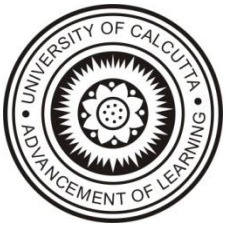
Syllabus for

M.Sc. in Zoology
University of Calcutta
(2 years Semester System)



Department of Zoology, University of Calcutta

UNIVERSITY OF CALCUTTA
SYLLABUS STRUCTURE FOR M.Sc. (ZOOLOGY)
SEMESTER COURSE (Session 2020-2022)
1st Semester

Code	Subject	Marks	Credits
ZCT 101	Invertebrate Functional Forms and Adaptations	50	4
ZCT 102	Ecological Theories	50	4
ZCT 103	Cell Biology	50	4
ZCT 104	Genetics	50	4
ZCP 105	Laboratory Course For Core Subjects	50	4

2nd Semester

Code	Subject	Marks	Credits
ZCT 206	Vertebrate Functional Forms and Adaptations	50	4
ZCT 207	Developmental Biology and Neurobiology	50	4
ZCT 208	Biochemistry and Genetic Engineering	50	4
ZCT 209	Parasitology and Immunology	50	4
ZCP 210	Laboratory course for core subjects	50	4

3rd Semester

Code	Subject	Marks	Credits
ZCT 311	Conservation biology	50	4
ZCT 312	Endocrinology and Comparative Animal Physiology	50	4
ZET 313-328	Elective Theory	50	4
CBCC A	CBCC A	50	4
CBCC B	CBCC B	50	4

Elective paper selection at the end of 2nd Semester for commencement of project work and theory classes. The students will be assigned specific dissertation projects during 3rd semester. Elective paper selection of the students based on grades obtained in 1st Semester.

4th Semester

Code	Subject	Marks	Credits
ZCT 429	Taxonomy & Biostatistics	50	4
ZCT 430	Animal Behavior and Evolutionary Biology	50	4
ZCP 431	Laboratory course for core subjects	50	4
ZCP 432	Comprehensive viva voce + Field Study* & Report	(30+20) = 50	4
ZEP 433#	a) Lab internship and Dissertation b) Seminar on dissertation/ Review work	(30+20) =50	4

***Field Study encompasses Case Study analysis of conservation measures for threatened species or Ecosystem/Field data collection (Population Study) and statistical analyses/ Habitat mapping /biodiversity assessment/Animal behaviour and Evolutionary significance**

#External Examination Only (ZEP 433), ZCP 432 will be evaluated by a Board of Examiners including both Internal and External Examiners as recommended by the PGBOS.

Elective papers with names of respective Advisor in parenthesis

1. ZET - 313Aquatic Ecology and Sustainable Development (SHC)
2. ZET- 314 Resource Ecology (GA)
3. ZET- 315Environmental Biology and Toxicology (SR)
4. ZET-316 Biodiversity and Ecosystem Functions (PB)
5. ZET- 317 Fish Biology and Aquaculture (SHC)
6. ZET - 318 Applied Entomology (AD)
7. ZET- 319Wild Life Biology and Conservation (GS)
8. ZET- 320 Molecular Cell biology (UC)
9. ZET - 321Disease Biology (SS)
10. ZET-322 Cytogenetics and Genomics (SG)
11. ZET - 323 Evolutionary Human Genetics (RT)
12. ZET - 324 Genetics of human diseases (MD)
13. ZET- 325 Translational biology (ERB)
14. ZET- 326Applied Immunology (AB)
15. ZET- 327 Reproductive Endocrinology (SBC)
16. ZET - 328Applied Parasitology (AB)

Division of practical marks:

Core Practical of 50 marks - 30 (Practical) + 10 (Internal Assessment) + 10 (Viva-voce)

The students will submit a Dissertation (30 marks) following laboratory internship 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 Elective subjects being offered

C] **Choice Based Credit Course** **:** Student will choose any two of the nine CBCCs being offered, one from each group

	MARKS/CREDIT					
	MARKS			**CREDIT**		
	THEORY	**PRACTICAL**	**TOTAL**	**THEORY**	**PRACTICAL**	**TOTAL**
SEMESTER I	**200**	**50**	**250**	**16**	**4**	**20**
SEMESTER II	**200**	**50**	**250**	**16**	**4**	**20**
SEMESTER III	**250**	**00**	**250**	**20**	**0**	**20**
SEMESTER IV	**100**	**150**	**250**	**8**	**12**	**20**
GRAND TOTAL:			**1000**			**80**

UNIVERSITY OF CALCUTTA

SYLLABUS STRUCTURE FOR M.Sc. (ZOOLOGY)

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ZCT 104	Genetics	50	4
ZCP 105	Laboratory Course For Core Subjects	50	4

ZCT 101 Invertebrate Functional Forms and Adaptations 50 Marks 4 Credits

1. Evolution of metazoans; origin, radiations and extinction of invertebrate groups; evolution of polarity and early organizer concept
2. Types of invertebrate feeding
3. Biological and medicinal importance of sponges
4. Biology of Entoprocta and Cycliophora
5. Mechanics of invertebrate movement/locomotion; muscular activity and skeletal system; invertebrate swimming and flight
6. Factors influencing respiration (body and size, activity, feeding, temperature, oxygen tension and salinity)
7. Invertebrate defense against predators and parasites
8. Regulation of reproductive process - reproductive cycle, biorhythmicity
9. Organization of nervous system: nervous system, nerve net, central and peripheral nervous system, invertebrate brain
10. Regeneration in Cnidaria and Annelida
11. Thermoregulation and Osmoregulation in different invertebrate groups
12. The language of Insect communication- Chemical mode of communication, Acoustic communication, Bioluminiscence
13. Chemical mimicry of Insects- Courtship and reproduction, Kin selection and aggression, Interpretations of signaling pathways

ZCT 102 Ecological Theories 50 Marks 4 Credits

1. Population Ecology

1.1 Population growth models- Mathematical Interpretations, Population fluctuations and Explanatory models (Beverton – Holt, Ricker), Synthesis of population regulation theories.

1.2 Life history strategies

1.3 Meta-population concept, Models of persistence and extinction risks

2. Community Ecology

2.1 Understanding community structure

2.2 Species coexistence – maintenance of species diversity, Island Biogeography theory, Biodiversity and Ecosystem Function

2.3 Interspecific Interactions – Competition, predation, mutualism

2.4 Community stability and Functions – Food web models and Network, Disturbance and Implications

2.5 Ecological modeling - Predator-prey models, Epidemiological models, Harvest models, Foraging models

3. Ecological crises and Management

3.1 Ecology of invasive species- Characteristics of invasive species, Species invasion model

3.2 Agroecology and Ecological Restoration- Domains of agroecology – science, practice and movement, Bioremediation, Phytoremediation, Natural degradation process, Eco-restoration – theories and applications

4. Behavioural Ecology

4.1. Ecological specialization and generalization

4.2. Parental investment

4.3 Evolution of Sex

5. Ecological Economics

5.1 Ecosystem services, types and valuation,

5.2 Ecological footprint analysis

ZCT 103 Cell Biology 50 Marks 4 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 50 Marks 4 Credits

1. Chromatin Dynamics:

1.1 Chromatin remodeling; Replicative nucleosomal assembly; Molecular nature and functional status of chromatin; chromatin silencing
1.2 position effect variegation
1.3 Histone code, reader-writer complex

2. DNA replication and regulation

1.1 Enzymes involved in prokaryotic and eukaryotic replication and gene amplification
1.2 Role of Non-coding RNA in prokaryotic and eukaryotic DNA replication

2. Regulation of gene expression

2.1 Transcription processes: Initiation, elongation & termination
2.2 Epigenetic regulation and post transcriptional changes
2.3 Dosage compensation in Mammals and *Drosophila*
2.4 Genetic imprinting: Mechanism and Model

3. Translation & Post Translational events

3.1 Translation processes: Initiation, Elongation and termination
3.2 Post translational modifications
3.3 Protein splicing, chaperones and protein folding

4. Recombination & repair

4.1 Recombination types and processes in eukaryotes
4.2 Enzymes involved in human meiotic recombination
4.3 DNA repair mechanisms

5. Transposable Genetic Element

5.1 Ac-Ds element in Maize, IS element in bacteria, P-element in *Drosophila*, Composite transposon, Retrotransposon
5.2 Hybrid dysgenesis and role of pi RNA in transposon silencing
5.3 Role of transposable element in evolution and genome modification

6. Genetics of Cell cycle

7. Microbial Genetics

Conjugation, Transduction, Regulation of Lytic and Lysogenic cycle

8. Somatic cell genetics.

Cell fusion, Heterokaryon selection &hybridoma technology, Chromosome mapping

ZCP 105 Laboratory Course for Core Subjects 50 Marks 4 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

6. Preparation of Polytene chromosome, Karyotyping

7. Identification of mammalian tissue sections

8. Tissue fixation, microtomy and double staining of tissue sections

9. Sessional work (Internal evaluation)

10. Viva voce

2nd Semester

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ZCT 206	Vertebrate Functional Forms and Adaptations	50	4
ZCT 207	Developmental Biology & Neurobiology	50	4
ZCT 208	Biochemistry and Genetic Engineering	50	4
ZCT 209	Parasitology & Immunology	50	4
ZCP 210	Laboratory course for core subjects	50	4

ZCT 206 Vertebrate Functional Forms and Adaptations 50 marks 4 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; functional and evolutionary significance.

3.2 Jaw kinetics in relation to feeding

4. Cardiovascular syatem

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.

5.3 Functional Associations of Central Nervous system

5.4 Evolution of Cerebral hemisphere

6. Respiratory system

6.1 Physics of respiration and respiratory medium

6.2 Ventilatory mechanisms, Ram ventilation

6.3 Structural design of aquatic respiration and functional significance

7. Structural Adaptation

7.1 Structural elements of body and their properties

7.2 Mechanics of support and movement

7.3 Swimming adaptation

7.4 Cursorial adaptation

ZCT 207 Developmental Biology & Neurobiology 50 marks 4 Credits

Developmental Biology and Neurobiology
(25 + 25 = 50 Marks; 2 + 2 = 4 Credits)

Developmental Biology:

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

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. Zebra fish: Cell movement and signal during early development, Patterning, polarity and regionalization of nervous system. Vertebrates: Limb development

3. Regenerative Biology- Cellular and molecular aspects, genomic equivalence and cytoplasmic determinants

Neurobiology:

4. Life of a neuron - Neurogenesis – role of stem cells, Neuronal ageing and death

5. Neurophysiology - Neuronal plasticity, Neurotransmitters and receptors, Electrical properties of nerve cells: membrane and action potential. Synaptic transmission and neural integration, Neuromuscular junctions. Neuro-endo-immune circuitry

6. Aspects of neuronal disorders- Neurotransmitter-related, Structural, Metabolic

ZCT 208 Biochemistry and Genetic Engineering 50 marks 4 Credits

Biochemistry:

1. Biomolecules: Amino acid (classification, basic properties; peptides: primary, secondary, tertiary and quaternary structures), Carbohydrate (basic structure, classification and properties of monosaccharides; examples of di-oligo & polysaccharides) and Lipid (basic structure & simple properties of membrane lipids)

2. Outline of metabolic pathways of the 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 billirubin, uric acid etc; Metabolic disorders.

3. Enzymes: classification, kinetics, examples of inhibitions & inhibitors; modulations

4. Bioenergetics (anaerobic and aerobic respiration, oxidative and substrate level phosphorylation) basic concept of ETC and ATP synthesis, uncouplers. Spontaneous reaction (concept of -ve del G)

5. Vitamins and minerals: use of vitamines as coenzymes with the relevant reaction involved; vitamindeficiencies.

6. Chemistry of free radicals and antioxidants.

Genetic Engineering:

7. Recombinant DNA technology

7.1 Eukaryotic cloning vectors, cloning strategies, identification of specific clones.
7.2 cDNA and Genomic library.
7.3 Gene knock-in/out; Generation of transgenic animals.
7.4 Mechanism of gene silencing.

8. Genomics, Proteomics & Bioinformatics

8.1 Definition and Basic concept; ESTs, Organization of human genome repeat sequence, multigene families and genome conservation.
8.2 DNA micro-array and its use.
8.3 Genome wide DNA methylation and acetylation and their significance.
8.4 Proteomics & Bioinformatics: Basic concept and use.

9. Gene therapy & Pharmacogenomics

9.1 Various approaches of gene therapy;Stem cell and microRNA therapy
9.2 . Tissue targeted gene therapy
9.3 Concept of pharmacogenomics; Use of pharmacogenetics for disease prognosis and treatment, response and toxicity.

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

ZCT 209 Parasitology and Immunology 50 marks 4 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
7. Phylogeny of Immunity: Immunobiology of Invertebrates. Principal strategies, immune-responsive cells and tissues. Phenoloxidase cascades, natural and inducible immune response.
8. 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
9. Antigens Capture and Presentation: Concept of APC. Structure and Function of MHC molecule. MHC processing and presentation
10. Antigen Recognition: B cell and T cell receptor complex. Formation and selection of diversity receptors. VDJ recombination
11. 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
12. Humoral Immunity: Neutralization and Opsonization. Functional aspect of B- cell. Class switching. B cell signaling
13. Disease immunobiology – role players and systems network, Immunotherapeutics

ZCP 210 Laboratory Course for Core Subjects 50 Marks 4 Credits

1. Comparative analysis of Morphometric characters, Gastrosomatic index, Hepatosomatic index and Relative Gut Length of herbivorous and carnivorous fishes.
2. Comparative study of Accessory Respiratory Organ of *Heteropneustes sp*. and *Anabas sp.*
3. Study of Olfactory Apparatus in *Oreochromis niloticus*.
4. Study of adaptive features and interpretation of significance from morphology of preserved specimen.
5. Preparation of standard curve and estimation of glucose and protein concentration from unknown samples.
6. DNA isolation and agarose gel electrophoresis; restriction digestion of genomic DNA
7. Study of developmental stages of Zebra fish.
8. Study of fin regeneration in Zebra fish.
9. Identification of gene expression pattern in developmental stages in *Drosophila sp.* (From slides / pictures)
10. Identification of parasitic forms
11. Dissection and Identification of histological slides of vertebrate spleen and thymus
12. Immunization Protocol Demonstration of Thioglycolate induced peritonitis (cell infiltration and inflammatory exudates).
13. Identification and demonstration of Primary and secondary lymphoid organ
14. Haemagglutination

15. Sessional Work (Internal Evaluation)
16. Viva-voce

3rd Semester

Code	Subject	Marks	Credits
ZCT 311	Conservation biology	50	4
ZCT 312	Endocrinology & Comparative Animal Physiology	50	4
ZET 313-328	Elective Theory	50	4
CBCC A	CBCC A	50	4
CBCC B	CBCC B	50	4

ZCT 311 Conservation biology 50 Marks 4 Credits

1. Emergence of Global conservation, multilateral treaties, Conservation driven by shared commercial interests; International protection of migratory species, forums for International Conservation.
2. Process and pattern of Biodiversity – theories explaining global patterns of biodiversity;Tracking Biodiversity using Indicator species- Taxon based Biodiversity indicators and Structure and Function- based Biodiversity Indicators
3. Climate change and Biodiversity – The global fingerprint of climate change on biodiversity; climate change in ecosystems- species loss and system degradation, Conservation planning and climate integrated conservation strategies.
4. Conservation at Genetic levels –Problems of Inbreeding and Genetic drift in small populations; Measuring Genetic Diversity of populations, Managing Genetic Diversity for conservation.
5. Conservation of Populations –Concept of Effective population numbers and Minimum viable population;Population viability analysis and making conservation decisions,Wild life Population management and restoration.
6. Conservation of Habitats and landscape– Problems of Habitat loss, Isolation and Fragmentation, Edge influence, Managing Habitat connectivity, Planning for Reserve Design, Habitat Management for Non Reserve lands
7. Selection, designing and management of protected areas - Criteria for measuring conservation value of areas, Practical approaches to protected area designation; Designing protected areas; Managing protected areas; Monitoring change in protected areas.

ZCT 312 Endocrinology & Comparative Animal Physiology 50 Marks 4 Credits

1. Hormones and human health: Stress (Adrenal) and metabolic disorders (Pituitary, Pancreas, Thyroid) - molecular basis and therapeutics.
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. Pheromones: Classification, chemical nature, structure, functions, relevance in applied fields, clinical applications.
6. Principles of animal physiology: Mechanistic and evolutionary approaches. Size and scaling of animals
7. Physiological homeostasis: Positive and negative feedback, Controlled variable, Set point
8. Thermal physiology: Heat transfer mechanism between animal and environment. Supercooling, Anti freeze compound, Behavioural thermoregulation, Pejus and Critical temperature, adaptational trend in subzero condition
9. 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.
10. 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
11. Insect sociality and physiology – Colony optimization theories, hypothesis and social algorithms, Concepts of insect bioenergetics, Development and hormonal regulations
12. Insect –plant Interaction – Interaction frequency dynamics and dependent factors, Regulation of bio-molecules and active ingredients, ,Plant and Insect resistance

Elective Papers

ZET 313 Aquatic Ecology and Sustainable Development 50 Marks 4 Credits

1. Ecological Zonations, characteristics and biodiversity of freshwater rivers, streams and wetlands. Nutrient generation, cycling and productivity.
2. Metapopulation and metacommunity theories governing fish assemblages.
3. Sea scape ecology and bioproductivity in coastal and marine ecosystems. Remote sensing and GIS for resource analysis.
4. Conservation of aquatic habitats and resources. Principles of harvesting for sustainable productivity.
5. Trophic ecology and immuno- ecology of aquatic living resources.
6. Genotype – environment interaction (GE), environmental risk of genetically modified aquatic organisms, genetic conservation, gene banking and maintaining genetic quality.
7. Sustainable technologies for aquatic resource development and stock improvement.
8. Ecological economics in relation to aquatic living resources.

ZET 314 Resource Ecology 50 Marks 4 Credits

1. Resource Populations – Continuous versus Discreet population growth: Model presentations and predictions; Metapopulation structure- Compensation of patch size and density, Modeling metapopulation dynamics, Metapopulation interactions and implications, Landscape and Metapopulation assemblage. Demographic analysis including life table, fecundity schedule and competitive interactions; census techniques
2. Resource-consumer interaction system, Mathematical modeling of Resource level and consumer population growth, The Monod equation, Resource synergism limiting consumer population.
3. Community Ecology - Theories of community development and applications in ecological management – eutrophication and biomanipulation; soil microbes and organization of the drillosphere and the rhizosphere
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 and environmental monitoring; biomimetics, biosubstitution, biomass and bioenergy
6. Quantitative methods in - biodiversity assessment; resource harvest; population growth assessment; food web, network and species interactions
7. Statistical methods and research design – exploratory data analysis, non-parametric methods, sampling methods and the principles of replication

ZET 315 Environmental Biology and Toxicology 50 Marks 4 Credits

1. Environmental impact assessment
2. Environmental Biomonitoring; Environmental DNA; bioindicators and biomarkers
3. Semiochemistry: Plant: animal interaction in the natural environment
4. Environmental Contamination and endocrine disruption
5. Toxin: Classification, examples
6. Xenometabolism: Phase I and phase II reactions
7. Interpretation of Dose- response relationships and toxicokinetics
8. Analytical toxicology: Immunohistochemistry, FACS, fluorescence microscopy.

ZET 316 Biodiversity and Ecosystem Functioning 50 marks 4 credits

1. Biodiversity Monitoring

a) Measuring global biodiversity and its decline with special reference to mammals, birds, herpetofauna, fish and insects.
b) Local and regional biodiversity-niche assembly theories, Unified Neutral theory
c) Threats to species diversity: Habitat loss, Habitat fragmentation and species extinction, Endemism and biodiversity, Population bottleneck, Genetic drift, inbreeding depression, Risks to biodiversity extinction, Extinction vortex

2. Biodiversity and Ecosystem function

a) Theories on relation between biodiversity and ecosystem function
Species Complementarity, Sampling effect, Redundancy
b) Decline of global biodiversity and loss of ecosystem function.
c) Functional diversity and ecosystem functioning.

d) Global pollinator loss and their effect on crop production and non-crop plant reproduction. Ecologial intensification of agriculture.

e) The economics of biodiversity and ecosystem function.

3. Biodiversity and 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, Scale perception

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

ZET 317 Fish Biology and Aquaculture 50 Marks 4 Credits

1. Zonations, Characteristics, Morphometry of fresh water resources; Stratification and dynamics of oxygen, nitrogen, phosphorus and inorganic carbon. Water quality for fish production; Coastal, marine, Mangrove ecosystem and fisheries potential.
2. Fish nutrition – Stages of nutrient acquisition, Temporal pattern of nutrient acquisition, Integration of nutrient acquisition. Principles of fish nutrition and terminologies, nutritional requirement of cultivable fish and prawn; Nutritional bioenergetics.
3. Fish pathology and defense mechanism: Integrated Health management, Infection and Immune responses towards pathogens, Cellular and Humoral Fish Defenses. Diseases in aquaculture.
4. Homeostasis and reproduction: Ion transport, osmoregulation and acid base balance, hormones involved in fresh water and sea water adaptation. endocrine regulation and estradiol production and vitellogenesis, teleost gonadotropin and their regulation, gonadotropin subunit gene expression.
5. Freshwater, marine and coastal aquaculture: Advancements in technology for finfish and shellfish culture; Modern hatcheries and managements; raceways, cages, Pen, enclosures, recirculating systems, Intensive Fish Hub; Integrated Aquaculture, Processing and preservation technology of shrimps and fish.
6. Fish genetics and biotechnology: Principles of genetics, mechanism of inheritance, structure of gene, mutation and sex determination in fish; cryopreservation, polyploidy in fish, production of sex reversed fish, transgenic fish; selective breeding.

ZET 318 Applied Entomology 50 marks 4 credits

1. **Agricultural Entomology:**

a) **Insect pest survey:** Identification, Methods/Techniques, Pest surveillance and assessment, Status ranking, Forecasting, Limitations.
b) **Crop and stored grain pests:** Principles and applications of integrated pest management, EIL-ETL dynamics, Action threshold, Pest spectrum, Secondary outbreak, Pest quarantine.
c) **Control measures:** Physical, Cultural, Chemical, Biological, Genetical, Biotechnological and Biorational methods of pest control. Application of artificial intelligence in IPM

2. Physiological Entomology:

a) **Feeding potential:** Feeding potential of insects, Feeding indices and relationships, Concepts on crop selection and switching (from phytochemicals to insect digestion).
b) **Reproductive potential:** Reproductive potential of insect, Calculation and assay, Responsible factors, Role in pest management and crop-yield prediction.
c) **Diapause and quiescence:** Dormancy mechanism in insects and ecological significances.

3. Insect Toxicology:

a) **Insect pesticides**: Properties and functional group variation of chemical pesticides, bio-insecticides, neonicotinoids, fumigants, IGRs, attractants, repellents.
b) **Application of pesticides:** Contact and systemic insecticides, Dose-response relationship, Dose standardization, Testing method/technique, Toxicity evaluation.
c) **Pesticide efficacy:** Metabolism of insecticides, CNS-AChoE action pathway, Antidotes, Nanocides: formulation, delivery technology, residual effects.

4. Ecological Entomology:

a) **Insect as bio-indicator:** Bio-indicator potential of insects for ecological surveillance and bio-monitoring.
b) **Soil entomology:** Diversity of soil micro-arthropods, Role of soil micro-arthropods in soil heath analysis.
c) **Insect-plant interaction:** Bipartite and tripartite interactions, Interaction frequency and net-working: assessment, analyze and signification, Concept of plant volatiles for bio-pesticide formulation, Theories of co-evolution. Plant resistance to insects.

5. Behavioural Entomology:

a) **Chronobiology and Unusual behaviour:** Biological rhythm in insects (foraging, reproduction and infestation), Periodicity in migration of locusts, Impacts of catastrophic earthquakes on insect communities.

b) **Sociobiology:** Concept of social evolution in insects, Role of cuticular hydrocarbon profiling and biogenic amines for insect recognition/aggression, Application of insect societal rules and behavioral algorithm for human welfare.

c) Insect cognition and engineering: Neural basis of insect foraging: role of mushroom bodies, Odometry and insect navigation, visual cognition for pollination success, Thermoregulation and ventilation in termite mound.

6. Functional Entomology:

a) Applications of insect flight aerodynamics to micro air-vehicles
b) Insect acoustics: a tool for taxonomy
c) Bio sensing technology for pest detection.

7. Economic Entomology:

a) Entomophagism: present and future prospect.
b) Entomotherapy: present and future prospect.
c) Bioprospecting of insects

8. Forensic and Medical Entomology:

a) **Forensic Entomology:** Insects for forensic importance, Role in forensic investigation (time and cause).
b) **Medical Entomology:** Causative agents and mode of transmission for vector-borne diseases (Dengue, Chikungunya, Malaria),
c) **Public health importance:** Control and management of Vector-borne diseases by Integrated Vector Management.

ZET 319 Wildlife & conservation biology 50 marks 4 credits

1. 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.

2. Behavioural biology of wild animals : Communication and signaling. Animal migration with special reference to birds, Home Range and Territory.

3. Wildlife tools and techniques:

a) **Wildlife sampling**: random sampling, systematic sampling, stratified sampling, cluster
b) sampling.
c) **Census-** objectives/ important consideration, line transact method, pugmarks and point count
d) **Telemetry, Remote sensing and GIS** in wildlife research
e) **Camera traps :** Application & importance

4. 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.

5. Captive breeding of wild animals: Concept of captive breeding; reintroduction of captive breeds – controversies and realities; release protocol; advantages and challenges of captive breeding. Case Studies : Red Panda & Sanghai

6. **Special management program of wild animals in India:** Origin, objectives, implementation, advantages and limitations of project tiger, project elephant, operation rhino, crocodile conservation project.
7. **Bio-ecology of important wildlife of India:** Himalayan Salamander, Olive Ridley turtle, Great Indian Bustard, Fishing Cat, Himalayan Musk dear – Threats & Conservation initiatives
8. **Man and wildlife:** Causes and consequences of human-wildlife conflicts; mitigation of conflict – an overview. Case study: Human-Elephant conflict.
9. **Wildlife trade &crime:** Major articles in wildlife trade; underlying causes of illegal wildlife trade; *Modus Operandi*, measures against illegal trade.
10. **Wildlife legislation:** Administrative measures, laws and ethics; National Acts related to wildlife conservation.

ZET 320 Molecular Cell Biology 50 Marks 4 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) Transgenics and Knock-outs

i) Drug-loaded functionalized nanoformulations for targeting cells

ZET 321 Genetics of Human Diseases 50 Marks 4 Credits

1. Effect of the environment on phenotypic development
2. Concept of monogenic and polygenic diseases
3. Mitochondrial inheritance and diseases
4. Concept of genetic polymorphisms
5. Genetic interaction during embryonic development and birth defects in human beings
6. Genetics of Schizophrenia
7. Genetic analysis of Diabetes Mellitus; Hypothyroidism;Kidney stone disease and Hearing Loss
8. Cancer genetics
9. Concept of genomics; genetic associations of diseases and functional studies
10. Personalized medicine and its significance
11. Applications of bioinformatics in the management and treatment of diseases
12. Genetic counseling

ZET 322 Cytogenetics and Genomics 50 Marks 4 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-323 Human Evolutionary Genetics 50 Marks 4 Credits

1. **Humans as apes**
   1.1. Evidence from molecules
   1.2. Genetic diversity among the great Apes
2. **Origin of modern humans**
   2.1. Evidence from fossils and morphology
   2.2. Evidence from archeology and linguistics

2.3. Evidence from genetics of present-day populations
2.4. Evidence from ancient DNA

3. Human genome variation

3.1. Single nucleotide polymorphisms (SNPs) in the nuclear genome
3.2. Sequence variation in mitochondrial (mt) DNA
3.3. Y chromosome markers
3.4. Variation in the tandemly repeated DNA sequences
3.5. Structural variations in the genome.
3.6. Effect of recombination on genome variation

4. Estimating genome diversity

1.1. Sanger sequencing
1.2. Next generation sequencing
1.3. SNP typing-low, medium and high throughput methods for assaying variation
1.4. Databases of sequence variations
1.5. Studying genetic variation in ancient samples

5. Making inferences from diversity

5.1. Summarizing genetic variations
5.2. Measuring genetic distance
5.3. Coalescent approaches to reconstructing population history
5.4. Dating evolutionary events using genetic data

6. Populations admixture

6.1. Genetic admixture
6.2. Impact of admixture
6.3. Detecting admixture

ZET 324 Disease Biology 50 Marks 4 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 325 Translational Biology 50 Marks 4 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-

4.1 Transplantation Immunology
4.2 Tracing lymphopoiesis
4.3 Animal models in Immunology
4.4 Mucosal immunity

5. Immunotherapy in diseases- Rheumatoid arthritis, Asthma

6. Regenerative Biology-
6.1 Animal models in research and development
6.2 Animal models in Development and Regeneration

7. Regenerative Medicine
7.1 Regenerative therapy
7.2 Tissue engineering and scaffolds

8. Nutrition and nutraceuticals-
8.1 Micronutrients
8.2 Functional food

9. Clinical pharmacology
9.1 General pharmacology- terms, definitions, representations
9.2 Classes of drugs
9.3 Bioassay of drugs

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

ZET 326 Applied Immunology 50 Marks 4 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 Tranplatation
5.2 Acute, Hyperacute and chronic Graft rejection
5.3 Modern techniques of transplantation (e.gBMT,liver,corneaetc)

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.)

ZET 327 Reproductive Endocrinology 50 Marks 4 Credits

1. Evolution of gonads: phylogeny and ontogeny of testis and ovary.
2. Sex determination and sex differentiation: from genes to gender (Model systems – Fish and Human).
3. Female reproductive system: Hormonal regulation of ovulation, gestation, parturition and lactation..
4. Male reproductive system: Hormonal regulation of spermatogenesis
5. Molecular basis of male and female reproductive disorders, therapeutics, male and female infertility.
6. Steroid receptors: Defects, modulators, clinical significance.
7. Endocrine disruption of reproduction: (Model system – Fish).
8. Endocrinology of photosexual activity: Extra-retinal photoreceptors, photorefractoriness, role of melatonin in reproduction (Model system – Fish).
9. Prostaglandins: Source, chemical nature, structure, functions, physiological significance and clinical implications.

ZET 328 Applied Parasitology 50 Marks 4 Credits

1. General morphology and ultrastructure of parasites (*Entamoeba histolytica*, *Giardia* sp., *Trichomonas* sp. *Leishmania* sp., *Trypanosoma* sp., *Plasmodium* sp., *Balantidium coli*); tegument of Cestodes and Trematodes; body wall of nematodes.
2. Host-parasite interaction in protozoan parasites (*Entamoeba histolytica*, *Giardia* sp., *Trichomonas* sp. *Leishmania* sp., *Trypanosoma* sp., *Plasmodium* sp., *Balantidium* sp.,
3.Host-parasite interaction in helminth parasites (*Fasciola* sp., *Schistosoma* sp., *Clonorchis* sp.,*Taenia* sp., *Echinococcus* sp., *Ascaris* sp., *Wuchereria* sp., *Trichinella* sp., *Ancylostoma* sp., *Drucunculus* sp.)
4. Metabolism of carbohydrate and protein in protozoa and lipids in helminth parasites
5. Biology of arthropods as parasites and vectors (Flies, Ticks, Mites, Lice, Bugs, Fleas)
6. Epidemiology of parasitic diseases: General and Landscape Epidemiology, epidemiology of Kala-azar, Echnococcus, Filaria and Malaria

7. Fish and poultry parasites and its impact on human society, Immunopathology and prevention of parasites of silkworm and poultry birds

8. Immune evasion strategies of virus, bacteria, protozoa and helminthes, Chemotherapeutic targets in parasites: properties of an effective drug, classes of drugs, mechanism of action of drugs and drug resistance in parasites, Vaccine targets

9. Host parasite Genetics –Molecular organization of gene structure and antigenic variation in Leishmania, and Trypanosoma Genetic architecture of host resistance, Number and location of host resistance genes, Genetics of parasitic virulence, Techniques for molecular analysis of parasites: Isolation of DNA,Elisa, Immunoblotting, GDP, IFA Monoclonal antibody, Amplification of DNA by PCR, Probe technology for parasite diagnosis.

10. Antigen antibody reaction and its role in clinical parasitology; common diagnostic methods

4th Semester

Code	Subject	Marks	Credits
ZCT 429	Taxonomy & Biostatistics	50	4
ZCT 430	Animal Behavior and Evolutionary Biology	50	4
ZCP 431	Core Practical for Endo+AnimalPhysiol +Taxonomy	50	4
ZCP 432	Comprehensive viva voce + Field Study & report	(30+20)= 50	4
ZEP 433	a) Lab internship and Dissertation b)Seminar on dissertation	(30+20)=50	4

ZCT 429 Taxonomy & Biostatistics 50 Marks 4 Credits

1. **Characters and character states-** Types of character: primitive and advanced, missing, polymorphic, micro, cryptic ,and internal, Character state transition, environmental effect and their significances, Artifacts and special characters

2. **Taxa and species-** ICZN-nomenclature rules, Species concept, Phylogenetic nomenclature

3. **Approaches in classification-** Cladistics , Phenetics, DNA Barcoding

4. Trends in Phylogenetic reconstruction - Tools used in building a phylogenetic tree: their advantage and drawbacks, Distance and character based methods in phylogenetic reconstruction

5. Descriptive Statistics- Statistics and Biological data – basics inclusive of the distributions, Measures of central tendency, Visual representation of data- leaf and stem diagram, box-plot

analysis ,Basics of probability

6. **Sampling and Analysis –**Sampling theory, Statistical inference and hypothesis testing, t-tests and applications in biology, Analysis of variance and experimental designs NonParametric Tests, Correlations and regression analysis

ZCT 430 Animal Behavior and Evolutionary Biology 50 Marks 4 Credits

1. **Cooperation and conflict-** Range of cooperative behavior and theories of cooperation, Kin selection, Elaborate ornaments: Fisher's hypothesis and Handicap hypothesis, Conflict over mate choice
2. **Foraging-** Optimal foraging theory, Foraging and predation risk: defense strategies against predators, Territoriality and Group foraging
3. **Aggression -** Aggressive behavior, Game theory models and strategies – Prisoners' dilemma and reciprocal altruism and evolution of sociality
4. **Natural Selection and Adaptation-** Ascent of Darwinism and Synthetic Darwinism Methods of studying natural selection and Models of selection, Recognizing adaptation, Punctuated equilibrium and stasis
5. **Evolutionary Process-** Mechanisms producing genetic diversity (mutation, migration and genetic drift), Phenotypic variation and plasticity, Molecular evolution, Speciation
6. **Gene Frequencies in Population-** The Hardy-Weinberg principle and analysis of gene frequencies in natural population. Major factors influencing gene frequencies (migration, inbreeding), effects of selection and mutation on gene frequencies
7. **Patterns and trends in evolution-** Constructing evolutionary trees, measures of genetic relationship among organisms, Tools of studying human evolution
8. **Species and Speciation-** Genetic basis of species difference and reproductive barriers, Evolution of interaction among species

ZCP 431 Laboratory course for core subjects 50 Marks 4 Credits

1. Specimen collection and preservation techniques
2. Preparation of key- dichotomous key based on invertebrates
3. Sampling methods (including diversity assessment) for invertebrates (Insects, snails) and vertebrates (birds)
4. Statistical assessment of morphological features (morphometry) using software, tools of
5. bioinformatics
6. Processing and double staining of different stages of estrous cycle of rats.
7. Identification of endocrine gland sections.
8. Comparative haematological profiling from invertebrate and vertebrate models.
9. Comparative nutritional and gastrointestinal profiling from invertebrate and vertebrate models through digestive enzymes analysis from alimentary tract.
10. 9. General Management protocol of mammalian experiments, Animal ethics standards and measures to be followed.
11. Demonstration of Instruments for advanced and precise biological methods- FACS/ Spectrophotometry/ Cell Imaging/ ELISA / Immunofluorescence etc. and functional principles of each.
12. Sessional

13. Viva Voce

Choice Based Credit Courses

The students will have to choose one course each from the following two 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.

GROUP-A

CBCCA1. Neurobiology: Function & Dysfunction (SN Pradhan Centre for Neuroscience)

CBCCA2. Human Genetics: Concepts and Paradigms (Dept. of Genetics)

CBCCA3. Fundamentals of Biochemistry (Dept. of Biochemistry)

CBCCA4. Biotechniques and Instrumentations (Dept. of Biotechnology)

GROUP-B

CBCCB1. Concepts in Zoological Science (Dept. of Zoology)

CBCCB2. Introduction to Marine Environment (Dept. of Marine Science)

CBCCB3. Perspectives of Environmental Science (Dept. of Environmental Science)

CBCCB4. Fundamentals of Plant Science (Dept. of Botany)

CBCCB5. Fundamentals of Bacteriology (Dept. of Microbiology)

CBCC A1. Neurobiology: Function & Dysfunction (SN Pradhan Centre for Neuroscience)

1. Brain Anatomy

Different Lobes/ Cortex

Brain Organisation – CNS, PNS, ANS; Structure of Cerebellum and Basal Ganglia

Histology of Brain Sections (Coronal/sagittal) – Normal vs. Diseased

Neuro-developmental Biology; Blood Brain Barrier

2. Cell Biology

Neurons and Glial Cells; Detection of different neuronal cells (by IHC/ICC)

Neuronal Transmission

i. Electrical Impulse – Action Potential, Excitatory and Inhibitory Postsynaptic Potentials (EPSP and IPSP)
ii. Chemical Impulse
iii. Synapse
iv. Neurotransmitters and their metabolism
v. Different Pathways (Dopaminergic, Adrenergic, Seretonergic etc.)
vi. Examples of malfunctions of pathways

Neuronal study in Cell/Organ

i. Isolation and culturing of primary neurons and means of manipulation
ii. Culturing and methods of differentiation of cultured neuronal cells
iii. Organotypic brain cultures

3. Sensation and Sensory Processing

i. The Somatic Sensory System: Touch and Proprioception
ii. Pain
iii. Vision – The Eye and Central Visual Pathways
iv. The Auditory System
v. Olfactory System
vi. Gustatory System

4. Neuropathology

i. Clinical, Cellular and Molecular Mechanisms of the Neurological Diseases:
Alzheimer's Disease, Parkinson's Disease, Huntington Disease, Dystonia, Wilson Disease, Epilepsy, Autism, Multiple Sclerosis, Amyotrophic Lateral Sclerosis (ALS), Attention Deficit Hyperactivity Disorder (ADHD), Schizophrenia, Depression, Dementia, Cerebro-vascular Disease (Stroke)

ii. Techniques and tools applicable in neuroscience: MRI, PET, Fluorescence microscopy, FACS, Electron Microscopy, Patch Clamp, etc., Database sequence information and mutation information on specific neurodegenerative diseases

5. Behavioral Testing using Animal Models

i. *C. elegans*, Fruit fly, Zebra Fish, Mouse

ii. Testing motor functions – Rotarod Test, Force Swimming Test, Beam Walking Test, Grip Strength Test

iii.Testing Cognitive Functions – Learning and memory related test (Any-arm Maze, Water Maze etc.)

CBCC A2. Human Genetics: Concepts and Paradigms (Dept. of Genetics)

1. Traits of interest

Inheritance pattern of Mendelian and complex trait: pigmentation, intelligence and creativity as models of complex trait; Microbiota shaping human traits.

2. Clinical Genetics and Genetic disorders

a) Concept of mutation and polymorphism

b) Single gene vs complex disorder: Cystic Fibrosis, Beta-thalassemia, ADHD, Haemophilia as models

c) Gene-environment interplay in diseases: cancer as model

d) Genetic variations and susceptibility of horizontal disease: Malaria as a case study.

3. Population Genetics and Evolution

a) Concepts of allele frequency, genotype frequency, HW equilibrium and genetic drift;

b) Human migration and 'Out of Africa' hypothesis and evolution of *Homo sapiens*.

4. Immunogenetics and Network Ecology

Evolution of genes involved in immune response to parasites; Genetics of diseases resistance.

5. Pharmacogenetics

Concept of personalized medicine.

6. Tools in human genetic research

a) PCR-sequencing based screening of disease genes; association study; Microarray analysis; b) Gene therapy, gene editing and gene replacement therapy;

c) Study of database in relation to human disorders: OMIM as a model.

7. Genetics and Society

a) Genetic counseling and risk assessment; Carrier detection

b) IVF and stem cell genetics

c) Forensic studies and paternity testing; Cord blood banking, New born screening in genetic disorders.

8. Community Genetics and legal issues

Ethics in genetic research; Case studies.

9. Genetic models of human diseases

Disease Models in *Drosophila melanogaster* and the role of the fly in therapeutic drug discovery; Humanized mice; Canine model of eye disorders].

10. Epigenetics

Methylation and histone modification in causation of disorders; Inheritance of fear as a case study

CBCC A3. Fundamentals of Biochemistry (Dept. of Biochemistry)

1. pH and Buffers

Bronsted-Lowry Concept of Acids and Bases, Buffers: Henderson-Hasselbalch equation, Biological buffer systems: The phosphate buffer system, The bicarbonate buffer system, The protein buffer system, The amino acid buffer system, The hemoglobin buffer system

2. Biomolecules

Carbohydrates: Importance, Nomenclature, Classification, Asymmetry, Optical Isomerism, Mutarotation, General structure of monosaccharide, disaccharide, oligosaccharides, polysaccharides (Lactose, Maltose, Cellobiose, Isomaltose, Trehalose, Starch, Glycogen, Cellulose, Pectin, Chitin, Heparin.

Proteins: Importance, Amino Acids: Structure, Distribution in Proteins, Location in proteins, Physical properties, Electrochemical properties, Classification, Nonprotein Amino Acids, Peptide bonds, Chemical Bonds involved in Protein structure, Protein Configuration: Primary Structure, Secondary Structure, Tertiary Structure, Quaternary Structure, Physical Properties of Proteins: Shape and Size, Molecular weight, Colloidal nature, Denaturation, Amphoteric nature, Solubility, Optical Activity, Chemical Properties of Protein: Hydrolysis, Reaction involving COOH group, NH2 group, R group, SH group.

Lipids: Importance, Definition, Alcohols and Fatty Acids, Biological roles of lipids, Classification: Simple Lipids and Compound Lipids, Properties of Fats and oils: Solubility, Melting Point, Insulation, Emulsification, Surface Tension, Chemical Properties: Reactions involving COOH group, Hydrolysis, Saponification, Rancidity, Hydrogenation, Halogenation, Oxidation, Oxidative Rancidity, Reactions involving OH group, Dehydration.

Nucleic Acids: Nucleosides, Nucleotides, DNA, Internucleotide linkages, Base composition, Evolution of Watson-Crick model, Double helical structure, Denaturation and renaturation, Molecular weight, Length, Shape and Size, Variants of Double helical DNA, DNAs with unusual structures, Single stranded DNA, RNA. Differences with DNA, Ribosomal RNA, Transfer RNA, Messenger RNA, Heterogeneous nuclear RNA.

3. Enzymes

Importance, Nomenclature and Classification, Isoenzymes, Multienzyme system. Biological roles of enzymes. Chemical nature of enzyme, Characteristics of enzymes, Specificity of enzyme action, Thermostability, Reversibility of a reaction, pH sensitivity, MichaelisMenten Hypothesis, MichaelisMenten equation, Lineweaver-Burk equation, Significance of Km and Vmax values, Active site, Enzyme reaction rates, Modifiers of Enzyme activity, Enzyme Inhibitors (Competitive, Noncompetitive, Uncompetitive), Allosteric enzymes.

4. Nutrition

Energy turnover, Assessment of nutrient transport and fate, Biochemical effects of neutraceuticals.

5. Bioenergetics and Metabolism

Definition of metabolism, Catabolic pathways, Anabolic pathways, Carbohydrate metabolism, Amino acid metabolism, Lipid metabolism, Nucleic acid metabolism. Regulation of metabolic pathways, Bioenergetics.

6. Analytical Biochemistry

Principles and application: equipments, sample preparation, Homogenization, Differential centrifugation, Chromatography, Spectrophotometry, Electrophoresis, Ultracentrifugation.

CBCC A4. Biotechniques and Instrumentations (Dept. of Biotechnology)

1. Molecular Biology and Recombinant DNA methods:

Isolation and purification of RNA , DNA (genomic and plasmid) and proteins, different separation methods. Analysis of RNA, DNA and proteins by one and two dimensional gel electrophoresis, Isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems. Expression of recombinant proteins using bacterial, animal and plant vectors. Isolation of specific nucleic acid sequences Generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC and YAC vectors. In vitro mutagenesis and deletion techniques, gene knock out in bacterial and eukaryotic organisms. Protein sequencing methods, detection of post translation modification of proteins.

2. Spectroscopic Methods:

Molecular analysis using UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy Molecular structure determination using X-ray diffraction and NMR, Molecular analysis using light scattering, and surface plasma resonance methods.

3. Mass spectroscopy and Proteomics:

Different types of mass spectrometry and applications in biology.

4. Modern Genomics Techniques:

DNA sequencing methods, strategies for genome sequencing. Methods for analysis of gene expression at RNA and protein level, large scale expression, western blot, such as micro array based techniques Isolation, separation and analysis of carbohydrate and lipid molecules RFLP, RAPD and AFLP techniques.

Gene mapping methods : Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants. Pedigree analysis, lod score for linkage testing. QTL mapping.

CBCC B1. Concepts in Zoological Science (Dept. of Zoology)

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 mega diversity 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

4.1Determination 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

CBCC B2. Introduction to Marine Environment (Dept. of Marine Science)

1. Earth system & hydrosphere. Hydrological cycle. Global ocean basin and their dimension. Physical characteristics of the ocean & zonation of the marine environment.

2. Estuary classification and its characteristics

3. Physical properties of seawater and their distribution in the global ocean.

4. Current, waves and tides in the ocean.

5. Composition and stoichiometry of seawater. Major, minor and trace elements

6. Marine pollution and its impact on biota with special reference to Heavy metals.

7. Dissolved gases and carbonate system in the seawater.

8. Air-sea interactions.

9. Primary and secondary production in the ocean.

10. Distribution of life in the marine environment and classification of marine organisms. Phytoplankton, zooplankton, nekton and fisheries oceanography. Mangroves and its adjacent Biota .

CBCC B3. Perspectives of Environmental Science (Dept. of Environmental Science)

1. Understanding the environment
1.1.Multidisciplinary approach of environment
1.2.Rise of environmentalism
1.3.Environmental ethics
1.4.Concepts of sustainability
2. Environmental systems
2.1. Concept of atmosphere, lithosphere, hydrosphere and biosphere
2.2. Natural Resources
2.3. Carbon footprint and low carbon economy
2.4. Biogeochemical cycles
2.5. Scale of meteorology
3. Ecology and Biodiversity
3.1. The order of the natural world
3.2. Ecosystem energetics
3.3. Population dynamics; Concept of community, niche and community development
3.4. Biomes, biogeography and landscape ecology
3.5. Behavioral ecology and sociobiology
3.6. Biodiversity: extinction, conservation and restoration
4. Disaster Management
4.1. Types of disasters
4.2. Case studies of natural and anthropogenic disasters
4.3. Disaster prediction, prevention
4.4. Pre and post disaster management
5. Environmental vulnerability
5.1. Air pollution: source, impacts and remedial measures
5.2. Water pollution: source, impacts and remedial measures

5.3. Soil pollution: source, impacts and remedial measures
5.4. Waste: solid, biomedical, electronic and radioactive wastes
5.5. Climate change mitigation and adaptation

6. Environmental Health

6.1. Disease ecology with special reference to vector and water borne diseases
6.2. Genotoxicity and epigenetic approach
6.3. Occupational toxicology and health
6.4. Xenobiotics and endocrine disruption

7. Prioritizing environmental concerns

7.1.Global and National initiatives
7.2.Recent Environmental Concerns and Debates
7.3.Environmental Regulations: Acts and Laws
7.4.Environmental Impact Assessment
7.5.Ecomark and Ecolabelling

8. Modern tools for addressing environmental challenges

8.1. Bio remediation
8.2. Analytical tools for solving environmental problems
8.3. Environmental applications of remote sensing and GIS
8.4. Environmental informatics and modeling

CBCC B4. Fundamentals of Plant Science (Dept. of Botany)

1. Plant Kingdom and Phylogeny

Basic concepts of phylogeny and classification of different plant groups

2. Plant Diversity and Conservation

Concept, levels, values, hotspots and hottest hotspots, megadiversity centers of world, loss of biodiversity, major threats, IUCN threat categories, *in situ* and *ex situ* conservation measures. Role of national Biodiversity Authority (NBA) in biodiversity management.

3. Phytogeography

General principles; phytogeographic regions of world; phytogeographic regions of India; Vegetation of Eastern & Western Himalayas and Sunderban vegetation. Endemism; Indian endemic flora; exotics & aliens.

4. Palaeobotany& Palynology

Preservation, Nomenclature, Dating and reconstruction of plant fossils; plant life through ages; application of plant fossil studies.

Spore/pollen morphology; basic concepts of neo and palaeopalynology; application of palynomorph studies.

5. Basic concepts of Plant Ecology

Plant Succession and Community Ecology; Ecological Adaptations in plants; Global change impacts on plant ecophysiology

6. Basic aspects of Plant Biotechnology

Introduction; Surface sterilization; Nutrient medium; De-differentiation; Cyto-differentiation; Plant regeneration; Organogenesis; Embryogenesis; Micropropagation (introductory); Protoplast culture and application; Haploid culture; Triploid culture; Genetic transformation.

7. Phytoremediation

Definition; Concept of excluders and accumulators; Mechanisms of phytoremediation, limitations and concerns.

CBCC B5. Fundamentals of Bacteriology (Dept. of Microbiology)

1. The discovery of microorganisms, the conflict over spontaneous generation, Koch's postulates, an overview of prokaryotic cell structure, cell wall, cell membrane, nucleoid, plasmids, endospore, comparison of prokaryotic and eukaryotic cells.
2. Microbial nutrition, growth and control: Common nutrient requirements, nutritional types of organisms, culture media, isolation of pure culture, continuous cultures of microorganism; control of microorganism by physical and chemical agents, basics of water bacteriology, influence of environmental factors on microbial growth in natural environments.
3. Identification of microbe and microbial community, comparison of ribosomal RNA sequences – Pairwise alignment: local and global alignment, Multiple sequence alignment, construction of phylogenetic tree.