



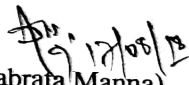
UNIVERSITY OF CALCUTTA

Notification No. CSR/ 78 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus of M.Sc. Course of Study in Zoology under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018


(Debabrata Manna)
Deputy Registrar (Acting)



Syllabus for a 2-year Semester System in M.Sc. (Zoology)

Session: 2018 -2020



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 2018-2020)

1 st Semester			
Code	Subject	Marks	Credits
ZCT 101	Non-Chordate Biology	40	3
ZCT 102	Ecological Theories	40	3
ZCT 103	Cell Biology	40	3
ZCT 104	Genetics	40	3
ZCT 105	Parasitology	20	1.5
ZCT 106	Insect Biology	20	1.5
ZCP 107	Laboratory Course for Core Subjects	50	5
2 nd Semester			
Code	Subject	Marks	Credits
ZCT 208	Chordate Biology	40	3
ZCT 209	Developmental Biology	40	3
ZCT 210	Immunology	40	3
ZCT 211	Biochemistry and Genetic Engineering	40	3
ZCT 212	Endocrinology	20	1.5
ZCT 213	Aquatic Biology	20	1.5
ZCP 214	Laboratory Course for Core Subjects	50	5
3 rd Semester			
Code	Subject	Marks	Credits
ZCT 315	Taxonomy and Biostatistics	40	3
ZCT 316	Animal Behavior and Wildlife Biology	40	3
ZCP 317	Laboratory Course for Core Subjects	30	3
ZET 318-331	Elective Theory*	40	3
CBCC A	CBCC A	50	4
CBCC B	CBCC B	50	4
4 th Semester			
Code	Subject	Marks	Credits
ZCT 432	Applied Ecology	40	3
ZCT 433	Evolution	40	3
ZCT 434	Comparative Animal Physiology	40	3
ZCP 435	Laboratory Course for Core Subjects	30	3
ZLI 436-449	Lab Internship (Internal Assessment, Dissertation & Seminar)*	20+30+30	6.5
ZCP 450	Grand Viva	20	1.5

*Elective Theory and Lab Internship (Lab Internship will be of one year duration, i.e., 3rd and 4th Semesters)

SHC	ZET 318/ ZLI 436	Aquatic Ecology & Fisheries Science	UC	ZET 325/ ZLI 443	Molecular Cell Biology
SR	ZET 319/ ZLI 437	Environmental Biology & Toxicology	SS	ZET 326/ ZLI 444	Disease Biology
GS	ZET 320/ ZLI 438	Entomology & Wildlife Biology	SG	ZET 327/ ZLI 445	Cytogenetics & Genomics
MD	ZET 321/ ZLI 439	Genetics of Human Diseases	ERB	ZET 328/ ZLI 446	Translational Biology
PB	ZET 322/ ZLI 440	Biodiversity & Ecosystem Function	AB	ZET 329/ ZLI 447	Applied Immunology
GA	ZET 323/ ZLI 441	Resource Ecology	SBC	ZET 330/ ZLI 448	Reproductive Endocrinology
AD	ZET 324/ ZLI 442	Applied Insect Science	RT	ZET 331/ ZLI 449	Human Evolutionary Genetics



Division of practical marks:

- Practical of 20 marks - 10 (Practical) + 5 (Internal Assessment) + 5 (Viva-voce)
- Practical of 30 marks - 20 (Practical) + 5 (Internal Assessment) + 5 (Viva-voce)
- Practical of 50 marks - 30 (Practical) + 10 (Internal Assessment) + 10 (Viva-voce)
- Practical of 75 marks - 50 (Practical) + 15 (Internal Assessment) + 10 (Viva voce)

The students will submit a Dissertation (50 marks) on their Elective paper opted. Both the Seminar and Dissertation Report will be evaluated by external examiner.

Course Structure

- A] **Core Subjects** : Compulsory for all
- B] **Elective Subjects** : Student will choose any one of the ten Elective subjects being offered
- C] **Choice Based Credit Course** : Student will choose any two of the nine CBCCs being offered, one from each group

<u>MARKS/CREDIT</u>	<u>MARKS</u>			<u>CREDIT</u>		
	<u>THEORY</u>	<u>PRACTICAL</u>	<u>TOTAL</u>	<u>THEORY</u>	<u>PRACTICAL</u>	<u>TOTAL</u>
SEMESTER I	200	50	250	15	5	20
SEMESTER II	200	50	250	15	5	20
SEMESTER III	220	30	250	17	3	20
SEMESTER IV	120	130	250	9	11	20
GRAND TOTAL:			1000			80



3. Evolutionary and Behavioral Ecology

- 3.1 Ecological specialization and generalization
- 3.2 Parent – offspring conflict
- 3.3 Evolution of sex and sex ratio.
- 3.4 Mating systems with special reference to birds and mammals.
- 3.4 Communication
- 3.5. Foraging

ZCT 103

Cell Biology

40 Marks 3 Credits

- 1. Plasma membrane- structure and functional inter-relationships including membrane assembly
- 2. Structure and function of animal tissues
- 3. The cytoskeleton, cellular transport, extracellular matrix
- 4. Cell signaling and cell-cell interaction
 - 4.1 Cell surface and intracellular receptors
 - 4.2 Signaling pathways and cross talk mechanisms
- 5. Cell death mechanisms
 - 5.1 Autophagy
 - 5.2 Apoptosis
 - 5.3 Anoikis
- 6. Staining and dyes in identification of specific tissues. Stains- definition, physical & chemical classification, nomenclature, mordants, metachromasia
- 7. Tools and techniques in cell biology

ZCT-104

Genetics

40 Marks 3 Credits

1. Chromatin Dynamics:

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

2. DNA replication and regulation

- 2.1 Enzymology of eukaryotic replication and gene amplification.
- 2.2 Role of Non-coding RNA in prokaryotic and eukaryotic DNA replication.

3 Regulation of gene expression

- 3.1 Transcription in eukaryotes: Initiation, elongation & termination
- 3.2 Epigenetic regulation: Dosage compensation in Mammals and Drosophila.
- 3.3 Genetic imprinting: Mechanism and Model
- 3.4 Catalytic & small RNAs; Gene silencing.

4 Translation & Post Translational events

- 4.1 Translation in eukaryotes: Initiation, Elongation and termination.
- 4.2 Protein splicing, chaperones and protein folding.
- 4.3 Post translational mRNA decay.



5 Recombination & repair

- 5.1 Recombination in eukaryotes; Recombination types.
- 5.2 Enzymology of human meiotic recombination; Molecular anatomy of synaptonemal complex.
- 5.3 Enzymes involved in DNA repair mechanisms.

6 Transposable Genetic Element

- 6.1 Ac-Ds element in Maize, IS element in bacteria, Composite transposon, Retrotransposon.
- 6.2 P-element in Drosophila, Hybrid dysgenesis and role of piRNA in transposon silencing.
- 6.3 Role of transposable element in evolution and genome modification.

7 Microbial Genetics

Conjugation, Transduction, Regulation of Lytic and Lysogenic cycle.

8 Somatic cell genetics.

- 8.1 Cell fusion, heterokaryon selection & hybridoma technology.
- 8.2 Chromosome mapping.

ZCT 105

Parasitology

20 Marks 1.5 Credits

- 1. Human clinical and veterinary parasitology- detection, diagnosis, prophylaxis, treatment, and pharmacology (emergent parasites)
- 2. Community medicine
- 3. Host parasite interaction- immunological nuances in vertebrates and invertebrates and epidemiological surveillance tools.
- 4. Vector biology with special reference to Malaria and Kala-azar.
- 5. Genome organization in Plasmodium
- 6. Molecular basis of antigenic variation in Plasmodium

ZCT 106

Insect Biology

20 Marks 1.5 Credits

- 1. Food and digestion, feeding potential of insects in response to food availability
- 2. Excretory mechanism of insects with special reference to Cryptonephridial mechanism
- 3. Tracheal and plastron respiration of insects
- 4. Insect immune defense
- 5. Metamorphosis, diapauses and their interrelationship and regulation
- 6. Atypical modes of reproduction
- 7. Stridulation and its biological significance
- 8. Bioluminescence

**ZCP 107 Laboratory Course for Core Subjects 50 Marks 5 Credits**

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.
3. Analysis of aquatic habitat and community.
4. Analysis of terrestrial habitat and community
5. Drosophila genetic crosses, Induction of mutation in Drosophila by P-M Mutagenesis, preparation of polytene chromosome, Karyotyping
6. DNA isolation and Agarose Gel Electrophoresis
7. Restriction digestion
8. Identification of mammalian tissue sections.
9. Tissue fixation, microtomy and double staining of tissue sections.
10. Sessional work (Internal evaluation)
11. Viva voce

2 nd Semester			
Code	Subject	Marks	Credits
ZCT 208	Chordate Biology – SBC/SG/SHC	40	3
ZCT 209	Developmental Biology – ERB/SG/AB/UC	40	3
ZCT 210	Immunology – ERB/SR/AB	40	3
ZCT 211	Biochemistry and Genetic Engineering – AS/GA/SS/SG/RT	40	3
ZCT 212	Endocrinology – SBC/MD	20	1.5
ZCT 213	Aquatic Biology – SHC/SBC	20	1.5
ZCP 214	Laboratory Course for Core Subjects	50	5

ZCT 208 Structure and Function of Chordates 40 marks 3 Credits

- 1. Protochordata**
 - 1.1. Fine structure of notochord in Amphioxus.
 - 1.2. Modern interpretation of origin of early chordata.
- 2. Integumentary system**
 - 2.1. Cell association
 - 2.2. 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. Circulation**
 - 4.1. Heart and circulation in fetal and neonatal mammal
 - 4.2. Evolution of portal system.



5. Nervous system & Sense organ

- 5.1. Sensory receptors and classification.
- 5.2. Organ of olfaction and taste.

6. Structural Adaptation

- 6.1. Structural elements of body and their properties.
- 6.2. Mechanics of support and movement
- 6.3. Swimming adaptation.
- 6.4. Cursorial adaptation.
- 6.5. Flying mechanism.

ZCT 209

Developmental Biology

40 marks 3 Credits

1. Principles of Developmental Biology

- Potency, commitment, specification, induction, competence.
- Determination and Differentiation; morphogenetic gradient, cell fate and cell lineages.
- Cell to cell communication during early development.

2. Metamorphosis and organogenesis in model organisms

- *Drosophila*: Axes, compartment and pattern formation, HOX gene and their regulation.
- *Caenorhabditis elegans*: Early development and vulva formation.
- *Xenopus*: Organizer formation, mesoderm specification.
- Zebrafish: Cell movement and signal during early development, Patterning, polarity and regionalization of nervous system.
- Limb development in vertebrate.

3. Regenerative Biology

- Cellular and molecular aspects, Genomic equivalence and cytoplasmic determinants.

4. Environment and Development

- Environmental control of gene regulation, Epigenetic regulation of developmentally relevant genes.

ZCT 210

Immunology

40 marks 3 Credits

Phylogeny of Immunity

Immunobiology of Invertebrates. Principal strategies, immune-responsive cells and tissues. Phenoloxidase cascades, natural and inducible immune response.

Innate Immunity

Overview. Features. Epithelial Barrier. Neutrophil and Macrophage Function. Defense mechanism to Infection (Migration, Inflammation and Phagocytosis). Function of NK cell. Cross-talk with Adaptive Immune system

Antigens Capture and Presentation

Concept of APC .Structure and Function of MHC molecule. MHC processing and presentation



Antigen Recognition

B cell and T cell receptor complex. Formation and selection of diversity receptors. VDJ recombination

Cell Mediated Immunity

APC- T cell interaction. IL-2 Receptor Role. Clonal Expansion. Th1, Th2 and Th17 response. Cytotoxic T cell function. T cell signaling

Humoral Immunity

Neutralization and Opsonization. Functional aspect of B- cell. Class switching. B cell signaling

ZCT-211 Biochemistry and Genetic Engineering 40 marks 3 Credits

1. Amino acid (classification, basic properties; peptides: primary, secondary, tertiary and quaternary structures, carbohydrate (basic structure, classification and simple properties of monosaccharides; examples of di-oligo & polysaccharides) and lipid (basic structure & simple properties of membrane lipids), outline of metabolic pathways of these major biomolecules with mention of rate limiting steps; names of simple precursors of some important bioactive molecules such as dopamine, melanine, porphyrin, cholesterol, purine & pyrimidines. Some important catabolites such as bilirubin, uric acid etc; Metabolic disorders.
2. Enzymes: classification, kinetics, examples of inhibitions & inhibitors; modulations
3. Bioenergetics (anaerobic and aerobic respiration, oxidative and substrate level phosphorylation) basic concept of ETC and ATP synthesis, uncouplers. Spontaneous reaction (concept of $-ve \Delta G$)
4. Vitamins and minerals: use of vitamins as coenzymes with the relevant reaction involved) deficiencies.
5. Chemistry of free radicals and antioxidants.
6. Recombinant DNA technology
 - a. Eukaryotic cloning vectors, cloning strategies, identification of specific clones.
 - b. cDNA library and Genomic library.
 - c. Generation of transgenic animals.
 - d. Gene knock-out and gene silencing.
7. Genomics, Proteomics & Bioinformatics
 - a. Definition and Basic concept; ESTs, Organization of human genome repeat sequence, multigene families and genome conservation.
 - b. DNA micro-array and its use.
 - c. Genome wide DNA methylation and acetylation and their significance.
 - d. Proteomics & Bioinformatics: Basic concept and use.



8. Gene therapy & Pharmacogenomics
 - a. Various approaches of gene therapy.
 - b. Stem cell therapy and microRNA therapy.
 - c. Concept of pharmacogenomics; Use of pharmacogenetics for disease prognosis and treatment, response and toxicity.

9. Molecular techniques.
Polymerase chain reaction (PCR), RT-PCR, Pulse Field Gel Electrophoresis, Site-directed mutagenesis, Gel retardation assay, RNase protection assay, DNA fingerprinting, FISH, Southern, Northern and Western blot technique.

ZCT 212 **Endocrinology** **20 marks** **1.5 Credits**

1. Pheromones: Classification, chemical nature, structure, functions, relevance in applied fields, clinical applications.
2. GI tract hormones: Source, composition and functions.
3. Thymic hormones and cell immunity.
4. Pineal gland structure, biosynthesis of melatonin, diurnal variations of pineal gland functions.
5. Hormones and human health: Stress, metabolic and reproductive disorders (Pituitary, Pancreas, Thyroid, Testis, Ovary) - molecular basis and therapeutics.

ZCT 213 **Aquatic Biology** **20 marks** **1.5 Credits**

1. Deep Sea Environment and Biological adaptations of Aquatic biota . Hydrothermal vent and life processes. Molecular mechanism of adaptation to salinity in euryhaline and stenohaline species in coastal and intertidal ecosystem.
2. Chemical cues for orientation and navigation of aquatic organisms in response to emergent sensory requirements in complex aquatic environment.
3. Respiration and energy yield as survival strategies in fauna inhabiting extremities of aquatic environments,
4. Molecular and integrative physiology of reproduction and larval recruitment of aquatic biota

ZCP 214 **Laboratory Course for Core Subjects** **50 Marks** **5 Credits**

1. Morphometric analyses of different fish specimen and interpretation of food habit and respiratory efficiency.
2. Collection of different swim bladder from different fish specimen (collected from market) and comparative study on functional efficiency of swim bladders.
3. Study of adaptive features and interpretation of significance from morphology of preserved specimen.
4. Determination of glucose in different patho-physiological condition.
5. Estimation of total protein from tissues of animal model.



5. Descriptive Statistics

- 5.1 Statistics and Biological data – basics inclusive of the distributions
- 5.2 Measures of central tendency
- 5.3 Visual representation of data- leaf and stem diagram, box-plot analysis
- 5.4 Basics of probability

6. Sampling and Analysis

- 6.1 Sampling theory: Statistical inference and hypothesis testing
- 6.2 t-tests and applications in biology
- 6.3 Analysis of variance and experimental designs Non Parametric Tests
- 6.4 Correlations and regression analysis

ZCT 316

Animal Behavior and Wildlife Biology

40 Marks 3 Credits

1. Genes and Behaviour

2. Cooperation and conflict

- 2.1 Range of cooperative behavior and theories of cooperation, Kin selection
- 2.2 Elaborate ornaments: Fisher's hypothesis and Handicap hypothesis
- 2.3 Conflict over mate choice

3. Foraging

- 3.1 Optimal foraging theory
- 3.2 Foraging and predation risk: defense strategies against predators
- 3.3 Territoriality and Group foraging

4. Aggression

- 4.1 Aggressive behaviour
- 4.2 Game theory models and strategies – Prisoners' dilemma and reciprocal altruism and evolution of sociality

5. Wildlife habitat ecology: Biomes of the world – an overview; biome types of India: alpine tundra, grassland, forest, desert, aquatic and wetlands (unique features, distribution, vegetation, faunal make up and adaptations). Forest types of India

6. Protected area concept: Protected area network in India; Design and management of nature reserve; concept of corridor; joint forest management.

7. Conservation biology of important wild animals: Conservation status, habit & habitat, behavioural biology, threats and conservation management of the following animals. Himalayan salamander / Olive ridley turtles / Great Indian bustard / Himalayan musk deer/ Greater one-horned rhinoceros / Fishing cat / Ganges river dolphin.

8. Basic Concept of Wildlife Biology: Definition and importance of wildlife ; Wildlife wealth of India ; Threatened wildlife and IUCN status - Concept of Extinct, Critically Endangered, Endangered, Vulnerable and rare species ; Red data book;

9. Wildlife conservation Indian perspective: Aims & Objectives of wildlife conservation. A brief idea about Indian wildlife, causes for depletion of Indian wildlife; wildlife conservation in India- through age, post-independence initiatives. Different approaches for conservation – *in situ* and *ex situ*, Conservation breeding; Threats to wildlife conservation in India.

10. Protected Area Concept: In situ conservation- problems and prospects; Sanctuaries, National parks, Community Reserves and Conservation Reserves; Biosphere Reserve, Case studies - Sundarban Biosphere Reserve.



11. Wildlife Habitat Ecology: Concept of Biome, Biome types of India –a general account. Case studies: Tropical rain forest – characteristics, faunal make up and animal adaptations.

12. Wildlife sampling: random sampling, systematic sampling, stratified sampling, cluster sampling.

13. Peoples' participation in wildlife activities: Community participation in conservation; JFM.

ZCP 317 Laboratory Course for Core Subjects 30 Marks 3 Credits

Developing habitat description, mapping and elevation, learning operations for estimation of wildlife populations, and description of wildlife populations. Addressing social issues of conservation. Some of the skills as in the following list are to be imparted:

- Bird / butterfly sampling
- Small mammal trapping
- Population estimation using Mark-recapture method, Transects.
- Habitat structure description methods
- Reptile and amphibian sampling
- GPS use, plant identification
- Introduction to radiotelemetry
- Larger mammal population estimation techniques

Elective Papers

SHC	ZET 318	Aquatic Ecology & Fisheries Science	UC	ZET 325	Molecular Cell Biology
SR	ZET 319	Environmental Biology & Toxicology	SS	ZET 326	Disease Biology
GS	ZET 320	Entomology & Wildlife Biology	SG	ZET 327	Cytogenetics & Genomics
MD	ZET 321	Genetics of Human Diseases	ERB	ZET 328	Translational Biology
PB	ZET 322	Biodiversity & Ecosystem Function	AB	ZET 329	Applied Immunology
GA	ZET 323	Resource Ecology	SBC	ZET 330	Reproductive Endocrinology
AD	ZET 324	Applied Insect Science	RT	ZET 331	Evolutionary Genetics

ZET 318 Aquatic Ecology and Fisheries Science 40 Marks 3 Credits

1. Ecological Zonations, characteristics and biodiversity of Freshwater, Estuarine and Marine ecosystems. Nutrient generation, cycling and productivity, Bioresources and Bioactive compounds from estuarine and Marine resources. Exclusive Economic Zone – Potentials and exploitation. Remote sensing and GIS for Fish stock analysis
2. Metapopulation and Metacommunity approaches for fish assemblages, Coarse and Fine filter methods for conservation of aquatic bioresources
3. Fish Nutrition- Stages of Nutrient Acquisition, Temporal pattern of nutrient acquisition, Integration of nutrient acquisition – compartment models, gut-reactor model, state-space model, nutritional requirement of cultivable fish and prawn, nutritional



bioenergetics, energy efficiency in fish production, Feeding schedules and ratio, feed performance, feed formulation, processing, storage and application, Fish growth estimation.

4. Fish Pathology and Defense mechanism - Factors of fish health and integrated health management, Infection and Immune responses to pathogens in environment – Transformation of infection into disease, cells and tissues of the immune system of fish – cellular and humoral defenses, Cells and tissues of the immune system of fish – cellular and humoral defenses, Immunomodulation – exogenous and endogenous factors.
5. Brief account of Sustainable technology for Aquaculture (Freshwater, Estuarine and Mariculture), Advancements in technology for finfish and shellfish culture, Modern hatcheries and management, Technology of stock improvement – cryopreservation, hybridization, polyploidy and transgenesis, xenogenesis, sex reversal and breeding. Principles and design of Raceway, cages and Pen enclosures, Recirculating systems, Intensive Fish Hub, Integrated Aquaculture.
6. Fisheries Biotechnology and Functional Genomics, Biochemical and Molecular markers, Population genetics and interaction of hatchery and wild fish, Gene mapping, Quantitative trait locus mapping and marker – assisted selection, Gene transfer technology, Genotype – environment interaction, environmental risk of aquatic organisms for genetic biotechnology, Genetic conservation, gene banking and maintaining genetic quality.

ZET 319 Environmental Biology and Toxicology 40 Marks 3 Credits

1. Environmental Biology and Toxicology: general Consideration
2. Environmental impact assessment and environmental monitoring
3. Semiochemistry: Plant: animal interaction in the natural environment
4. Environmental Contamination and endocrine disruption
5. Toxin: Classification, examples
6. Xenometabolism: Phase I, phase II reaction
7. Analytical toxicology: Immunohistochemistry, FACS, fluorescence microscopy
8. Dose- response relationships

ZET 320 Entomology And Wildlife Biology 40 marks 3 credits

1. Capture, handling and rescue operations of wild animals and their management. Capture methods, handling of capture animals; transportation. Case study – Capture, collection and rescue of injured dead wildlife during oil spills.
2. Captive breeding of wild animals: Concept of captive breeding; reintroduction of captive breeds – controversies and realities; release protocol; advantages and challenges of captive breeding.
3. Special management program of wild animals in India: Origin, objectives, implementation, advantages and limitations of project tiger, project elephant, operation rhino, lion conservation project, crocodile conservation project.
4. Bio-ecology of important wildlife of India: Himalayan Salamander, Olive Ridley turtle, Great Indian Bustard, Fishing Cat.



2. Biodiversity and Ecosystem function

- a) Theories on relation between biodiversity and ecosystem function
 - i. Species Complementarity
 - ii. Sampling effect
 - iii. Redundancy
- b) Decline of global biodiversity and loss of ecosystem function.
- c) Functional diversity and ecosystem functioning.
- d) Insurance Hypothesis: The effect of habitat fragmentation and dispersal on ecosystem functioning.
- e) Biodiversity and stability in soil ecosystem: pattern processes and the effect of disturbance.
- f) Global pollinator loss and their effect on crop production and non-crop plant reproduction.
- g) Multi-trophic dynamics and ecosystem processes.
- h) The economics of biodiversity and ecosystem function.

3. Landscape Ecology:

- a) Theories in landscape ecology.
 - Hierarchy theory and the structure of the landscape
 - Percolation theory
 - Metapopulation theory
 - The systems source sink
- b) Scale and landscape
 - Scaling the landscape
 - Change of scale perception
 - Importance of parameters at different scales
- c) Processes in the landscape
 - Disturbance
 - Fragmentation
 - Landscape connectivity
 - Corridors
- d) Methods in landscape ecology
 - Spatial data processing
 - fractal geometry approach
 - Remote sensing in landscape ecology
 - Geographic Information System
 - Spatially explicit population models (SEPM)

ZET 323

Resource Ecology

40 Marks 3 Credits

1. Community structure and function – organization, ordination, niche concept and community development; theories of community development and applications in ecological management – eutrophication and biomanipulation; soil microbes and organization of the drillosphere and the rhizosphere
2. Population - growth models, regulations, metapopulation, demographic analysis including life table, fecundity schedule and competitive interactions; census techniques



3. Resource-consumer interactions; food web and species interactions direct and indirect; microbes and plants; Modelling species interactions – apparent competition, intraguild predation, succession, bipartite network and applications
4. Natural resources and sustainable development – principles and models; environmental worldviews; wild life resources, aquatic living resources, forest resources; ecosystem services valuation, links with biodiversity; ecological footprint analysis; ecosystem health;
5. Natural resources and technologies related to bioremediation, bioindicators, biosensors, biomarkers, biomanipulation of lakes, biomimetics, biosubstitution
6. Quantitative methods in biodiversity assessment; resource harvest; modelling diversity and distribution of species in time and space; population growth assessment;
7. Statistical methods and research design – exploratory data analysis, non-parametric methods, sampling methods and the principles of replicates

ZET 324

Applied Insect Science

0 Marks 3 Credits

1. Crop pests, principles and applications of integrated pest management, conventional, non-conventional insecticides, and nano-insecticides, application success and limitations
2. Insect eusocialism concepts, principals, algorithms and applications to human societies
3. Insect-plant interaction, resistant insect, insect parasitoides, Crop health and protection
4. Ecological surveillance, monitoring and bio-indicator aspect applications through insect models
5. Agricultural entomology: insect/pest survey, methods and techniques, crop feeding potential, reproductive potential assays, scope, limitations and crop-yield prediction
6. Mechanism of insect flight, luminescence, acoustics and their applications
7. Neural, endocrinal and immunological modulations on insect behaviors, defense, kin selection, migration and aggression.
8. Commercial, forensic and medical applications of insects and it various products/forms

ZET 325

Molecular Cell Biology

40 Marks 3 Credits

1. Integration of cellular macromolecules and protein sorting

- a) Transport of macromolecules between the nucleus and cytosol
- b) Transport of macromolecules between the cytosol and mitochondria
- c) Transport from ER to Golgi
- d) Post-translational modifications of proteins (folding, etc), and destruction mechanisms

2. Cell-to-cell communication

- a) Gap junctions, tight junctions and cell signaling
- b) Role of calcium and NO in signal transduction
- c) Fate of cells with regard to morphogen gradients
- d) Crosstalk mechanisms and integrative pathways

3. Stem Cell Biology

- a) Concept, types, self-renewal, pluripotency, differentiation
- b) Isolation and characterization of stem cells
- c) Use of stem cells in tissue repair



4. Cell Cycle, Cell Death and Cell Renewal

- a) Mechanisms of cell cycle regulation
- b) Programmed cell death
- c) Autophagy
- d) Cellular senescence

5. Cancer and oncogenesis

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

6. Methods in Molecular Cell Biology

- a) Cell culture techniques, transfection and infection of cells
- b) Protein purification, characterization and detection
- c) Nucleic acids, miRNAs and RNA interference
- d) RNA isolation and real-time RT-PCR
- e) Immunohistochemistry / Immunocytochemistry
- f) Microscopy and imaging (light, fluorescence/confocal, SEM)
- g) Fluorescence-activated cell sorting
- h) Isolation and characterization of cancer stem cells
- i) Transgenics and Knock-outs
- j) Drug-loaded functionalized nanoformulations for targeting cells

ZET 326

Disease Biology

40 Marks 3 Credits

1. Communicable and non-communicable human diseases - brief outline and pathophysiology of diseases caused by bacteria, viruses and salient metabolic disorders
2. Recombinant DNA technology and creation of recombinant molecules
Role of genes within cells, genetic elements that control gene expression, restriction and modifying enzymes, safety guidelines of recombinant DNA research.
Restriction mapping, design of linkers and adaptors. Characteristics of plasmid and phage vectors, prokaryotic and eukaryotic expression vectors. Screening of libraries with DNA probes and with antisera. Transgenesis and knockout animals
3. Polymerase Chain Reaction as a tool for disease biology
Nested PCR, Taqman assay, RACE PCR, RAPD, site directed mutagenesis
4. Omics technology to address genetic basis of human diseases
5. Gene therapy in disease biology
6. Stem cells as tool to repair damaged tissue
7. Nanotechnology and targeted tissue engineering



ZET 327

Cytogenetics and Genomics

40 Marks 3 Credits

- 1. Human Genome Organization**
- 2. Mapping of Human genome**
Genetic Mapping and Physical mapping process; Human Genome project and its ethical and social implications.
- 3. Identification of human disease genes and etiology of selected genetic disorders in human.**
- 4. Genes in Pedigree and Population**
Monogenic vs Multifactorial inheritance; Mendelian Pedigree and complications to basic Mendelian pedigree; Genetic counseling.
- 5. Techniques for studying Eukaryotic genome and Gene Function**
Isolation of X linked and autosomal conditional mutations in *Drosophila*, P-mediated mutagenesis, Enhancer Trap and UAS-GAL4 in *Drosophila*; FLP-FRT system, Cre-LoxP system, GWAS; Chromatin immunoprecipitation, Yeast two hybrid system, Human karyotyping.
- 6. Genetic testing**
- 7. Genome Evolution:**
Comparative genomics; concerted events of X-chromosome evolution and dosage compensation in the genus *Drosophila* and related molecular changes. Y-chromosome evolution in Human.

ZET 328

Translational Biology

40 Marks 3 Credits

1. Drug discovery school- in vitro pharmacology
2. Drug discovery school- in vivo pharmacology including ADMET
3. Preclinical to clinical transition in drug discovery and development
4. Experimental immunology-
 - Transplantation Immunology
 - Tracing lymphopoiesis
 - Animal models in Immunology
 - Mucosal immunity
5. Immunotherapy in diseases- Rheumatoid arthritis, Asthma
6. Regenerative Biology-
 - Animal models in research and development
 - Animal models in Development and Regeneration
7. Regenerative Medicine
 - Regenerative therapy
 - Tissue engineering and scaffolds
8. Nutrition and nutraceuticals-
 - Micronutrients
 - Functional food
9. Clinical pharmacology
 - General pharmacology- terms, definitions, representations
 - Classes of drugs
 - Bioassay of drugs



10. Functional and systems approach to experimental molecular cell biology-
- Emphasis on molecular approaches to understand
 - (i) Cell structure, function, and regulation
 - (ii) Analyses of experimental design and data interpretation
 - Systems Biology

ZET 329

Applied Immunology

40 Marks 3 Credits

I. Infection and Immunity

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

2. Hypersensitivity

- 2.1 Type I
- 2.2 Type II
- 2.3 Type III
- 2.4 Type IV

3. Tolerance and Autoimmunity

- 3.1 General features and mechanisms of immunologic tolerance
Regulation of immunity and tolerance by dendritic cells
- 3.2 Malfunction and different autoimmune disease.

4. Tumor Immunology

- 4.1 Strategies of tumor cell to evade Immune system
- 4.2 Anti-tumor Immune response
- 4.3 Modern Immunotherapy of Cancer

5. Transplantation Immunology

- 5.1 Basis of Transplantation
- 5.2 Acute, Hyperacute and chronic Graft rejection
- 5.3 Modern techniques of transplantation (e.g BMT, liver, cornea, etc)

6. Immunodeficiencies

- 6.1 Congenital Immunodeficiencies
- 6.2 Acquired Immunodeficiencies

7. Immunoprophylaxis

- 7.1 Principles and Significance
- 7.2 Types of Vaccines (subunit, killed, attenuated etc.)



ZCT 434 **Comparative Animal Physiology** **40 Marks** **3 Credits**

- 1. Principles of animal physiology :**
Mechanistic and evolutionary approaches. Size and scaling of animals
- 2. Physiological homeostasis:**
Positive and negative feedback, Controlled variable, Set point
- 3. Thermal physiology :**
Heat transfer mechanism between animal and environment. Supercooling, Anti freeze compound, Behavioural thermoregulation, Pejus and Critical temperature, adaptational trend in subzero condition
- 4. Physiology of excretion**
Physiology of ultrafiltration, reabsorption, tubular secretion
Counter current theory of urine concentration, Regulation of urine formation
Method of urine formation, Nitrogenous wastes
Renal regulation of acid- base balance
- 5. Physiology of Circulation and Respiration**
Comparative structure of cells in circulation of invertebrates and vertebrates
Composition of blood, plasma and blood Corpuscles, in vertebrates, Functions
- 6. Physiology of behaviour**
Pheromones in colonial interactions, foraging and mating
Allelo-chemicals in Plant-Insect interaction

ZCP 435 **Laboratory Course for Core Subjects** **30 Marks** **3 Credits**

1. Trait analyses of an invasive species
2. Pollen transport by any common insect pollinator
3. Water quality assessment for determination of trophic state of a pond
4. Construction of phylogenetic tree from supplied data
5. Enzymatic Method for Determining Amylase Activity (Comparative)
6. Sessional (Internal Assessment)
7. Viva-voce



Choice Based Credit Courses

The students will have to choose one course each from the offered groups.

No student is allowed to choose the course offered by his/her parent department.

Each course is of 50 marks and carries 4 credits.

THE CBCC syllabus offered by the Department of Zoology, University of Calcutta entitled "Concepts in Zoological Science" is as follows:

Concepts in Zoological Science

1. Outline of animal classification

1.1 Linnaean Hierarchy and species concept

1.2 Phylogenetic reconstruction, characters and character states, cladistic and phenetic methods

1.3 Molecular taxonomy and evolutionary theories

2. Ecological principles and Biodiversity

2.1 Population and community ecology revisited: basis for conservation

2.2 Conceptual framework of biological diversity including threats and management options

2.3 Biodiversity indicators: Taxon based indicators, Surrogate species and global pattern of diversity endemism and megadiversity centers

2.3 Global pattern of biological diversity endemism and megadiversity centres

2.4 Wild life resources of India: conservation framework and status of threatened taxa

3. Evolutionary Biology

3.1 Methods of studying natural selection and adaptation; Models of selection

3.2 Gene flow (Hardy Weinberg equilibrium), genetic drift and Neutral Theory of Evolution

3.3 Molecular clock of evolution

4. Principles of Developmental Biology

4.1 Determination and differentiation; morphogenetic gradients; cell fate and cell lineages

4.2 Production of gametes, prerequisites of fertilization

4.3 Zygote formation, cleavage, blastula formation, embryonic fields,

4.4 Gastrulation and formation of germ layers in animals; embryogenesis

5. Metamorphosis and Organogenesis in model animal systems

5.1 Axes, compartment formation and pattern formation in *Drosophila*.

5.2 Vulva formation in *Caenorhabditis elegans*

5.3 Organizer formation and Mesoderm specification in *Xenopus*

5.4 Development of heart and circulatory systems in vertebrate

5.5 Development and maturation of the immune system

5.6 Limb development and regeneration in vertebrates

6. Animal Physiology

6.1 Size and scaling of organisms

6.2 Physiological adjustments to extreme environmental conditions;

6.3 Thermal and sensory physiology; chemical communications

7. Animal Behaviour

6.5 Animal behaviour study: proximate and ultimate causes

6.6 Sociobiology of social insects and vertebrates: theory and empirical studies

6.7 Optimal foraging theory and parent offspring conflict