Syllabus for

M.Sc. in Zoology

University of Calcutta

(2 years Semester System)

Department of Zoology,
University of Calcutta

35, Ballygunge Circular Road,
Kolkata – 700 019

The regulations for the Two-year M.Sc. Course)
for the departments/centers participating in Choice Based Credit Course
in the Taraknath Palit Siksha Prangan, University of Calcutta)
viz. Biochemistry, Biotechnology, Botany, Environmental Science, Genetics,
Marine Science, Microbiology, Neuroscience and Zoology

1. ADMISSION CRITERIA: The University of Calcutta shall provide instructions leading towards two year M.Sc. degree. A candidate who has passed the 3-year B.Sc. (Hons.) Examination will be eligible to seek admission to the course as may be approved and notified from time to time by the University. Reservation of seats will be governed by the rules of the University of Calcutta or as mentioned in admission regulations framed by the University time to time. At present, applicants from University of Calcutta will get admission to the sixty percent of seals (Part-A) and forty percent of the seats (Part-B) will be filled up from candidates from both CU and non CU from a common merit list. Non-CU students, however, will have to satisfy the same eligibility criteria applicable to the students of University of Calcutta,

2. EXAMINATION STRUCTURE: The duration of the course shall be two academic years and the examination for the M.Sc. degree shall be held over four semesters over a total of 1000 marks and 80 credits. The duration of the semesters shall be as follows:

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

Examinations would be held after the completion of curriculum at the end of each semester. However, evaluation of the practical will be based on continuous assessment as well as on the final Viva-Voce examination of the students on the experiments, to be conducted by internal and/or external examiners.

Examination timing:
Theory

Up to 25 marks: 1 hour
26 to 40 marks: 1.5 hours
41 to 50 marks: 2 hours
51 to 75 marks: 3 hours
76 to 100 marks: 4 hours

3. FEES STRUCTURE: Monthly and yearly fees to be collected from a student as per academic year July to June. Examination fees and other related fees are payable by the candidates as may be prescribed by university from time to time.

4. ATTENDANCE: A candidate shall be eligible for appearing at the examination provided he/she prosecutes a regular course of studies in the concerned Post Graduate (PG) Department for that semester in the subject and attends at least 65% of the total number of the Theoretical, Practical and Seminars separately held during the semester. A candidate failing to secure pass marks in a specific paper(s) shall not have to attend classes for appearing in the corresponding back paper(s) in a subsequent semester.

Condonable Limit: A student who has attended at least 55% of the classes but less than 65% of the classes shall, however, be eligible to appear in the examination upon payment of condonation fee as may be prescribed by the university from time to time and after obtaining condonation order from the Vice Chancellor.

A candidate who becomes ineligible to appear in a semester examination due to shortage of attendance will have to attend the classes in the corresponding semester of the following academic session by paying prescribed fees.

5. MAXIMUM PERMISSIBLE TIME FOR COMPLETING THE COURSE: Students have to clear the entire course within 4 years from the year of first admission.

6. EXAMINER: Paper setters, moderators, examiners, scrutineers for each paper will be appointed on the recommendations of the Board of Post Graduate studies in the concerned subject. Scripts will be examined by single/multiple examiner(s) for all theory papers and double/multiple (internal and external) for all practical papers, dissertation, viva voce etc.

7. PASSING CRITERIA: A candidate is required to appear at the examination in each and every paper/course/module/part/group of the respective syllabus. A candidate in order to be declared to have passed an examination, must obtain at least 40% marks in each paper/course/module/part/group. In case of a paper/course/module/part/group containing both theoretical and practical portions, a candidate is required to secure at least 35% marks separately in the theoretical and practical portions and at least 40% marks in aggregate in that paper. Candidates shall not be allowed to appear at any higher semester examination without appearing and clearing the minimum number of requisite paper(s) of all the previous semester examinations as mentioned here in after.

8. CRITERIA FOR RE-APPEARING AT SUPPLEMENTARY EXAMINATION: If a student gets 'F' in a particular paper, he/she shall be deemed to have failed in that paper only and shall be required to appear in a supplementary examination to be offered within six months of the original examination. Candidate who fails in one or two papers can clear the paper/s in two more consecutive chances **(excluding the main examination)** along with higher semester examination. If the candidate is unable to clear the same within two consecutive chances, he/she shall be dropped from the concerned course.

A candidate who has **failed** in more than two papers will have to appear at the same semester without appearing at the higher semester. In that case, attendance in the theoretical classes

will not be mandatory; however, the candidate has to attend practical classes, considering the evaluation of practical is through continuous assessment. A failed candidate, intending to re-appear in a subsequent semester has to take permission from the concerned Faculty Secretary through the Head of the Department immediately after publication of result.

If all the chances of a candidate (Main + 2) has been exhausted, he/she has to drop or leave the course. He may apply for re-admission in the same course of study in the 1st Semester of the next academic session along with the fresh applicants. In any case, the candidate has to clear the entire course within 4 years from the year of first admission.

9. ABSENT CRITERIA: Failure to fill up the examination form shall be considered as missing a chance and such candidates who have not filed up the examination form shall have to appear at the same semester examination with required attendance. A candidate who has filled up the examination form but remains absent in the entire examination or more than two courses will be considered to have lost a chance and shall be required to re-appear at the same semester examination. A candidate clear those as stated above.

10. READMISSION CRITERIA: If a student is dropped from the respective course of study because of his failure to clear a particular course within 4 years, he/she may apply for readmission in the same course of study in the 1st semester of the next academic session along with the fresh applicants.

11. CONSOLIDATED MARK SHEET: After passing all the semesters a candidate may apply for a consolidated mark sheet to the Controller of Examinations upon payment of such fees as prescribed by the University.

12. DATE OF PUBLICATION OF FINAL RESULT: For a regular student who has cleared al the semesters in normal course the date of publication of final result shall be the date of publication of result of the 4th semester. The final date of publication of result for students clearing previous semester(s) subsequent to their clearing 4h semester examination will be **date of publication of the last result clearing all papers.**

13. CALCULATION OF GRADE POINTS, SGPA AND CGPA: The schedule of papers, distribution of marks and credits, for the M.Sc course shall be determined by the concerned department duly approved by the respective Faculty Council/PG Board of studies. Credit-weighted grade point system will be followed and therefore only the grade points but not the overall percentage of marks either in individual paper of in aggregate marks will be provided. The grade points will be given according to the following computation.

Grading of students' performance:
Grade scores will be calculated in a scale of 6 (six) as per the following table:

Marks (%)	Grade Score Brackets	Grade Score added per each additional mark to minimum grade score in the bracket
80-100	5.00 - 6.00	0.05
70-79	4.50 - 4.99	0.05
60-69	4.00 - 4.49	0.05
55-59	3.75 - 3.99	0.05
50-54	3.50 - 3.74	0.05
40-49	3.00-3.49	0.05
00-39	Below 3.00	0.075

Award of Grade Points:

For example, if a student scores 53% in theory and 68% in practical in a 3-credit course (2+1), his/her grade point for the course will be as follows:

Grade point = $\frac{2x(3.5+0.05x3)+1x(4.0+0.05x8)}{2+1}$ = 3.90

For a credit course with no practical component, for example a 2-credit course, if a student scores say, 56%, then the grade point will be:

Grade point = $\frac{2x(3.75+0.05x1)}{2}$ = 3.80

Semester Grade Point Average (SGPA):
The computation of average grade point of a student in a semester will be worked out as follows:

N^{th} Semester

Course	Credits	Grade Scored
1	3+1	5.65
2	3+1	5.33
3	2+0	3.99
4	2+0	5.05
5	3+1	4.22
6	3+1	4.46

Semester Grade Point Average (SGPA) = 4.836
SGPA = $\frac{(5.65x4)+(5.33x4)+(3.99x2)+(5.05x2)+(4.22x4)+(4.46x4)}{20}$ = 4.836

Cumulative Grade Point Average (CGPA) over four semesters:
Working out simple average of SGPA obtained over four semesters, cumulative grade point average will be given after four semesters.

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

Grade points	Grades	Class
5.00-6.00	Outstanding (O)	First (I)
4,50-4.99	Excellent (A+)	First (1)
4.00-4.49	Very good (A)	First (1)
3.75-3.99	Good (B+)	Second (Il)
3.50-3.74	Fair (B)	Second (11)
3.00-3.49	Satisfactory(C)	Second (11)
Below 3.00	Fail (F)	Fail

If a candidate gets "F" grade in one or more courses/modules/groups in a semester examination, his SGPA in that semester shall be temporarily withheld and GPW (Grade Point Withheld) shall be marked against SGPA on the mark sheet. A fresh mark sheet with duly calculated SGPA shall be issued only when a candidate clears the course subsequently but within the stipulated period.

14. GRACE MARKS: A candidate failing to obtain the pass marks in a semester examination shall be given benefit of one additional mark in the paper in which he/she secured lowest marks and the same shall be shown in the Tabulation Rolls. However, in the mark sheet, only the marks shall be shown after such addition.

A candidate failing to obtain 50% or 55% or 60% marks in the aggregate of all the semesters by one mark only shall be given the benefit of one additional mark in the result of final semester and the same shall be reflected both in the Tabulation Roll as well as in the mark sheet.

15. RANKING: Candidate unable to clear each part of all the semester examinations in one chance shall not be entitled to any position in order of merit. To be eligible for award of rank in order of merit, a candidate must pass all the semesters at first chance as regular candidate.

16. CANCELLATION OF EXAMINATION: Candidates may apply to the Controller of Examinations for cancellation of enrolment of the said examination within fifteen days from the date of completion of theory papers. The said cancelled examination will also be counted as a chance.

17. DIPLOMA: A candidate shall be declared to have obtained the degree of M.Sc (2 year course) shall get a degree certificate in the format specified hereunder (a candidate who has passed his/her undergraduation with honours in B.Sc will get the M.Sc degree)

"This is to certify that _____ obtained the degree of Master of Science in this university in _____, under semester examination system, the special branch in which he/she was examined having been _____ and that he/she was placed in the class attaining grade _____."

Senate house
Dated Vice Chancellor

18. CHOICE BASED CREDIT COURSE: A student will have to take two courses from Choice Based Credit Courses (CBCCs) in addition to courses offered by the department. The students will have to choose one course each from the following two groups. Each course is of 50 marks and carries 4 credits.

* No student is allowed to choose the course offered by his/her parent department.
* Intake capacity for optional papers will be as per the Table 1.
* Students would be given the opportunity to choose the optional courses on the basis of their M. Sc. 1st semester marks or any process framed by the department/university from time to time. This process would be supervised by the parent department.

* Attendance for the optional course would be maintained by the parent departments. Percentage of attendance will be as per University rules.

UNIVERSITY OF CALCUTTA
SYLLABUS STRUCTURE FOR M.Sc. (ZOOLOGY)
SEMESTER COURSE (Session 2023-2025)
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	Insect and Fish 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
ZEP 431	Laboratory course for core subjects viva voce at least 20	80	6
ZEP 432#	a) Lab internship and Dissertation b)Seminar on dissertation/ Review work	(35+35) =70	6

***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 432), the viva voce examination of ZEP 431 will be evaluated by at least 3 external examiners apart from the Internal Examiners.

Elective papers with names of respective Advisor in parenthesis

Paper Code	**Name (Teacher)**		**Paper Code**	**Name (Teacher)**
ZET 313	Aquatic Ecology and Sustainable Development (SHC)		ZET 321	Disease Biology (SS)
ZET 314	Resource Ecology (GA)		ZET 322	Cytogenetics and Genomics (SG)
ZET 315	Environmental Biology and Toxicology (SR)		ZET 323	Evolutionary Human Genetics (RT)
ZET 316	Biodiversity and Ecosystem Functions (PB)		ZET 324	Genetics of Human diseases (MD)
ZET 317	Fish Biology and Aquaculture (SHC) for Colleges only		ZET 325	Translational biology (ERB)
ZET 318	Applied Entomology (AD)		ZET 326	Applied Immunology (AB)
ZET 319	Wildlife Biology and Conservation (GS)		ZET 327	Reproductive Endocrinology (SBC)
ZET 320	Molecular Cell Biology (UC)		ZET 328	Applied 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)
SEMESTER COURSE (Session 2023-2025)
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

ZCT 101 Invertebrate Functional Forms and Adaptations 50 Marks 4 Credits

1. Types of invertebrate feeding
2. Biological and medicinal importance of sponges
3. Biology of Entoprocta and Cycliophora
4. Mechanics of invertebrate movement/locomotion; muscular activity and skeletal system; invertebrate swimming and flight
5. Factors influencing respiration (body and size, activity, feeding, temperature, oxygen tension and salinity)
6. Regulation of reproductive process - reproductive cycle, biorhythmicity
7. Organization of nervous system: nervous system, nerve net, central and peripheral nervous system, invertebrate brain
8. Regeneration in Cnidaria and Annelida
9. The language of Insect communication- Chemical mode of communication, Bioluminiscence
10. Chemical mimicry of Insects- Courtship and reproduction,

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. Cell Systems

3. Structure and function of animal tissues

4. The cytoskeleton, intra-cellular transport, extracellular matrix and protein sorting

5. Cell signaling and cell-cell interaction

5.1 Cell surface and intracellular receptors

5.2 Signaling pathways and cross talk mechanisms

6. Cell death mechanisms

6.1 Autophagy

6.2 Apoptosis

6.3 Anoikis

7. Cell cycle

8. Staining and dyes in identification of specific tissues. Stains - definition, physical & chemical classification, nomenclature, mordants, metachromasia

9. Tools and techniques in cell biology

8.1 Isolation of cell and its visualization

8.2 Cell engineering

8.3 Cell culture – 2D and 3D

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 Pposition effect variegation

1.3 Histone code, reader-writer complex

2. DNA replication and regulation

2.1Enzymes involved in prokaryotic and eukaryotic replication and gene amplification

2.2Role of Non-coding RNA in prokaryotic and eukaryotic DNA replication

3.Regulation of gene expression

1.1 Transcription processes: Initiation, elongation & termination

1.2 Epigenetic regulation and post transcriptional changes

1.3 Dosage compensation in Mammals and *Drosophila*

1.4 Genetic imprinting: Mechanism and Model

4. Translation & Post Translational events

1.5 Translation processes: Initiation, Elongation and termination
1.6 Post translational modifications
1.7 Protein splicing, chaperones and protein folding

2. 5. Recombination & repair

2.1 Recombination types and processes in eukaryotes
2.2 Enzymes involved in human meiotic recombination
2.3 DNA repair mechanisms

3. 6. Transposable Genetic Element

3.1 Ac-Ds element in Maize, IS element in bacteria, P-element in *Drosophila*,Composite transposon, Retrotransposon
3.2 Hybrid dysgenesis and role of piRNA in transposon silencing
3.3 Role of transposable element in evolution and genome modification

4. 7. Genetics of Cell cycle

5. 8. Microbial Genetics

Conjugation, Transduction, Regulation of Lytic and Lysogenic cycle

6. 9. 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 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

Code	Subject	Marks	Credits
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. Special sensory organs

5.1 Chemoreceptors: Nasal passages, Vomeronasal organ, Mouth

5.2 Radiation receptors: Infrared receptors

5.3 Mechanoreceptors: Lateral line system

5.4 Electroreceptors

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; Stem cells and tissue renewal – regeneration and repair. Cell programming

Neurobiology:

4. Life of a neuron - Neurogenesis – role of stem cells, neuronal differentiation, Neuronal ageing and death
5. Functional associations of the central nervous system
6. Evolution of the cerebral hemisphere
7. 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
8. Sensory receptors and classification
   Aspects of neuronal disorders- Neurotransmitter-related, Structural, Neuro-disorders arising from metabolic defects

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- & poly- saccharides) and Lipid (classification and structure & properties)

2. Outline of metabolic pathways of the major biomolecules with mention of rate limiting steps;
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 vitamins as coenzymes with the relevant reaction involved; vitamin deficiencies.
6. Chemistry of free radicals and antioxidants.

Genetic Engineering:

7. Recombinant DNA technology

9.1 Eukaryotic cloning vectors, cloning strategies, identification of specific clones.
9.2 cDNA and Genomic library.
9.3 Gene knock-in/out; Generation of transgenic animals.
9.4 Mechanism of gene silencing.

10. Genomics, Proteomics & Bioinformatics

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

11. Gene therapy & Pharmacogenomics

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

12. **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) and community medicine
2. Molecular basis of antigenic variation in Plasmodium

3. Mosquitoes, ticks, mites, snails- disease transmission and biology
4. Phylogeny of Immunity: Immunobiology of Invertebrates. Principal strategies, immune-responsive cells and tissues. Phenoloxidase cascades, natural and inducible immune response.
5. 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
6. Antigens Capture and Presentation: Concept of APC.Structure and Function of MHC molecule. MHC processing and presentation
7. Antigen Recognition: B cell and T cell receptor complex. Formation and selection of diversity receptors. VDJ recombination
8. 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
9. Humoral Immunity: Neutralization and Opsonization. Functional aspect of B- cell. Class switching. B cell signaling; Thymic hormones and cell immunity
10. 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	Insect and Fish 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: Insect and Fish Biology 50 Marks 4 Credits

Group A: Insect Biology 25 marks 2 credits

1. Insect flight aerodynamics: Functional organization and coordination of flight muscles and wings.
2. Insect acoustics: Acoustic organs and communication mechanism, Call types and characteristics, applications of acoustics in IPM.
3. Insect pest management: EIL and ETL dynamics, Nano pesticides, Transgenic insects.
4. Insect behaviour: Mechanism of solitary to gregarious phase transition in Locusts, Locust plague movement and migration prediction.
5. Insect-plant interaction: Interaction frequency dynamics and dependent factors, Role of biomolecules in IP interaction. Development of Attracticides.
6. Insect cognition: Detection and learning of floral characteristics in pollination.
7. Insect behavioural algorithm: Ant colony optimization theory and applications.

Group B: Fish Biology and fisheries 25 marks 2 credits

1. Origin, evolution and distribution of major groups of fishes; biosystematics, biogeography and phylogenetic studies
2. Comparative anatomy of scales and fins
3. Growth and metabolism: feeding and digestion; hormonal regulation of feeding; nutritional energetics
4. Riverine fisheries, estuarine and marine fisheries – emergent culture systems; Fish farming and fish feed; culture of shellfish; Post harvest technology

5, Role of genetics in aquaculture – Androgenesis, gynogenesis and applications for fisheries diversification; breeding and transgenic fishes

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. Pineal gland structure, biosynthesis of melatonin, diurnal variations of pineal gland functions.
4. Pheromones: Classification, chemical nature, structure, functions, relevance in applied fields, clinical applications.
5. Principles of animal physiology: Mechanistic and evolutionary approaches. Size and scaling of animals
6. Physiological homeostasis: Positive and negative feedback, Controlled variable, Set point
7. Thermal physiology: Heat transfer mechanism between animal and environment. Supercooling, Anti freeze compound,Behavioural thermoregulation, Pejus and Critical temperature, adaptational trend in subzero condition
8. 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.
9. Physiology of Circulation: Comparative structure of cells in circulation of invertebrates and vertebrates, Composition and function of blood, plasma and blood corpuscles

Elective Papers

ZET 313 Aquatic Ecology and Sustainable Development50 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. 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; ecosystem services valuation, links with biodiversity; 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) 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. 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, 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 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-responserelationship, 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
   a) Protein purification, characterization and detection
   b) Real-time PCR ; RNA interference
   c) Immunohistochemistry / Immunocytochemistry
   d) Microscopy and imaging (light, fluorescence/confocal, SEM)
   e) Fluorescence-activated cell sorting
   f) Transgenics and Knock-outs
   g) 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

Sanger sequencing
1.1. 4.2Next generation sequencing
1.2. 4.3SNP typing-low, medium and high throughput methods for assaying variation
1.3. 4.4Databases of sequence variations
1.4. 4.5Studying 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 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-IV

3. **Tolerance and Autoimmunity**
3.1 General features and mechanisms of immunologic tolerance
3.2 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 and acquired immuno-deficiencies

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	Laboratory course for core subjects (Semester III and IV)	80	6
ZEP 432	a) Lab internship and Dissertation b) Seminar on dissertation	(35+35)=70	6

ZCT 429 Biosystematics, Conservation and 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 **Taxa and species-** ICZN-nomenclature Phylogenetic nomenclature
2. **Approaches in classification-** Cladistics, Phenetics, DNA Barcoding
3. **Trends in Phylogenetic reconstruction -** Tools used in building a phylogenetic tree: their advantage and drawbacks, Distance and character based methods in phylogenetic reconstruction
4. 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: Climate change and biodiversity

5. 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
6. 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.

Group B Biostatistics

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, Non-parametric 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 80 Marks 4 Credits

1. Specimen collection and preservation techniques: **submission of field report and collection on insects, fish and snails**
2. Preparation of key- dichotomous key based on invertebrates and fish and birds

3. Sampling methods (including diversity assessment) for invertebrates (Insects, snails) and vertebrates (birds)
4. Statistical assessment of morphological features (morphometry) DNA sequence using software, tools of Bioinformatics
5. Processing and double staining of different stages of estrous cycle of rats.
6. Identification of endocrine gland sections.
7. Comparative haematological profiling from invertebrate and vertebrate models.
8. Comparative nutritional and gastrointestinal profiling from invertebrate and vertebrate models through digestive enzymes analysis from alimentary tract.
9. General Management protocol of mammalian experiments, Animal ethics standards and measures to be followed.
10. Demonstration of Instruments for advanced and precise biological methods- FACS/ Spectrophotometry/ Cell Imaging/ ELISA / Immunofluorescence etc. and functional principles of each.
11. Sessional **(not more than 5 marks)**
12. **Comprehensive Viva-voce (At least 3 external examiners should be present for evaluation)**

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.

Zoology General Electives:
CBCC ZOO GE 32
Animal world: diversity and evolution **50 marks**

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

2.4 Global pattern of biological diversity endemism and megadiversity centres

2.5 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), gon drift and Neutral Theory of Evolution

3.3 Molecular clock of evolution

4. Animal Behaviour

4.1 Animal behaviour study: proximate and ultimate causes
4.2 Sociobiology of social insects and vertebrates: theory and empirical studies
4.3 Optimal foraging theory and parent offspring conflict

CBCC ZOO GE 32

Organismal biology **50 marks**

1. Principles of Developmental Biology

1.1 Determination and differentiation; morphogenetic gradients; cell fate and cell lineages
1.2 Production of gametes, prerequisites of fertilization
1.3 Zygote formation, cleavage, blastula formation, embryonic fields, ,
1.4 Gastrulation and formation of germ layers in animals; embryogenesis

2. Metamorphosis and Organogenesis in model animal systems

2.1 Axes, compartment formation and pattern formation in Drosophila.
2.2 Vulva formation in Caenorhabditis elegans
2.3 Organizer formation and Mesoderm specification in Xenopus
2.4 Development of heart and circulatory systems in vertebrate
2.5 Development and maturation of the immune system
2.6 Limb development and regeneration in vertebrates

3. Animal Physiology

3.1 Size and scaling of organisms
3.2 Physiological adjustments to extreme environmental conditions;
3.3 Thermal and sensory physiology; chemical communications

4. Animal Immunology

4.1 Host parasite interaction with examples from specific animal associations
4:2 Molecular parasitology - biology, diagnosis, therapy
4.3 Invertebrate and vertebrate immunity
4.4 Immuno-therapeutics

5. Animal Endocrinology

5.1 Hormonal regulation of stress 5
5.2 Endocrinology of male and female infertility and fertility control
5.3 Endocrine effects on animal products