shall be required to repeat that course at a supplementary examination along with the next oncoming semester when offered. A student can attempt a maximum number of two times to clear a particular course (including the first one) failing which he/she shall be dropped from the rolls of the University on the advice of the concerned authority.
10. If a student is dropped from the University rolls because of the failure to clear a particular course, he/she may apply for readmission in the beginning of the next academic session along with fresh applicants.
11. Paper-setters and examiner for each of the core theory papers will comprise of three faculty members of the Department appointed on recommendations of the Board of Post Graduate Studies in Zoology.
12. Comprehensive via-voce (ZEP 441) examination of 4th Semester will be conducted by 3 external examiners and HOD covering all papers of 1st, 2nd, 3rd and 4th Semester examinations. Average marks of all the examiners will be computed.
13. There shall be at least one external paper-setter and examiner for the elective theoretical paper in 3rd and 4th Semester, appointed by the authority for this purpose.
14. The external paper-setters may be from the other Universities / faculty members of premier research institutions.
15. Examination time for theory papers with 40 and 50 will be 2 hours and for 100 marks 3 hours .
16. Continuous evaluation of laboratory practicals of core and elective papers will be taken into account by the concerned faculty members throughout the course in all the semesters. Terminal practical examination of each semester should include both internal and external (at least one) examiners.
17. The students will be required to give a seminar (marks 20) on their dissertation/review work related to the elective paper opted during the 4th Semester. A panel comprising of both internal and external examiners shall evaluate the work performed and the presentation.
18. For each of the semester examination, there shall be a Board of Moderators.

Grading of Student's Performance

MARKS (%)	NUMERICAL GRADE	GRADES	LETTER GRADES	DIVISION
75 - 100	5.50 - 6.00	Outstanding	O	1st division
65 - 74	4.50 - 5.49	Good	A ⁺	1st division
60 - 64	4.00 - 4.49	Fair	A	1st division
55 - 59	3.50 - 3.99	Satisfactory	B	2nd division
50 - 54	3.00 - 3.49	Average	C	2nd division
0 - 49	Below 3.00	Fail	F	
		Incomplete	I	

Cumulative grade point average over four semesters:

Working out simple average, cumulative grade point average will be obtained over four semesters.

Significance of grades

On the basis of the cumulative results of the student's performance the grades will be given in each semester as well as over four semesters.

Detailed syllabus

1st Semester

Marks distribution:

<u>1st Semester</u>		<u>MARKS</u>	<u>CREDIT</u>
ZCT 101	Structure & Functions of Nonchordates	50	4
ZCT 102	Ecological theories & Applications	50	4
ZCT 103	Cell & Tissue Biology	50	4
ZCT 104	Genetics and Genetic Engineering	50	4
ZCP 105	Laboratory Course I (2 modules ZCT 101 & 102)	25	1
ZCP 106	Laboratory Course II (2 modules ZCT 103 & 104)	25	1
		250	18

ZCT 101: Structure and Function of Non chordate **50 Marks** **4 Credits**

1. Non chordate body forms

- 1.1 Diversity of non chordate phyla
- 1.2 Non chordate body forms and adaptive significance.
- 1.3 Cellular spectrum and its functional implications in sponges.

2. Feeding and Digestion

- 2.1 Feeding diversity in insects
- 2.2 Filter feeding in Crustacea and Mollusca-functional mechanism
- 2.3 Feeding & digestion in Bryozoa and Echinodermata

3. Excretion

- 3.1 Organs of Excretion in non chordate animals
- 3.2 Excretory structures and their functions in Helminthes
- 3.3 Excretory structures and their functions in Annelida and Insecta.

4. Sense organs

- 4.1 Mechanoreception in nonchordates.
- 4.2 Chemical senses and orientations in nonchordates.
- 4.3 Statocysts in Mollusca
- 4.4 Photoreception and photosensitivity in non chordate forms; functional morphology of compound eye in arthropods

5. Reproduction

- 5.1 Functional form variations of reproductive organs in nonchordate.
- 5.2. Reproductive mechanisms in non chordates – asexual, sexual, parthenogenesis, hermaphroditism.
- 5.3. Hormones of reproduction in annelids, molluscs and insects.

6. Movements

- 6.1 Hydrostatic selection in annelids.
- 6.2 Insect flight mechanism.

7. Growth & Development

- 7.1 Hormonal regulation of moulting, metamorphosis and diapause.

ZCT 102: Ecological Theories and Application **50 Marks** **4 Credits**

1. Population Ecology

- 1.1 Age structured population growth and empirical projections
- 1.2 Deterministic and stochastic growth models, time lags and limit cycles, oscillations, chaos.

- 1.3 Population cycles in discrete time logistic population models-Beverton-Holt and Ricker model.
- 1.4 Evaluating controls on population size, key factor analysis and contemporary ideas on population control.
- 1.5 Meta-population – concept and types.
- 1.6 Levin’s model of meta-population and development of theories.
- 1.7 Meta-population dynamics-empirical examples.

2. Ecological Communities

- 2.1 Structure of ecological communities, Species abundance models.
- 2.2 Niche preemption and Random Niche model of species association.
- 2.3 Species diversity across ecological gradient, elements of Landscape ecology
- 2.4 Competition theory, modeling competitive exclusion and coexistence.
- 2.5 Structure of food webs and food web theories, Diversity-stability hypothesis
- 2.6 Ecological network and energy analysis
- 2.7 Processes in grassland and wetland ecosystems

3. Ecological crises and remediation

- 3.1 Eutrophication in freshwater, coastal and marine ecosystem, faunal interaction and changes; Remediation of eutrophication.
- 3.2 Acidification in aquatic and terrestrial environment, Consequences and control strategies.
- 3.3 Ecology of invasive species
- 3.4 Meltdown of agro-biodiversity, maladies of agricultural intensification and genetically modified Crops.
- 3.5 Bioremediation
- 3.6 Strategies and examples of ecological restoration

ZCT 103: Cell & Tissue Biology

50 Marks

4 Credits

1. The Plasma Membrane

- 1.1 Cell membrane structure, lipid bilayer, proteins and principles of membrane assembly
- 1.2 Membrane transport: Protein diffusion and osmosis, ion channels, active transport, ion pumps, mechanisms of sorting and regulation of intracellular transport.

2. The Cytoskeleton and Cellular Transport

- 2.1 Structure and organization of actin filaments
- 2.2 Actin, myosin and cell movement
- 2.3 Microtubules and intermediate filaments
- 2.4 Protein sorting & mechanism of vesicular transport

3. Cell Walls, the Extracellular Matrix, and Cell Interactions

- 3.1 Cell Walls
- 3.2 The Extracellular Matrix and Cell–Matrix Interactions
- 3.3 Cell–Cell Interactions

4. Cell Signaling

- 4.1 Signaling Molecules and receptors
- 4.2 Intracellular signal transduction pathways

5. Cell Death and Cell Renewal

- 5.1 Programmed cell death and senescence
- 5.2 Stem cells and maintenance of adult tissue
- 5.3 Embryonic stem cells and application

6. Epithelial tissue

- 6.1 Characteristics and basics of epithelial tissue
- 6.2 Molecular organization of cell surface modifications
- 6.3 Ultra structure of transport, synthetic-secretory and specialized epithelial cells

7. Muscle tissue

7.1 Characteristics, ultra structure and functions of muscle cells

7.2 Molecular aspects of primary and accessory muscle proteins

7.3 Muscle contraction

8. Bone tissue

8.1 Ultra structure and functions of bone cells

8.2 Bone development – cancellous and compact bones

8.3 Roles of hormones and vitamins on bone regulation

ZCT 104: Genetics & Genetic Engineering 50 Marks 4 Credits

1. Organisation of genes and chromosomes

1.1 Organization of chromatin and nucleosome, structure and organization of telomere, centromere and kinetochore, molecular anatomy of eukaryotic chromosomes, polytene chromosome.

1.2 Unique and repetitive DNA, euchromatin and heterochromatin, chromatin domains and boundary function.

1.3 Basic ideas of prokaryotic and eukaryotic genome.

1.4 Sex-determination and dosage compensation (w.r.t. *C. elegans*, *Drosophila* and Human).

1.5 Transposable elements in prokaryotes and eukaryotes

2. Genetic Imprinting

2.1 Imprinting of genes, Epigenetic regulation of gene expression

3. Somatic Cell Genetics

3.1 Cell fusion technology

3.2 Heterokaryon selection and chromosome mapping, Hybridoma technique

4. Microbial genetics

4.1 Bacterial conjugation, transformation and transduction

5. Genetics of Cell Cycle

5.1 Genetic regulation of cell cycle.

5.2 Cell cycle check points

5.3 Molecular basis of neoplasia

6. Recombination and repair

6.1 Homologous and non-homologous recombination, site-specific and transpositional recombination

6.2 DNA repair mechanism: types in prokaryotes and eukaryotes

7. Recombinant DNA technology

7.1 Cloning and expression vectors

7.2 Mechanism of DNA-cloning, Genomic/cDNA library, methods of clone identification

7.3 PCR and cloning of PCR products

7.4 Gene cloning and DNA analysis in medicine and forensic science

8. Genome expression analysis

8.1 Southern and Northern analysis, RT-PCR, Western blotting

8.2 DNA and RNA sequencing, Gel retardation of DNA-protein complex

8.3 DNA Microarray and its application.

8.4 In-situ hybridization techniques Laboratory Course

ZCP-105: Laboratory Course I

25 Marks

1 Credit

(A) Module 1 - Non-chordate Anatomy

1. Special structures (i) Stomatogastric nervous system in cockroach (ii) Poison gland of Ant/Spider (iii) Mounting of mouth parts of mosquito-identification of genera & sex, (iv) Haltere in housefly, mouth parts of housefly.

2. Comparative anatomy of Excretion & Nervous systems in Annelid, Insect and Molluscan models.

(B) Module 2 - Ecological methods

1. Analysis of aquatic habitat and community.
2. Analysis of terrestrial habitat and community

(C) Sessional work (Internal evaluation)

(D) Viva voce

ZCP-106: Laboratory Course II

25 Marks

1 Credit

(A) Module 1 - Genetics and Genetic Engineering

1. Drosophila genetic crosses, Induction of mutation in Drosophila by P-M Mutagenesis preparation of polytene chromosome, Karyotyping
2. DNA isolation and Agarose Gel Electrophoresis
3. Restriction digestion

(B) Module 2 - Cell & Tissue Biology.

1. Identification of mammalian tissue sections.
2. Tissue fixation, microtomy and double staining of tissue sections.

(C) Sessional work (Internal evaluation)

(D) Viva voce

2nd Semester

Marks Distribution:

<u>2nd Semester</u>		<u>MARKS</u>	<u>CREDIT</u>
ZCT 207	Structure and Function of Chordates	50	4
ZCT 208	Biochemistry & Molecular Biology	50	4
ZCT 209	Endocrinology & Neurobiology	50	4
ZCT 210	Parasites & Immunity	50	4
ZCP 211	Laboratory Course I (2 modules ZCT 207 & 208)	25	1
ZCP 212	Laboratory Course II (2 modules ZCT 209 & 210)	25	1
		250	18

ZCT 207 : Structure and Function of Chordates 50 marks 4 Credits

1. Protochordates

1.1 Fine structure and role of notochord and endostyle in *Amphioxus* and *Ascidia* with evolutionary significance.

2. Integument

2.1 Integumentary System in Chordates

2.2 Cell Association and Glandular System

3. Skeletal System

3.1 Origin of Jaw and modification of Jaw bones and types. Functional and evolutionary significance

3.2 Jaw kinetics in relation to feeding.

4. Respiration

4.1 Pre-requisites of respiratory system and functional requirements

4.2 Ventilatory mechanisms

4.3 Analysis of structures and functions

5. Circulation

5.1 Heart and circulation in foetal and neonatal mammal.

5.2 Evolution of portal systems

6. Sense organs

6.1 Sensory receptors and classification

6.2 Organs of olfaction and taste

6.3 Special senses: Vomero-nasal organs in reptiles, electroreception in fish.

7. Nervous System

7.1 Functional organization of Brain

7.2 Evolution of cerebrum

7.3 Functional association of CNS and information processing

8. Excretion

8.1 Evolution of urino-genital system in vertebrate series.

8.2 Ultrastructure of kidney and its role in homeostasis.

8.3 Juxtaglomerular apparatus.

9. Structural Adaptations

9.1 Structural elements of the body

9.2 Energetics and Locomotion

9.3 Feeding adaptations

9.4 Swimming, flying and gliding mechanics

ZCT 208: Biochemistry & Molecular Biology 50 marks 4 Credits

1. Amino Acid, Proteins, Carbohydrate and Lipid :

- 1.1 Amino acid classification and structure of protein.
- 1.2 Detoxification of Ammonia
- 1.3 Amino Acid Metabolism.
- 1.4 Lipids, classification, digestion and metabolism, cholesterol biosynthesis and prostaglandins, lipoprotein.
- 1.5 Carbohydrate metabolism: glycolysis, glycogenolysis, gluconeogenesis, TCA cycle.
- 1.6 Digestion and absorption of carbohydrate.
- 1.7 Interrelationship between different carbohydrate metabolism.
- 1.8 Nucleic Acid metabolism.

2. Enzymes:

- 2.1 Classification, Catalysis, Co-enzyme, Co-factor.
- 2.3 Active site determination.
- 2.3 Michaelis-Menten equation, Significance of K_m & V_{max} .
- 2.4 Enzyme kinetics, Enzyme inhibitor.
- 2.5 Allosteric modulation of enzyme.

3. Bioenergetics:

- 3.1 Energy producing and utilizing systems,
- 3.2 Electron transfer and oxidative phosphorylation,
- 3.3 Concept of CYP enzymes and implications in pharmacology.

4. Vitamins and minerals.

5. Free radicals and Anti-oxidants.

6. DNA Replication:

- 6.1 Prokaryotic and eukaryotic DNA replication; mechanism of DNA replication.

7. Transcription:

- 7.1 Basic concept of prokaryotic and eukaryotic transcription.
- 7.2 Transcriptional and post-transcriptional events-splicing, capping, polyadenylation, other RNA processing events (Transplicing, Editing and receptor mRNA Stability)
- 7.3 Post transcriptional gene silencing.

8. Translation:

- 8.1 Prokaryotic and eukaryotic translational including mechanism of initiation, elongation and termination.
- 8.2 Co-and post translation modification of proteins.

9. Antisense and Ribozyme Technologies:

- 9.1 Molecular mechanism of antisense molecules.
- 9.2 Biochemistry of Ribozyme.
- 9.3 Gene therapy with special reference to antisense and ribozyme technologies.

10. DNA based Molecular Markers:

- 10.1 DNA fingerprinting (AFLP, RFLP and RAPD-PCR).
- 10.2 Expressed sequence tags and their use for developing STSs, SSRs and SNPs.

ZCT 209: Endocrinology and Neurobiology 50 marks 4 Credits

1. Classification of hormones.

2. Hypothalamic hormones - their structure and functions.

3. Anterior pituitary cell ultrastructures, nature of hormones and their functions.

4. Neurosecretion - structure and functions of oxytocin and vasopressin

5. Structure and functions of hormones:

- 5.1. Thyroid hormone structure and functions.
- 5.2. Pancreatic cell types, hormone structure and their role in glucose homeostasis.

- 5.3. GI tract hormones: source, composition and functions.
- 5.4. Adrenocorticomedullary hormones _ structure and functions
- 6. Endocrinology of estrous cycle**
- 7. Neurogenesis Neuronal Ageing and death**
- 7.1. Sequential development of neurons from stem cells
- 7.2. Development of neuronal functionality
- 7.3. Factors leading to neuronal death
- 8. Electrical properties of nerve cells**
- 8.1. General organization of neuron
- 8.2. Neuronal cytoskeletons
- 8.3. Molecular aspect of development of action potential and conduction
- 9. Overview of synaptic and immunological functions**
- 9.1. Ionotropic and metabotropic receptors and neurotransmission
- 9.2. Mechanism of neurotransmitter release
- 9.3. Role of calcium in biochemistry of exocytosis and endocytosis
- 9.4. Immunological functions
- 10. Neuromuscular Junction**
- 10.1. Organization and properties of neuromuscular junction
- 10.2. Neurotransmitters, neurohormones and neuromodulators
- 10.3. Role of neurotransmitters on endocrine feedback
- 11. Aspects of neuronal disorders**
- 11.1. Strokes and excitotoxicity and NMDA receptors
- 11.2. Epilepsy
- 11.3. Parkinson's disease
- 11.4. Alzheimer's disease

ZCT 210 : Parasites and Immunity

50 marks 4 Credits

1. Vector Biology

- 1.1 Vectors and its importance in transmission of parasites.
- 1.2 Major malaria vectors of India : Distribution, potentially and present sustainability status, form & function

2. Biology (Form & function) of Parasites.

- 2.1 Protozoan parasites - Toxoplasmosis, Chagas Disease
- 2.2 Helminthic parasites - Taeniasis, Schistosomiasis, filariasis
- 2.3 Arthropod Parasites - Ticks & Mites

3. Host parasite interaction

- 3.1 Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells.
- 3.2 Alteration of host cell behaviour

4. Immune System

- 4.1 Phylogeny of Immunity, Evolution of Immune system
- 4.2 Primary and Secondary lymphoid organ.
- 4.4 Tissue, cells and molecules of the animal immune system.

5. Innate Immunity

- 5.1 Overview, Features, Epithelial barrier. Neutrophil and Macrophage function.
- 5.2 Inflammation.
- 5.3 NK cell.
- 5.4 Complement pathway & Disease

6. Antigen Presentation and Recognition

- 6.1. APCs
- 6.2 MHC

6.3 Antigen receptor-Diversity and selection

7. Cell Mediated Immunity

7.1 Peptide recognition, adhesion and co-stimulation

7.2 Cell mediated immune response

7.3 Th1 and Th2 Response

8. Humoral Immunity

8.1 Immunoglobulin function

8.2 Class switching Mechanism

8.3 B-cell function, maturation and development

ZCP 211: Laboratory Course I (2 modules)

25 Marks

1 Credit

(A) Module - I Chordate Anatomy

1. Study of Jaw suspension in different vertebrate skull (from museum specimen).
2. Study of different types of vertebrate teeth pattern and interpretation of food habit. (from museum specimen).
3. Comparative study of limb bone in different vertebrates and interpretation of locomotory adaptation. (From museum specimen).
4. Morphometric analyses of different fish specimen and interpretation of food habit and respiratory efficiency.
5. Collection of different swim bladder from different fish specimen (collected from market) and comparative study on functional efficiency of swim bladders.
6. Study of adaptive features and interpretation of significance from morphology of preserved specimen.

(B) Module II Biochemistry and Molecular Biology

1. Determination of glucose in different patho physiological condition.
2. Estimation of total protein from tissues of animal model
3. DNA isolation and Agarose gel electrophoresis
4. Thin Layer chromatography

(C) Sessional Work (Internal Evaluation)

(D) Viva-Voce

ZCP 212 : Laboratory Course II (2 modules) 25 Marks 1 Credit

(A) Module – I Endocrinology and Neurobiology

1. Processing and double staining of different stages of estrous cycle of rats.
2. Identification of endocrine gland sections
3. Estimation of Acetylcholinesterase in animal model.
4. Sympathetic nervous system / Spinal nerves in rat model.

(B) Module – II Parasite & Immunity

1. Identification of parasitic forms
2. Dissection and identification of histological slides of spleen and thymus
4. Immunization Protocol Demonstration of Thio glycolate induced peritonitis (cell infiltration and Inflammatory exudates).

(C) Sessional Work (Internal Evaluation)

(D) Viva-Voce

3rd Semester

Marks Distribution:

<u>3rd Semester</u>		MARKS	CREDIT
ZCT 313	Taxonomy & Biodiversity	50	4
ZCT 314	Developmental Biology & Evolution	50	4
ZCT 315	Comparative Animal Physiology	50	4
ZCT 316 -325	Elective paper (Unit I)	50	4
ZCT 326	Laboratory course (3 modules, ZCT 313,314 & 315)	30	1
ZEP 327	Laboratory course on Elective Paper	20	1
		250	18

Optional Elective Subjects (Unit I) : Ecology(316) / Genetics (317)/ Endocrinology(318)/ Entomology(319) / Environmental Biology and Toxicology(320)/ Immunology (321)/ Molecular Cell Biology(322)/ Wildlife & Conservation Biology(323) / Fisheries Science(324)/ Bioresources& Biotechnology (325). **For optional elective subjects, the laboratory course work as mentioned in the 4th semester syllabus will be distributed in the 3rd and 4th semester**

ZCT 313 : Taxonomy & Biodiversity 50 Marks 4 Credits

Group A : Taxonomy (FM 25)

1. Characters

- 1.1 Discrete and overt characters
- 1.2 Identifying primitive, advanced character states, character state transitions.
- 1.3 Missing data and polymorphic characters, characters of special consideration, characters subject to strong selection pressure
- 1.4 Environmental effects
- 1.5 Molecular sequence characters
- 1.6 Microcharacters, cryptic and internal characters
- 1.7 Artifacts
- 1.8 Behavioural characters

2. Taxa and species

- 2.1 Phylogenetic groups, Monophyly, Polyphyly and Paraphyly
- 2.2 Problem with parthenogenetic and asexuals

3. Phylogenetic reconstruction, cladistic and related methods

- 3.1 Cladistics and Cladogram
- 3.2 Parsimony

4. Phenetic methods

- 4.1 Similarity and distance measure
- 4.2 Measures using binary characters
- 4.3 Similarity distance measures using continuous data

Group B : Biodiversity (FM 25)

1. The meanings to Biodiversity

- 1.1 Conceptual framework of Biodiversity
- 1.2 Problems and scales of Biodiversity extinctions in time and space
- 1.3 Levels and Measures of Biodiversity, Interrelationship between Biodiversity measures, applications and integration of diversity measures.

1.4 Process and pattern of local and regional biodiversity-Niche assembly theories, unified Neutral theory, Island biogeography model

2. Threats to species diversity

- 2.1 Natural and Human induced threats and vulnerability of species to extinctions
- 2.2 Biodiversity and Rarity, Endemism and Biodiversity
- 2.3 Problem of Genetic diversity loss over time: Bottlenecks, Genetic drifts, Inbreeding depression
- 2.4 Effective and minimum viable population size, measurements and variations
- 2.5 Review of Risks to Biodiversity extinctions. Extinction vortex
- 2.6 Uncertainties and biodiversity extinction

3. Global pattern of biodiversity

- 3.1 Diversity in biogeographical region and marine zones
- 3.2 Diversity clines in relation to area, latitude, altitude and deep sea
- 3.3 Theories on biodiversity dispersions

4. Conservation of Biodiversity

- 4.1 Information on CITES, IUCN, CBD
- 4.2 International agreements for conserving marine life
- 4.3 Convention on wetlands of International Importance (Ramsar convention)
- 4.4 Population viability analysis-conceptual foundation, uses of PVA models.
- 4.5 Management Decisions for small populations using PVA models.
- 4.6 Minimum viable populations & recovery strategies for threatened species

5. Tracking biodiversity towards management

- 5.1 Biodiversity indicators : Taxon based indicators, Surrogate species
- 5.2 Structure and Function based biodiversity indicators
- 5.3 Biodiversity and ecosystem function, Ecological redundancy and resilience

ZCT 314 : Developmental Biology and Evolution 50 Marks 4 Credits

Group A : Developmental Biology (FM 25)

1. Principles of Developmental Biology

- 1.1 Potency, commitment, specification, induction, competence,
- 1.2 Determination and differentiation; morphogenetic gradients; cell fate and cell lineages

2. Gametogenesis, fertilization and early development:

- 2.1 Primordial Germ cells and development of sex organs
- 2.2 Production of gametes, prerequisites of fertilization
- 2.3 Zygote formation, cleavage, blastula formation, embryonic fields,
- 2.4 Gastrulation and formation of germ layers in animals; embryogenesis

3. Metamorphosis and organogenesis in model animal system:

- 3.1 Axes, compartment formation and pattern formation in *Drosophila*.
- 3.2 Organogenesis – vulva formation in *Caenorhabditis elegans*
- 3.3 Organizer formation and Mesoderm specification and metamorphosis in *Xenopus* and Chick
- 3.4 Maternal effect mutations and Neurulation in zebrafish
- 3.5 Limb development and regeneration in vertebrates

4. Environmental regulation of normal development

- 4.1 Molecular bases for environmental regulation of gene expression
- 4.2 Genetic assimilation of environmentally induced traits

Group B : Evolution (FM 25)

1. Arguments of evolutionary ideas and evolutionary theories since Darwin

2. Evolutionary Process

- 2.1 Mechanisms producing genetic diversity and sources of phenotypic variation
- 2.2 Variation among populations

3. Natural Selection and Adaptation

- 3.1 Methods of studying natural selection and Models of selection
- 3.2 Recognizing adaptation
- 3.3 Gene flow, genetic drift and Neutral theory of evolution

4. Gene Frequencies in Population

- 4.1 The Hardy-Weinberg principle and analysis of gene frequencies in natural population.
- 4.2 Major factors influencing gene frequencies (migration, inbreeding), effects of selection and mutation on gene frequencies.

5. Patterns and trends in evolution

- 5.1 Constructing evolutionary trees, measures of genetic relationship among organisms
- 5.2 Molecular clock of evolution
- 5.3 Molecular phylogeny

6. Species and Speciation

- 6.1 Genetic basis of species difference and reproductive barriers
- 6.2 Evolution of interaction among species

ZCT 315: Comparative Animal Physiology 50 Marks 4 Credits

1. Principles of Animal Physiology

- 1.1 Idea of mechanistic and Evolutionary physiology
- 1.2 Homeostasis in different forms.

2. Size and Scale of organisms

- 2.1 Size and Surface area to volume ratio
- 2.2 Metabolic scope (Scaling relationship) between BMR and Body mass
- 2.3 Metabolic rates as a function of body mass in mammals and arthropods.
- 2.4 Metabolic rate as a function of animal locomotor speed

3. Thermal Physiology

- 3.1 Heat Transfer between animal and environment
- 3.2 Poikilothermy and Homeothermy
- 3.3 Physiological adjustments in extreme environmental conditions.

4. Sensory Physiology

- 4.1 Lateral Inhibition and enhanced edge effect in invertebrates under different Illumination
- 4.2 Receptor system and sensory perception in phytophagous insects.
- 4.3 Phototransduction in compound and vertebrate eye.

5. Physiology of Excretion

- 5.1 Physiology of ultrafiltration, Reabsorption, tubular secretion.
- 5.2 Counter current theory of urine concentration, Regulation of urine formation.
- 5.3 Method of Urine formation, Nitrogenous wastes
- 5.4 Renal regulation of acid-base balance

6. Physiology of blood and body fluids:

- 6.1 Comparative structure of cells in circulation of invertebrate and vertebrates.
- 6.2 Composition of blood, Plasma and blood Corpuscles, in vertebrates, Functions.

7. Physiology of Respiration

- 7.1 Respiratory pigments in animals
- 7.2 Physiology of aerial and aquatic respiration in invertebrates and vertebrate examples.
- 7.3 Respiratory adaptations in animals living in O₂ deficient environment.

8. Physiology of behaviour

- 8.1 Pheromones in colonial interactions, foraging and mating
- 8.2 Allelo chemicals in plant-Insect interaction

8.3 Chemotaxis

ZET 316-325 : Elective Papers (Unit I) 50 Marks 4 Credits

ECOLOGY ZET 316

1. EVOLUTIONARY ECOLOGY

- 1.1. Evolution and adaptive strategies; Phenotypic plasticity
- 1.2. Ecological specialization and generalization\
- 1.3. Offspring size and number
- 1.4. Host – Parasite and Plant – Animal Interactions
- 1.5. Sex and gender
- 1.6. Parent – offspring conflict

2. BEHAVIOURAL ECOLOGY

- 2.1. Mating systems, mate choice and conflicts
- 2.2. Dispersal, navigation and migration
- 2.3. Resource competition
- 2.4. Living in groups
- 2.5. Ecology and evolution of signals

3. ECOLOGY OF POPULATION AND COMMUNITIES

- 3.1. Population dynamics – models
- 3.2. Metapopulation structure, metapopulation models, metapopulation and extinction risks
- 3.3. Metacommunity concepts, Importance and trade offs
- 3.4. Resources and consumers
- 3.5. Interactions in microbial populations

ZEP 327 : Laboratory Course for Ecology Elective Paper (Internal Assessment) Marks 20 1 Credit

GENETICS ZET 317

1. Chromatin dynamics

- 1.1. Chromatin remodeling; Replicative nucleosomal reassembly; Nucleosome positioning at functional promoter.
- 1.2. Molecular nature of functional status of chromatin: Chromatin silencing & Position effect variegation, 1.3. Histone code, reader-writer complex.

2. DNA Replication & Its Regulation

- 2.1. Telomeric DNA replication.
- 2.2. Enzymology of replication and Gene amplification.
- 2.3. Role of Non-coding RNA in prokaryotic and eukaryotic DNA replication
- 2.4. Mitochondrial DNA replication

3. Regulation of Gene Expression:

- 3.1. Transcription in Eukaryotes: RNA Pols subunit composition & transcription factors, Models of transcription termination
- 3.2. Epigenetic regulation of gene expression
- 3.3. Post transcriptional events
- 3.4. Catalytic & small RNAs, Gene silencing

4. Translation & Post translational protein folding

- 4.1. Translation in Eukaryotes: Initiation, elongation & termination.
- 4.2. Protein splicing, Chaperons & protein folding.

5. Developmental Genetics

- 5.1. Genetic signaling for wing imaginal disc differentiation in *Drosophila*
- 5.2. Mechanism of dosage compensation system in early development of mammals & *Drosophila*
- 5.3. Temperature dependent sex determination.
- 5.4. HOX genes and their developmental regulation in vertebrates

6. Recombination & Repair:

- 6.1. Recombination in eukaryotes; recombination types
- 6.2. Enzymology of human meiotic recombination; Molecular anatomy of Synaptonemal complex.
- 6.3. Gene conversion
- 6.4. Enzymes involved in DNA repair mechanism

7. Transposable Genetic Element

- 7.1. Ac/Ds system in Maize, P-M System in *Drosophila*. IS element in bacteria
- 7.2. Retrotransposon: Retrovirus, Copia in *Drosophila*, SINE, LINE, Alu in Human
- 7.3. Role of transposable element in evolution and genome modification.

8. Behavioural Genetics

- 8.1. Molecular regulation of *Drosophila* circadian rhythm.
- 8.2. Genetic control of Honey bee foraging behaviour
- 8.3. Human intelligence: Gene, Genome, genetics.
- 8.4. Implication of gene-environment interaction in human behavioural disorder

ZEP 327 : Laboratory Course for Genetics Elective Paper (Internal Assessment) Marks 20 1 Credit

ENDOCRINOLOGY

ZET 318

1. Chemical nature and classification of hormones
2. Mechanism of hormone action.
3. Endocrine function of hypothalamus.
4. Biosynthesis, characteristics and functions of hormones: Molecular basis
 - 4.1. Anterior pituitary hormones and target organs: signal transduction mechanism
 - 4.2. Posterior pituitary hormones and neuroendocrine modulation.
 - 4.3. Diurnal variations of biosynthetic components of pineal gland.
 - 4.4. Parathyroid hormone: Control of calcium homeostasis.
 - 4.5. Thyroid hormone: Incidence of pathophysiology and disorders.
 - 4.6. Thymic hormones and cell immunity.
 - 4.7. Pancreatic hormones: Impact on carbohydrate metabolism.
 - 4.8. Adrenocortical and Adrenomedullary hormones: Stress physiology.
 - 4.9 Ovarian hormones: Interrelationship between ovarian hormones and ovarian follicles, corpora lutea, uterus and vagina.
 - 4.10 Androgens: Influence on sex accessory glands, Spermatogenesis, sertoli- spermatid interaction
5. Endocrine physiology of gestation, parturition and lactation.
6. Endocrinology of fertilization and conception: Endocrine malfunction induced male and female infertility.
7. Photoperiodism and endocrinology of photosexual activity:
 - 7.1. Responds to different photoperiods.
 - 7.2. Role of Extra-retinal photoreceptors.
 - 7.3. Photorefractoriness, scotorefractoriness and relative refractoriness.
 - 7.4. Prevention of refractoriness.

ZEP 327 : Laboratory Course for Endocrinology Elective Paper (Internal Assessment) Marks 20 1 Credit

Insect Organization and Physiology**1. External Morphology**

- 1.1 Integuments-epidermis; cuticle-structure, types, formation, functions
- 1.2 Head/ Thorax/ Abdomen
- 1.3 Pre and Post Genital appendages.

2. Anatomy and Physiology

- 2.1 Digestion: Structure, Types and Mechanism
- 2.2 Excretion in insects: Ultrastructure of malpighian tubule, Cryptonephridial condition, significance, Physiology of excretion.
- 2.3 Respiration in insects: Terrestrial and aquatic form, Accessory respiratory organs.
- 2.4 Reproduction and Development: Male and female reproductive organs; Spermatogenesis and Oogenesis, Accessory reproduction.

3. Blood and Circulatory system

- 3.1 Structure, Types of Haemocytes, Function, Coagulation, Defense mechanism.

4. Endocrine Organs and Hormones

- 4.1 Endocrine organs, mode of action of hormones, chemical nature and functions, role in moulting and metamorphosis, Diapause – environmental & endocrine regulation.
- 4.2. Exocrine glands, pheromones, semiochemicals and defensive secretions.

5. Nervous and sensory system

- 5.1 Eyes and vision-occurrence and structure of compound eyes, light reception, image formation.
- 5.2 Sound production- Structures, mechanisms and significance;
- 5.3 Light production – Structure, mechanisms and significance

ZEP 327: Laboratory Course for Entomology Elective Paper (Internal Assessment) Marks 20 1 Credit

ENVIRONMENTAL BIOLOGY AND TOXICOLOGY**ZET 320****Environmental Biology**

1. Fundamentals of Environmental biology:
 - 1.1 General consideration.
 - 1.2 Earth's physical & chemical environment.
2. Environment & animal adaptation:
 - 2.1 Mechanism of adaptation at molecular level.
 - 2.2 Physiological regulation of gene expression & its plasticity against changing environment.
3. Semiochemical mediated interaction between plant & animal in natural environment.
 - 3.1 Role of phenolics, flavonoid, steroids, pigments & glycosides in plant-animal interactions.
 - 3.2 Co-evolutionary implications.
4. Extreme & special environmental regimes & adaptation (case studies).
5. Environmental contamination & endocrine disruption.
 - 5.1 Endocrine disruptors & endocrine disruption hypothesis.
 - 5.2 Mechanism of endocrine disruption & its consequence.
6. Environmental Impact Assessment.
 - 6.1 Philosophy & principle.
 - 6.2 General consideration & modality.
 - 6.3 Environmental Management Plan.

**ZEP 327: Laboratory Course for Environmental Biology & Toxicology Elective Paper
(Internal Assessment) Marks 20 1 Credit**

IMMUNOLOGY ZET 321

I. Infection and Immunity

- 1.1 Immune response to bacteria
- 1.2 Immune response to Virus
- 1.3 Immune response to Parasites

2. Inflammation and Immunity

- 2.1 Overview of Inflammation
- 2.2 Inflammatory mediators
- 2.3 Inflammation and disease
- 2.4 Therapeutic Aspect

3. Cellular & non-cellular components of Immune mechanism

- 3.1 Lymphocyte Homing and Function
- 3.2 Mechanisms of Peripheral Tolerance
- 3.3 Development and Activation of B Cells
- 3.4 Signal Transduction in B-Cells
- 3.5 Structures and cell types producing cytokines and chemokines
- 3.6 Their interaction with the target cell and biological actions
- 3.7 Role of cytokines and chemokines in various inflammatory diseases
- 3.8 Mucosal Immunity
- 3.9 Role of miRNAs in Modulating the Immune System

4. The Complement System

- 4.1 Complement components, their structures and functions,
- 4.2 Mechanism of complement activation by classical and alternate pathway
- 4.3 Complement function test

5. Asthma and Hypersensitivity

- 5.1 Type I
- 5.2 Type II
- 5.3 Type III
- 5.4 Type IV

6. Tolerance and Autoimmunity

- 6.1 General features and mechanisms of immunologic tolerance
- 6.2 T cells in autoimmunity
- 6.3 Regulation of immunity and tolerance by dendritic cells
- 6.4 Malfunction and different autoimmune disease.

**ZEP 327: Laboratory Course for Immunology Elective Paper (Internal Assessment) Marks
20 1 Credit**

MOLECULAR CELL BIOLOGY ZET 322

1. Integration of cellular macromolecules and protein sorting

- 1.1 Transport of macromolecules between the nucleus and cytosol
- 1.2 Transport of macromolecules between the cytosol and mitochondria
- 1.3 Transport from ER to golgi
- 1.4 Post-translational modifications of proteins (folding, etc), and destruction mechanisms
- 1.5 Differential response of cells to external signals, developmental perspectives

2. Cell-to-cell communication

- 2.1 Gap and tight junctions and cell signaling
- 2.2 Role of calcium and NO in signal transduction
- 2.3 Fate of cells with regard to morphogen gradients
- 2.4 Crosstalk mechanisms and integrative pathways
- 2.5 Differential response of cells to external signals, developmental perspectives

3. Stem Cell Biology

- 3.1 Concept, types, self-renewal, pluripotency, differentiation
- 3.2 Isolation and characterization of stem cells
- 3.3 Niche and stem cell engineering
- 3.4 Regenerative biology and tissue repair

4. Cell Cycle, Cell Death and Cell Renewal

- 4.1 Mechanisms of cell cycle regulation
- 4.2 Programmed cell death
- 4.3 Autophagy
- 4.4 Senescence

ZEP 327: Laboratory Course for Molecular Cell Biology Elective Paper (Internal Assessment) Marks 20 1 Credit

WILDLIFE & CONSERVATION ZET 323

MODULE I: WILDLIFE HABITAT

1. Characteristics of wildlife habitats
2. Tropical forests and faunal adaptation
3. Protected area network; design of nature reserves
4. Community management of nature reserves

MODULE II: WILDLIFE BEHAVIOUR

1. Communication and signaling, courtship display
2. Territoriality and home range, scent markings
3. Social structure of wild animals
4. Mating systems

MODULE III: WILDLIFE CONSERVATION: INDIAN CONTEXT

1. Wildlife wealth of India
2. Forest types of India
3. Status of wildlife in India and extinction risks
4. Distribution, habitat utilization and conservation status of Musk deer, Great Indian Bastard, Olive Ridley Turtle

MODULE IV: CONSERVATION APPROACHES

1. Managing small population, Conservation genetics
2. Conservation breeding
3. Species reintroduction and translocation
4. Captive breeding
5. In situ conservation and Zoo gardens

ZEP 327 : Laboratory Course for Wildlife & Conservation Elective Paper (Internal Assessment) Marks 20 1 Credit

FISHERIES SCIENCE ZET 324

1. Systematics, genetics and speciation

- 1.1 Evolutionary trends in fish diversity

- 1.2 Genetic variability and speciation in fishes
- 1.3 Phylogenetic relationships based on Nuclear and mitochondrial DNA sequences.

2. Homeostasis and reproduction

- 2.1 Ion transport, osmoregulation and acid base balance
- 2.2 Hormones involved in freshwater and seawater adaptation
- 2.3 Calcium homeostasis
- 2.4 Sex determination and sex differentiation, genetic sex determination, sex determination affected by external factors.
- 2.5 Vitellogenesis, endocrine regulation of estradiol production and vitellogenesis
- 2.6 Teleost Gonadotropins and their regulation.
- 2.7 Regulation of gonadotropins, regulation of gonadotropins subunit gene expressions
- 2.8 Endocrine disruptors and Fish reproduction

3. Fish pathology and defense mechanisms

- 3.1 Factors of fish health and integrated health management, Infection and immune responses to pathogens in environment - Transformation of infection into diseases
- 3.2 Cells and tissues of the immune system of fish - cellular and humoral defenses
- 3.3 Immunomodulation - exogenous and endogenous factors

4. Feeding and nutrition

- 4.1 Stages of nutrient acquisition
- 4.2 Temporal pattern of nutrient acquisition, Integration of nutrient acquisition-compartment models, gut-reactor model, state-space model
- 4.3 Principles of fish nutrition and terminologies, nutritional requirement of cultivable fish and prawn, nutritional biochemistry
- 4.4 Nutritional bioenergetics, energy efficiency in fish production
- 4.5 Nutritional physiology-digestion and nutrient flow, factors affecting digestibility
- 4.6 Feeding schedules and ratio, feed performance, feed formulation, processing, storage and application.
- 4.7 Fish growth estimation

5. Sustainable technology for freshwater aquaculture

- 5.1 Advancements in technology for finfish and shell fish culture
- 5.2 Modern hatcheries and management
- 5.3 Technology of stock improvement – cryopreservation, hybridization, polyploidy and transgenesis, xenogenesis, sex reversal and breeding.
- 5.4 Raceways, cages and Pen enclosures, Recirculating systems, Intensive Fish Hub
- 5.5 Integrated Aquaculture

ZEP 327 : Laboratory Course for Fisheries Science Elective Paper (Internal Assessment)
Marks 20 1 Credit

BIORESOURCE & BIOTECHNOLOGY

ZET 325

Module 1: Biodiversity and Bioresource

- 1.1 Faunal Bioresources in biogeographical regions in India (Forest Wetlands, Mangrove and marine)
- 1.2 Endemism and categories of endemics
- 1.3 Biopiracy and Biodiversity protection act
- 1.4 Intellectual Property Right (IPR)

Module 2: Bioresource and Bioprospecting

- 2.1. Invertebrates as Bioindicators
- 2.2. Sustainable use of animal resources for food security and Biomedicine
- 2.3. Vermiculture, Vermicomposting for soil fertility

2.4. Ecological Services of Soil organisms

Module 3: Biotechnology for Livestock Manipulation

3.1. Transgenesis

3.2. Genetically engineered animals for pharmacological research

3.3. Gene Transfer methods in animals

3.4. Applications and Ethics of Biotechnology

Module 4: Medical Biotechnology

4.1. Disease diagnostic markers

4.2. Mechanism of gene therapy

4.3. Drug Delivery and Targeting

ZEP 327 : Laboratory Course for Bioresource & Biotechnology Elective Paper (Internal Assessment) Marks 20 1 Credit

ZCP 326 : Laboratory Course 30 Marks 1 credit

(A) Module I Taxonomy & Biodiversity

1. Taxonomic Study: Insect spider model, Fish Model.

2. Recognition of fauna from museum study and taxonomic key preparation.

3. Biodiversity assessment, measuring species diversity of aquatic community, Dominance diversity analysis.

4. Diversity Parameters for comparative study of habitats.

5. Community analysis indices

(B) Module II Development Biology & Evolution

1. Identification of diagnostic features of the early stages of developing Chick embryo (brain, eye, heart and somites)

2. Preparation of different stages of chick embryo from blastoderm to subsequent changes.

(C) Module III Comparative Animal Physiology

1. Determination of activity of amylase from ecto and endothermic organisms.

2. Haemocytes in invertebrate models Blood corpuscles in a vertebrate model.

(D) Sessional work (Internal evaluation)

(E) Viva Voce

4th Semester

Marks distribution

<u>4th Semester</u>		<u>MARKS</u>	<u>CREDIT</u>
ZCT 428	Animal Behaviour & Biostatistics	50	4
ZCT 429-438	Elective Paper (Unit II)	50	4
ZEP 439	Laboratory course on Elective Paper	80	6
ZEP 440	Dissertation/Review work	40	2
ZEP 441	Comprehensive Viva-voce	30	2
		250	18

Optional Elective Subjects (Unit II) : Ecology(429) / Genetics (430)/ Endocrinology(431)/ Entomology(432) / Environmental Biology and Toxicology(433)/ Immunology (434)/ Molecular Cell Biology(435)/ Wildlife & Conservation Biology(436) / Fisheries Science(437)/Bioresources& Biotechnology (438). **For optional elective subjects, the laboratory course work as mentioned in the 4th semester syllabus will be distributed in the 3rd and 4th semester**

ZCT 428 : Animal Behaviour and Biostatistics 50 Marks 4 Credits

Group A : Animal Behaviour (FM 25)

1. Principles and mechanisms of animal behaviour:

1.1 Four propositions of Tinbergen

2. Gene, Environment and Behaviour:

2.1 Survival value and fitness

2.3 Fundamental of Behavioral Genetics and molecular tools

3. Cooperation and conflict:

3.1 Range of cooperative behaviours and theories of cooperation, Kin selection

3.2 Communication

3.3 Elaborate ornaments: Fisher's hypothesis and Handicap hypothesis

3.4 Conflict over mate choice

3.5 Parent-offspring conflict

4. Foraging:

4.1 Optimal foraging theory

4.2 Foraging and predation risk: defense strategies against predators

4.3 Territoriality and Group foraging

5. Aggression:

5.1 Aggressive behaviour

5.2 Game theory models and strategies

Group B: Biostatistics (FM 25)

1. Biostatistical approach

1.1 Statistics and biological world

2. Descriptive Statistics

2.1 Frequency distribution

2.2 Central Tendency

2.3 Dispersion

2.4. Visual representation of data

3. Sampling and Analysis

3.1 Sampling theory: Statistical inference and hypothesis testing

3.2 Analysis of variance and experimental designs

3.3 Non Parametric Tests

- 3.4 Analysis of categorical data
- 3.5 Correlation and Regression

ZET 429-438 : Elective Papers (Unit II) 50 Marks 4 Credits

ECOLOGY ZET 429

- 1. HABITAT AND ECOSYSTEM ECOLOGY
 - 1.1. Food web: theories and models
 - 1.2. Nutrient regeneration in aquatic system
 - 1.3. Ecosystem function in terrestrial and aquatic systems
 - 1.4. Biodiversity and ecosystem functions
- 2. CONSERVATION ECOLOGY
 - 2.1. Conservation challenges from climate change, habitat loss & fragmentation
 - 2.2. Theory and analyses of conservation of population
 - 2.3. Elements of ecological economics
 - 2.4. Protected area network, Species translocation and restoration
 - 2.5. Fragile ecosystems: status and conservation strategies
 - 2.6. Conservation genetics
- 3. ECOLOGICAL MANAGEMENT
 - 3.1. Development of ecosystem management theories
 - 3.2. Evaluation of ecosystem management as a performance based system
 - 3.3. Remote sensing, GIS and ecosystem management
 - 3.4. Ecological restoration of degraded ecosystem
- 4. SUSTAINABLE DEVELOPMENT AND ECOLOGICAL ECONOMICS
 - 4.1. Ecological footprints and sustainability indicators
 - 4.2. Guiding principles of sustainable development
 - 4.3. Environmental sustainability index, EIA, Impact identification methods
 - 4.4. Value of ecosystem services and nature capital at global level

ZEP 439 (Ecology Practical) 80 Marks 6 Credits

- 1. Ecological sampling and census techniques
- 2. Morphometric evidence of niche separation
- 3. Ethogram and ad libitum observation of animals
- 4. Study of adaptive characters from museum specimens
- 5. Productivity determination of different ecosystems
- 6. Microbial analyses of soil and water
- 7. Habitat quality assessment
- 8. Ecological impact assessment methods
- 9. Molecular methods of ecology
- 10. Application of ecological statistics
- 11. Assignment on ecological literature
- 12. Field experiments and analyses
- 13. Sessional
- 14. Viva voce

GENETICS ZET 430

1. Human Genetics

- 1.1. Human Genome organization: Unique gene, Repetitive gene family & Pseudogene
- 1.2. Evolution of genomic sequence: Exon shuffling, HLA complex, Y chromosome sequence

- 1.3. Concept of linkage analysis in family pedigree: LOD score, PLINK software. GWAS
- 1.4. Regulation of proto-oncogene, oncogene and tumor suppressor genes in human
- 1.5. Genetic etiology of some common genetic disorders in human

2. Population & Quantitative Genetics

- 2.1. Polygenetic traits and measurement of trait variation
- 2.2. Norm of reaction, phenotypic distribution, Heritability
- 2.3. Concept of QTL.
- 2.4. Polymorphism study by Isozyme, RAPD, RFLP, SNP, microsatellite, AFLP.

3. Genomics, Proteomics & Bioinformatics

- 3.1. Structural genomics: Concept of genetic map and Physical Map, Principle of dideoxy sequencing, whole genome shotgun sequencing, Pyrosequencing
- 3.2. Analysis of Transcriptome and Proteome
- 3.3. Interactive learning of GenBank, EMBL-Bank and FlyBase.
- 3.4. Sequence alignment, Homology search by BLASTn and BLASTp.
- 3.5. Primer designing and binding site search by GeneRunner software.

4. Recombinant DNA Technology

- 4.1. Eukaryotic cloning vectors, Cloning strategies, Identification of specific clones.
- 4.2. cDNA library and Genomic DNA library.
- 4.3. Principle of whole animal cloning.
- 4.4. Generation of transgenic animals.
- 4.5. Gene knock out and gene silencing.

5. Gene Therapy & Pharmacogenetics

- 5.1. Various approaches of gene therapy
- 5.2. Stem cell therapy and Micro-RNA therapy
- 5.3. Concept of pharmacogenomics; Use of pharmacogenetics for predicting disease prognosis and treatment exposure, response and toxicity.

6. Molecular Techniques:

- 6.1 Chromosome walking, PCR & RT-PCR, Restriction mapping, Pulse field gel electrophoresis, Site directed mutagenesis, Gel retardation assay, RNase protection assay, DNA foot printing.

ZEP 439 (Genetics Practical)

80 Marks 6 Credits

1. *Drosophila* polytene chromosomes (Inversion and translocation).
2. Human Karyotyping from peripheral blood
3. Isolation of genomic DNA and RNA.
4. Gel electrophoresis for analysis of nucleic acids and proteins (Native & SDS PAGE).
5. Design of genetic crosses using *Drosophila* as model system.
6. Developmental genetics in *Drosophila*
7. Southern, northern and western blot analysis
8. PCR and RT-PCR

ENDOCRINOLOGY

ZET 431

1. Pheromones: Classification, chemical nature, structure, functions, relevance in applied fields and clinical implications.
2. Prostaglandins: Source, chemical nature, structure, functions, physiological significance and clinical implications.
3. Hormones and human health: Pituitary and hypothalamic disorders; Disorders of thyroid and parathyroid gland; Disorders of adrenal gland
4. Molecular basis of Diabetes and therapeutics.
5. Production of hormones using recombinant DNA technology.
6. Clinical uses of steroid receptors and defect of receptors

7. Evolution of endocrine glands: phylogeny and ontogeny of pituitary, pancreas, adrenal, thyroid.
8. Geriatric endocrinology.
9. Developmental abnormalities of endocrine glands.

ZEP 439 (Endocrinology Practical)

80 Marks 6 Credits

1. ELISA of selected hormone (demonstration).
2. Identification of endocrine organs and estrous cycle.
3. Planimetry and oculoetry of endocrine tissues
4. Surgical techniques: Unilateral and bilateral ablations of selected endocrine glands.
6. Effects of surgical ablation of testis on seminal vesicle and prostate.
7. Effects of surgical ablation of ovary on uterus.
8. Estimation of adrenal ascorbic acid and cholesterol in
[i]. Normal mice / rat; [ii] After administration of ACTH / epinephrine
9. Effect of insulin / epinephrine administration on blood sugar level of mice / rat.
10. Comparative histology of gonads in various vertebrate groups.
11. Induction of polycystic ovary and effect of drug
12. Viva voce

ENTOMOLOGY ZET 432

A. Agricultural Entomology :

- 1.1 Soil insects and acarines; Distribution, Types, Role in soil formation and productivity
- 1.2 Insects & Acarines Pest: Assessment of pest status; EIL & ETL etc. Important pests of Jute, paddy, sugarcane, vegetable, mango, tea, stored products and forest insects- their distribution, nature of damage, biology and control measures.
- 1.3. Pest Management: Cultural, chemical - nature, mode of action of insecticides (organochlorine, organophosphorous, carbamates, botanical insecticides). Biological control, pheromones and other attractants, Biotechnology in insect control, Concept of IPM.

B. Medical Entomology:

- 2.1 Mosquito vectors, Types, Role in disease transmission. Case studies- Malaria and Filariasis
- 2.2 Sandflies - Morphology, Life cycle, Vector status, Disease relationship.
- 2.3 Flies – Types, Role in disease transmission, Case studies – Myiasis.
- 2.4 Fleas- Morphology, Life cycle, Role in plague transmission, Control strategy
- 2.5 Bee Venom – Stinging apparatus, Mechanism, Effect, Remedial measures
- 2.6 Acarines of Medical Importance -
 - i) Scabies – Morphology and Life cycle of the causative agent, Habit & habitat, Mode of Transmission, Pathogenesis and Control
 - ii) Trombiculid mites: Morphology, Habit & Habitat, Life cycle and medical importance
 - iii) Ticks: General consideration, Soft and Hard ticks - External morphology, Internal anatomy, Life cycle, Disease relationship and control measures.
 - iv) Allergenic mites-General account, Mechanism, Control measures

ZEP 439 (Entomology Practical)

80 Marks 6 Credits

1. Insect Diversity: Collection, Identification, Preservation & Display
2. Identification of insect body parts: Mounting
3. Pest of crops/ plantations: Identification of pests of different crops/ vegetables/ stored products and forest insects. Identification of insect infesting agricultural crops and evaluation of their pest status. Life cycle studies on some important pest population.
4. Anatomy, physiology and histology: Tissue sections and their identification

5. Medical entomology: life cycle studies of medically important arthropods. Diptera, Anoplura, Siphonaptera and Acarina.
6. Identification of major vector species with special reference to malaria, Filariasis, Kala azar, Japanese Encephalitis, Dengue etc.
7. Social Insects: Behavioral studies of social insects with special reference to ants.
8. Appliances used in insect control – Types and applications.
9. Determination of LC₅₀ and LD₅₀ against commonly used insecticides.
10. Observation on the insect host-plant interaction with special reference to butterflies.
11. Extensive field studies to cover the ecological aspects of commonly occurring insects
12. Submission of specimens & laboratory note book
13. Sessional (Internal evaluation)
14. Viva voce

ENVIRONMENTAL BIOLOGY AND TOXICOLOGY

ZET 433

1. Toxicology:
 - 1.1 Definition and scope
 - 1.2 History
 - 1.3 Branches and relationship with other branches of science
2. Types and classification of toxins
 - 2.1 According to dose
 - 2.2 According to method of isolation from natural sources.
 - 2.3 According to physical state and chemistry
 - 2.4 According to physiological effects
 - 2.5 According to mode of isolation, labels and toxicity rating chart
3. Mechanism of toxicity
 - 3.1 Delivery of toxin from exposure site to target
 - 3.2 Reaction of toxicant with target molecule
 - 3.3 Cellular dysfunction and toxicity
 - 3.4 Inappropriate repair and adaptation
4. Toxins:
 - 4.1 Dose-response relationship
 - 4.2 Levels of toxicity: acute, subacute and chronic
 - 4.3 Environmental movement and fate of toxins
5. Metabolism of toxin in cellular environment
 - 5.1 phase I reaction
 - 5.2 phase II reaction
6. Analytical toxicology
 - 6.1. Immunohistochemistry: Principle, direct/indirect labeling, different labels and application.
 - 6.2 FACS
 - 6.3 Fluorescence & confocal microscopy.

ZEP : 429 (Environmental Biology & Toxicology Practical) 50 Marks 3 Credits

1. Monitoring of heart rate of aquatic molluscs exposed to different toxins & study of recovery response *in situ*.
2. Cellular dye retention assay as biomarker of toxicity in aquatic environment.
3. Isolation & staining of murine peritoneal macrophages.
4. Determination of phagocytic index of murine macrophages under the challenge of toxic particulates *in vitro*.
5. Sessional.
6. Viva.

IMMUNOLOGY

ZET 434

1. Tumor Immunology

- 1.1 Strategies of tumor cell to evade Immune system
- 1.2 Anti-tumor Immune response
- 1.3 Modern Immunotherapy of Cancer

2. Transplantation Immunology

- 2.1 Basis of Transplantation
- 2.2 Acute, Hyperacute and chronic Graft rejection
- 2.3 Modern techniques of transplantation (e.g.BMT,liver,corneaetc)

3. Immunodeficiencies

- 3.1 Congenital Immunodeficiencies
- 3.2 Acquired Immunodeficiencies

4. Immunoprophylaxis

- 4.1 Principles and Significance
- 4.2 Types of Vaccines (subunit, killed, attenuated etc.)

5. Specialized Immune System

- 5.1 Mucosal Immunology
- 5.2 Neonatal Immunology
- 5.3 Neuroimmunology
- 5.4 Liver-A lymphoid organ

6. Immunotherapy of disease

- 6.1 Rheumatoid arthritis
- 6.2 DLE & SLE
- 6.3 HLH
- 6.4 Asthma

ZEP 439 (Immunology Practical)

80 Marks 6 Credits

1. Cell counting and cell viability, Cell fractionation and extraction, Cytotoxicity Analysis-Titrations/Microscopy/Hemocytometer
2. Mouse lymphoid system display. Mononuclear leukocyte separation, Peritoneal Lavage, Bronchoalveolar lavage, Bone marrow aspiration, Macrophage Activity
3. Preparation of serum and Isolation of Spleen, Thymus and Bone marrow cells from research animal.
4. Histology and Immunohistochemistry-Immunopathology
5. Immunofluorescence
6. ELISA
7. Immunoprecipitation
8. Flow cytometric measurement
9. Viva Voce

MOLECULAR CELL BIOLOGY

ZET 435

1. Cancer and oncogenesis

- a) Classification through gene expression profiling
- b) Initiation, promotion, progression, cell behaviour
- c) Benign versus malignant, EMT
- d) Role of niche, and angiogenesis
- e) Cancer immunology
- f) Cancer-critical genes and epigenetic mechanisms
- g) Treatment strategies

h) Prediction of how alterations or given drugs/chemical treatments would impact cellular behavior

2. Functional and systems approach to experimental MCB

- a) Emphasis on molecular approaches to understand
 - i. cell structure, function, and regulation, and
 - ii. the analysis of experimental design and data interpretation.

b) Systems Biology

3. Methods in Molecular Cell Biology

- a) Cell culture techniques, transfection and infection of cells
- b) Protein purification and characterization
- c) Nucleic acids, miRNAs and RNA interference
- d) Immunohistochemistry
- e) Microscopy and imaging (light, fluorescence, confocal, EM)
- f) Fluorescence activated cell sorting
- g) Transgenics and Knock-outs

ZEP 439 (Molecular Cell Biology Practical)

80 Marks 6 Credits

- 1. Cell culture techniques, cell proliferation and viability assay
- 2. Assessment of cell growth and cell cycle by FACS analysis
- 3. Identification and characterization of stem cells by CFU assay
- 4. Isolation of stem cells by cell sorting
- 5. Histology and Immunohistochemistry
- 6. ELISA
- 7. Protein purification and analysis, PAGE
- 8. Viva Voce

WILDLIFE & CONSERVATION

ZET 436

MODULE I: WILDLIFE STUDY: TOOLS & TECHNIQUES

- 1. Population estimates: Census techniques and Sampling strategies with special reference to mammals, birds and herpeto - fauna
- 2. Application of telemetry
- 3. Application of Remote sensing and GIS
- 4. Animals signs as indicators of habitat use

MODULE II: MAN & WILDLIFE

- 1. Community participation in wildlife management
- 2. Conservation and development linkage
- 3. Man – animal conflict. Case studies from India and other parts of the world

MODULE III: WILDLIFE HEALTH

- 1. Major diseases of wild animals in captivity and free ranging situation
- 2. Monitoring wildlife health and management of diseases
- 3. Capture and handling of wild animals in diseased condition
- 4. Wildlife forensics
- 5. Determinants of disease and disease transmission

MODULE IV: WILDLIFE TRADE, LAWS AND ETHICS

- 1. Wildlife trade, assessment and documentation
- 2. Trans-boundary wildlife trade
- 3. International laws and conventions relating to wildlife
- 4. Wildlife legislation in India

ZEP 439 (Wildlife & Conservation Practical)**80 Marks 6 Credits**

1. Census techniques
2. Quantitative habitat survey and mapping
3. Digitization of Maps and Projection
4. Methods of behavioural observation: collection and analysis of behavioural data on few commonly seen species
5. Review of forest working plans and maps. Study of nearby forests management regime
6. Project work and assignment
7. Sessional
8. Viva voce

FISHERIES SCIENCE**ZET 437****1. Limnology and aquatic productivity**

- 1.1 Freshwater Resources- River, Lakes and Reservoirs - zonations, characteristics, Morphometry and Productivity
- 1.2 Stratifications in lakes and reservoirs. Thermal stratifications, stratification and dynamics of oxygen and inorganic carbon, stratification and dynamics of nitrogen and phosphorus.
- 1.3 Aquatic organisms of functional significance
- 1.4 Water quality criteria for aquaculture productivity and aquaculture generated changes-stress response in fishes

2. Estuarine and Marine Resources

- 2.1 Bioresources and Bioactive compounds
- 2.2 Exclusive economic zone-Potentialities and exploitations
- 2.3 Modern Device of Exploitation
- 2.4 Major Fisheries of Indian coasts
- 2.5 Mariculture
- 2.6 Fish processing and preservation technology

3. The conservation of aquatic resources

- 3.1 Conservation challenges of aquatic habitats
- 3.2 Coarse - filter and fine filter approaches to conservation of freshwater systems
- 3.3 Management of wetlands for conservation
- 3.4 Marine resources, marine protected area and commercial fisheries

4. Fisheries biotechnology and functional genomics of fish

- 4.1 Biochemical and molecular markers
- 4.2 Population genetics and interaction of hatchery and wild fish
- 4.3 Gene mapping, Quantitative trait locus mapping and marker - assisted selection
- 4.4 Gene transfer technology
- 4.5 Genotype-environment interaction, environmental risk of aquatic organisms for genetic biotechnology, food safety of transgenic organism
- 4.6 Genetic conservation, gene banking and maintaining genetic quality

ZEP 439 (Fisheries Science Practical)**80 Marks 6 Credits**

1. Teleosts organ systems
2. Estimation of Reproductive maturity and fecundity of fish specimens
3. Hydrological and soil analysis methods
4. Estimation of productivity and relationship with Aquatic biodiversity
6. Fish Microbiology Experiments
7. Studies on fish diversity- Documentation of endangered fish fauna and morphometric analysis

8. Fish diseases and pathological experiments
9. Fish physiology experiments- Digestive enzymes, biochemical composition
10. Bioinformatics and statistics of aquaculture data
11. Demonstration of research methods on modern fish biology
12. Field study and case analysis
13. Sessional (Internal Evaluation)
14. Viva voce

BIORESOURCE & BIOTECHNOLOGY

ZET 438

Module 1: Regeneration of Bioresource

- 1.1. Conservation breeding of wild Bioresources
- 1.2. Propagation methods for Bioresources from natural and controlled environment.
- 1.3. Causes behind loss of Bioresource and its remedial strategies

Module 2: Conservation of Bioresource

- 2.1. Conservation of animal genetic resource
- 2.2. Ex-situ conservation of microbial resource
- 2.3. Conservation challenges in Aquatic (Freshwater and Marine) and terrestrial Bioresources: coarse and fine filter approaches.
- 2.4. Indigenous knowledge on uses of Bioresources
- 2.5. Criteria for sustainable systems and sustainable development.

Module 3: Microbial Biotechnology

- 3.1. Microorganisms for waste management
- 3.2. Bioprocess Technology: Microbial production of amino acids, antibiotics and microbial enzyme
- 3.3. The Fermentation Process: procedures and equipments, fermented foods and probiotics
- 3.4. Candidate microbiology for Biopesticides and Biofertilizers
- 3.5. Microbes in mineral and energy recovery, Fuel and Biomass production.

Module 4: Aquatic Biotechnology

- 4.1. Gene mapping, isolation and genetic improvements in cultivable fishes
- 4.2. Shrimp genomics: Development of a genetic map to identify QTLs responsible for economically important traits
- 4.3. Genomic approaches to marker development and mapping in edible oysters
- 4.4. Recent Advances in transgenic fish technology

ZEP 439 (Bioresource & Biotechnology Practical)

80 Marks 6 Credits

1. Cell and Tissue culture techniques
2. Biotechnological methods
3. Microbial Growth Curve
4. Microbial load from aquatic and soil samples
5. Cloning and Isolation of Plasmid Vector
6. Characterization of microbes from given samples
7. Survey of Bioresources
8. Field visits
9. Sessional (Internal Evaluation)
10. Viva-voce.