MURSHIDABAD UNIVERSITY

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Memo No.- MU(R)/1/C/518/24 **Date: 30/10/2024**

NOTIFICATION

It is notified for information of all concerned that in terms of the provision of the Murshidabad University Act, 2018, and, in existing of his powers, of the said Act, the Vice-Chancellor has, by and order dated 30.10.2024 approved the syllabi of the subject Zoology for semester wise programme of PG Course of study under this university, as laid down in the accompanying pamphlet.

Place: Berhampore
Date: 30.10.2024

Rajib Mukherjee
Registrar
Murshidabad University

Registrar
Murshidabad University

MURSHIDABAD UNIVERSITY
Estd-2021
Berhampore (W.B.)

M.Sc. (Zoology) Syllabus

2-year Semester System

(4 Semester course)

[CHOICE BASED CREDIT SYSTEM]

W.E.F: 2024

Department of Zoology, Murshidabad University

1, Sahid Surya Sen Road, Gora Bazar, Murshidabad, Berhampore,
West Bengal 742101

Murshidabad University

Master of Science (M.Sc.)

CHOICE BASED CREDIT SYSTEM (CBCS)

Syllabus in Zoology (2024)

Semester wise distribution of courses:

	Courses	**No. of Courses**	**Marks**	**Credits**
1st Semester	Core courses	05	250	**20**
2nd Semester	Core courses	05	250	**20**
3rd Semester	Core courses	03	150	**12**
	Discipline Specific Elective course	01	50	**04**
	Generic Elective	01	50	**04**
4th Semester	Core course	02	75	**06**
	Discipline Specific Elective course	02	100	**08**
	Add on Course	01	25	**02**
	Dissertation	01	50	**04**
			1000	**80**

MURSHIDABAD UNIVERSITY

SYLLABUS STRUCTURE FOR M.Sc. (ZOOLOGY)
SEMESTER COURSE (W.E.F: 2024)

1st Semester

Course Code	Subject	Marks	Credits	Hours/ week
PG-ZOO-CC-101	Fundamentals of Non-chordate and Chordate biology	50	**4**	**4**
PG-ZOO-CC-102	Cell biology and Inheritance biology	50	**4**	**4**
PG-ZOO-CC-103	Ecology and Toxicology	50	**4**	**4**
PG-ZOO-CC-104(P)	Fundamentals of Non-chordate and Chordate biology practical & Cell biology and Inheritance biology practical	50	**4**	**8**
PG-ZOO-CC-105(P)	Ecology and Toxicology practical & field/institutional visit	50	**4**	**4**
Total		**250**	**20**	**24**

An institutional / Field visit report (2 credits) during the course of 1st semester is to be prepared and submitted along with the Ecology and Toxicology practical.

- **Institutional visits encompass visit to sericultural institute / fishery farms / Bee keeping centers etc.**
- **Field visits encompass visit to any national park / wildlife sanctuary / reserve forest / marine ecosystem / wetland area etc.**

2nd Semester

Course Code	Subject	Marks	Credits	Hours /week
PG-ZOO-CC-201	Biostatistics and Taxonomy	50	**4**	**4**
PG-ZOO-CC-202	Evolution and Animal behaviour	50	**4**	**4**
PG-ZOO-CC-203	Biochemistry and Animal physiology	50	**4**	**4**
PG-ZOO-CC-204(P)	Biostatistics, Taxonomy, Evolution and Biochemistry practical	50	**4**	**8**
PG-ZOO-CC-205(P)	Animal Behaviour, Animal physiology & seminar presentation	50	**4**	**4**
Total		**250**	**20**	**24**

A seminar presentation (2 credits) will be given by the students at the end of 1st semester about any topic from the 1st semester curriculum. The topic of seminar shall be selected by the students during the course.

3rd Semester

Course Code	Subject	Marks	Credits	Hours/ week
PG-ZOO-CC-301	Developmental biology and Endocrinology	50	4	**4**
PG-ZOO-CC-302	Immunology and Molecular biology	50	4	**4**
PG-ZOO-CC-303(P)	Developmental biology and Endocrinology & Immunology and Molecular biology practical	50	4	**8**
PG-ZOO-DSE-304 (A, B, C, D)	Discipline Specific Elective course (Theory)	50	4	**4**
PG-ZOO-GE-327	GE (for other than Zoology PG students)	50	4	**4**
Total		**250**	**20**	**24**

- **Elective paper selection after the end of 2nd Semester for commencement of project work, theory classes.**
- **The students will be assigned specific dissertation project/review during 4th semester. Elective paper selection of the students based on the cumulative score obtained in graduation and 1st semester.**
- **A choice-based credit course (4 credits) shall be opted by the students at semester 3 other than zoology.**

4th Semester

Course Code	Subject	Marks	Credits	Hours/ week
PG-ZOO-CC-401	Applied biology and Methods in biology	50	**4**	**4**
PG-ZOO-CC-402(P)	Applied biology and Methods in biology practical	25	**2**	**4**
PG-ZOO-DSE-403 (A, B, C, D)	Discipline Specific Elective course (Theory)	50	**4**	**4**
PG-ZOO-DSE-403 (PA, PB, PC, PD)	Discipline Specific Elective course (Practical)	50	**4**	**8**
PG-ZOO-AO-405	Add on course	25	**2**	**2**
PG-ZOO-DIS-406	Dissertation/ Review work	50	**4**	**-**
Total		**250**	**20**	**22**

Name of Elective papers:

1. **PG-ZOO-DSE-304(A)/PG-ZOO-DSE-403(A)/405(PA): System ecology, wildlife and conservation biology**
2. **PG-ZOO-DSE-304(B)/PG-ZOO-DSE-403(B)/406(PB): Entomology**

Division of theory and practical marks:

Core practical of **50** marks - **40** (semester end) + **10** (Internal Assessment)
4th Semester Core practical of **25** marks - **20** (semester end) + **05** (Internal Assessment)
Core theory of **50** marks - **40** (semester end) + **10** (Internal Assessment)

The students will submit a Dissertation (**50** marks) following laboratory internship on their Elective paper opted. The Review or Dissertation report will be evaluated by external examiner along with internal examiners.

Examination pattern

Course	Internal assessment (20%)	End term (80%)	Total
Theory (Core)	10	40	50
Practical (Core)	10	40	50
Practical (Core) 4th Sem	5	20	25
Theory (GE)	10	40	50
Theory (DSE paper)	10	40	50
Practical (DSE paper)	10	40	50
Dissertation/ review work	-	50	50

Question Pattern

Internal assessment	Semester end term
For written tests **10 marks** 5 x 2 marks (out of 8)	For written tests **40 marks** 5 x 2 marks (out of 8) 2 x 5 marks (out of 4) 2 x 10 marks (out of 4)
For Practical tests **10 marks** Experiment/ viva - 10 marks **05 marks** Experiment/ viva - 05 marks	For Practical tests **40 marks** Experiment - 30 marks LNB + Viva voce – 5+5= 10 marks **20 marks** Experiment - 15 marks LNB + Viva voce – 2+3= 5 marks
	Field visit **25 marks** Field report - 20 marks Viva - 05
	Seminar **25 marks** Seminar presentation – 15 marks Viva – 10 marks

Course Structure:

	MARKS/ CREDIT					
	MARKS			CREDIT		
	Theory	Practical	TOTAL	Theory	Practical	TOTAL
SEMESTER I	**150**	**100**	**250**	**12**	**8**	**20**
SEMESTER II	**150**	**100**	**250**	**12**	**8**	**20**
SEMESTER III	**200**	**50**	**250**	**16**	**4**	**20**
SEMESTER IV	**125**	**125**	**250**	**10**	**10**	**20**
GRAND TOTAL			**1000**			**80**

A] **Core Subjects** **:** Compulsory for all

B] **Elective Subjects** **:** Student will choose any one of the Elective subjects being offered by the department

C] **Choice Based Credit Course** **:** Student will choose any one of the GEs being offered, apart from own subject.

1st Semester

PG-ZOO-CC-101: (Group A) **Non-chordate biology** **Marks 25 Credit 02**

Course objectives: The non-chordate and chordate biology are the fundamental and very important parts of the subject to be taught to every student of Zoology. This paper starts with evolution of the metazoans and the course is aimed to provide the students knowledge about different structural and functional insights of the non-chordate life. This paper is designed to describe distinctive features and important biological processes in both non-chordates and chordates, important concepts in non-chordate organization including body symmetry, body cavity and segmentation, locomotion, body support, feeding and digestion, excretion and osmoregulation, respiration, circulation, sensory perception, behavior, reproduction and development of different non-chordates and chordates.

1. **Origin and evolution of metazoans:** Symmetry, coelom, segmentation and cephalization.
2. **Nutrition and digestion:** Types and structure of invertebrate feeding organs; feeding patterns in non-chordates.
3. **Respiration:** Structural organizations of respiratory organs in Arthropoda and Mollusca.
4. **Excretion:** Structure of excretory organ and mechanism of excretion in Annelida; osmoregulation in Protozoa.
5. **Locomotion:** Locomotory system in Protozoa and Annelida; flight-mechanism in insects.
6. **Nervous system:** Structural evolution of nervous system in non-chordates; special sensory organs (chemoreception, photoreception and mechanoreception.)
7. **Non-chordate larva:** Types, structure and organization of non-chordate larval forms with their evolutionary significance.

PG-ZOO-CC-101: (Group B) **Chordate biology** **Marks 25 Credit 02**

1. **Proto-chordata:** Fine structure of notochord in Amphioxus; modern interpretation of origin of early chordates.
2. **Skeletal system and muscular system:** Mechanics of body support and movement; aerodynamics of flight; modification and functions of jaw bones in across different vertebrate classes; types of muscles in vertebrates; flight muscles in birds.
3. **Circulatory system:** Heart and circulation in Mammals; structure and evolution of aortic arch.
4. **Nervous system:** Functional associations of central nervous system; sensory receptors and their classification.
5. **Thermoregulation:** Ectothermic and endothermic mode of life.
6. **Osmoregulation and excretory system:** Osmoregulatory adaptation in aquatic and terrestrial animals, structure and function of kidney in Mammals.

Learning outcome: The course is designed to prepare the students with knowledge and skills of non-chordate and chordate life. The paper has made the students enriched in view of knowledge about the morphological, physiological and evolutionary aspects of Non chordates and Chordates. It provides a working knowledge of fundamental principles in Zoology that will provide a foundation for their later advanced course work in more specific biological subjects. As functional biology is a basic course, students have become familiar with the diagnostic characteristics and morphological diversity among different animal group as well as developing an understanding and ability to apply basic zoological principles.

PG-ZOO-CC-102: (Group A) **Cell biology** **Marks 25 Credit: 02**

Course objective: The curriculum in cell biology aims to introduce the students of the course to the building blocks of living organisms, the cells. The course is designed to give the students the opportunity to learn about cell signaling, cellular communication, cell cycle, cellular organization and cancer biology. The curriculum also includes inheritance biology which includes Mendelian inheritance and its extension, microbial genetics, recombination, mutation, gene mapping, molecular diagnosis and genetic screening.

1. Cell communication and signaling

1.1 **Cell signaling:** Hormones and their receptors, cell surface receptor, signaling through G-protein coupled receptors, MAP kinase pathway, JAK-STAT pathway, Wnt pathway, second messengers, regulation of signaling pathways, bacterial chemotaxis and quorum sensing.

1.2 **Cellular communication:** General principles of cell communication, cell adhesion and roles of different adhesion molecules, gap junctions, extracellular matrix, integrins, neurotransmission and its regulation.

1.3 **Cell division and cell cycle:** Mitosis and meiosis, their regulation, steps in cell cycle, and regulation of cell cycle.

2. Cellular organization

2.1 **Membrane structure and function:** Structure of model membrane, lipid bilayer and membrane protein diffusion, osmosis, ion channels, active transport, membrane pumps, mechanism of sorting and regulation of intracellular transport, electrical properties of membranes.

2.2 **Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, golgi bodies, lysosomes, endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility.

3. Cancer biology

3.1 Genetic rearrangements in progenitor cells, oncogenes, tumor suppressor genes, cancer and the cell cycle.

3.2 Virus-induced cancer, metastasis, interaction of cancer cells with normal cells.

3.3 Apoptosis, reactive oxygen species (ROS).

PG-ZOO-CC-102: (Group B) **Inheritance biology** **Marks 25 Credit 02**

1. **Mendelian principles and its extensions:** Dominance, segregation, independent assortment, co-dominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, sex limited and sex influenced characters.
2. **Microbial genetics:** Transformation, conjugation, sex-duction, transduction and mapping genes by interrupted mating.
3. **Recombination:** Concept of homologous recombination; Site specific recombination; FLR-FRT system; Cre-lox system

4. **Mutation:** Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
5. **Gene mapping:** Three-point test cross; Somatic Cell hybridization and gene mapping; Molecular Marker (RFLP, RAPD, AFLP, SNP)
6. **Molecular diagnosis and genetic screening:** Genetic disorders; Pedigree analysis.

Learning outcomes: Successful completion of the curriculum of cell biology and inheritance biology, the students should have a comprehensive idea on structural and functional aspects of the cellular components and genome which would help them to pursue research in the field of cell biology and genetics which are amongst the most promising fields of biological researches.

PG-ZOO-CC-103: (Group A) **Ecology** **Marks 25 Credit: 02**

Course objectives: Understanding on the ecology and ecosystem is important to make the human society sustainable on earth. The course aims to provide the students with an understanding on i) Environment and ecology and their roles ii) Concepts on population, its growth and control mechanisms, iii) Community structure, feature and dynamics, iv) Applications of ecological knowledge and v) Economical aspects of ecology.
Toxic substances are released to the environment by natural process and some developmental activities. This leads to hazards and pose risk on the human society. To minimize the toxicity related risk an understanding on the toxicity pathways, their metabolism and tolerance limits is required. The course aims to provide the students with an understanding on i) Body processes and their response to toxic substances ii) Toxic effects of heavy metals and exposures of different toxicants on our health.

1. **Ecosystem structures**
   1.1 Physical environment, biotic environment.
   1.2 Concept of habitat and niche, niche width and overlap, fundamental and realized niche, resource partitioning.
2. **Population ecology**
   2.1 Population growth models- mathematical interpretations.
   2.2 Life history strategies (r and K selection)
   2.3 Meta-population concept.
3. **Community ecology**
   3.1 Understanding community structure,
   3.2 Species coexistence – maintenance of species diversity; Island biogeography theory.
   3.3 Interspecific interactions – competition, predation, mutualism.
4. **Applied ecology**
   4.1 Bioremediation, phytoremediation, natural degradation process.
   4.2 Biodiversity: Major drivers of biodiversity change; Biodiversity management approaches.

5. Ecological economics

5.1. Ecosystem services, types and valuation,

5.2. Ecological footprint analysis.

PG-ZOO-CC-103: (Group B) **Toxicology** **Marks 25 Credit: 02**

1. Xenobiotics

1.1. Types of toxic substances (including natural toxins, concept of xenobiotics, mutagens, clastogens, teratogens, carcinogens)

1.2. Types of exposure, absorption, metabolism and excretion of toxicants (Phase I and Phase II reaction)

2. Ecotoxicology

2.1. Biomarkers, Bioaccumulation, Biomagnification

2.2. Toxicity of heavy metals (Pb, Cd, Hg and As)

2.3. Dose, dose response, Bioassay, LC50 and LD50, Probit analysis and significance

2.4. Health consequences of different occupations: Anthracosis, silicosis, asbestosis

3. Pesticides Concept and classification:

3.1. Insecticides and herbicides: Types, effects and degradation kinetics

3.2. Mechanism of action: Organochlorine, Organophosphate, Carbamates, Pyrethroids

Learning outcome: On completion of the course, the candidate will be able to understand a) the concept of ecosystem and ecological processes, b) concept of population and population attributes c) concept of community structure, features, important models of community structures d) application and e) economic aspects of ecosystem. On completion of the course in toxicology, the candidate will be able to understand a) Basic concepts about toxicology and xenobiotics b) Bioaccumulation of toxic substances and heavy metal toxicity. c) absorption, distribution and excretion of toxic substances d) effects of different toxicants on reproductive health and development. e) different occupational hazards associated with the working environment and exposure to different toxic substances

PG-ZOO-CC-104(P): **Marks 50 Credit 04**

Fundamentals of Non-chordate and Chordate biology practical & Cell biology and Inheritance biology practical

Non-chordate:

1. Preparation of key to different categories of non-chordate specimens up to class (preferably considering one typical specimen of each class)

2. Mounting of:

a) Protozoans: *Gregarina*, *Paramoecium*, *Nyctotherus*, *Opalina*

b) Arthropods: *Cyclops*, *Daphnia*, mouth parts of mosquito/ housefly.

3. Dissections / demonstration of

a) Nervous system of Cockroach.

Chordate:

4. Preparation of key to different categories of chordate specimens up to orders (preferably considering one typical specimen of each order)

5. a) Accessory air-breathing organs of *Anabas / Clarias / Heteropneustes* (market specimen)

b) *Rattus* (Laboratory bred): Arterial system.

Cell biology and inheritance biology:

6. Study of meiosis from grasshopper testes.

7. Barr body preparation and staining.

8. Karyotype preparation (Human)

9. Pedigree analysis of common human dominant/recessive traits.

10. Genomic DNA extraction. Quantification and estimation of DNA by UV-spectrophotometer.

PG-ZOO-CC-105(P): Marks 50 Credit 04

Ecology and Toxicology practical & field/institution visit

1. Study of the biotic and abiotic components of any simple ecosystem- natural pond or terrestrial ecosystem or human modified ecosystem.
2. Determination of species richness, density, abundance, frequency, diversity etc. in a terrestrial community or a hypothetical community by quadrate method and calculation of the Simpson's and Shannon-Weiner diversity index for the same community.
3. Biochemical analysis of pond or river water for alkalinity, pH, dissolved O_2/ CO_2, Chloride, Nitrate, Phosphate and sulphate.
4. Determination of LC_{50} / LD_{50} of toxicants.
5. Field / Institution visit.

2nd Semester

Course objective: The objective of the curriculum in Biostatistics and taxonomy is to introduce the students with basic statistics and taxonomy. The module will help the students to learn about different concepts and practices about biostatistics and taxonomy like data dispersion, parametric and non-parametric statistics, regression and correlation, hypothesis testing, species concept, classification, molecular taxonomy etc. Along with that this curriculum also gives the opportunity to develop some practical biological knowledge and skills.

PG-ZOO-CC-201: (Group A) **Biostatistics** **Marks 25 Credit 02**

1. **Introduction to Biostatistics:** Definition and utility of biostatistics in biological studies.
2. **Basic concepts of biostatistics:** Data, Variable, attribute, Population, Sample, Arrangement of data, Frequency distribution.
3. **Measures of Central Tendency:** Mean; Mode; Median.
4. **Measures of data dispersion:** Variance; Standard deviation; Noise and Error: Standard error, Kurtosis, Skewness, interquartile range.
5. **Parametric and non-parametric statistics**
6. **Graphical representation of data:** Line diagram; Bar diagram; Pie chart; Histogram.
7. **Simple Linear Regression and Correlation.**
8. **Testing Hypothesis:** level of significance, p value, Students' 't' distribution, Paired t-test, Chi-Square Test (goodness of fit and contingency chi square)
9. **Analysis of Variance.** (One way ANOVA)

PG-ZOO-CC-201: (Group B) **Taxonomy** **Marks 25 Credit 02**

1. **Taxonomic characters:** Concept of character, qualitative and quantitative, homology
2. **Species concepts:** Biological, Evolutionary and Phylogenetic
3. **Species taxon:** Polytypic; Linnean hierarchy, Category, Supra and infra-specific categories, intra-populational variations, delimitation criteria
4. **Classification:**
   - Phenetics: Concept, phenograms
   - Cladistics: Concept, homology, homoplasy, cladograms
   - Evolutionary: Concept of monophyly, paraphyly & polyphyly
5. **Molecular taxonomy:**
   - Genomics and Proteomics in taxonomy: Concept and applications
   - Molecular basis of taxonomy: nuclear DNA, mitochondrial DNA, ribosomal
   - RNA, cytochrome-C, α globin polypeptide chain
   - Phylogenetic trees: Cluster (UPGMA), Neighbor joining method & cladistic methods, parsimony and maximum likelihood method
   - DNA barcoding, Barcode gap, Barcode databases

Learning outcome: The course is designed to prepare the students with knowledge and skills of biostatistics and taxonomical aspect of the subject. The paper has made the students enriched in view of knowledge about real life sampling methods, modern approaches in data handling along with the classical and newest trends of taxonomy studies like classification and molecular taxonomy.

Course objectives: The first group of the paper has been designed to explain how life originated on earth and then how the simplest life form gradually evolved throughout geological eras to give rise to more and more complex form of life. The course topics also gives knowledge about how genetic variations evolved in natural population and how species has evolved. Finally, the course will have an insight of patterns and trends in evolution which is an essential tool for studying human population.
Second group of the paper deals with behaviour biology of animals. The topics include the background of behavioural study, development of behaviour in animals, social behaviour, learning behaviour, communication, orientation and navigation.

PG-ZOO-CC-202: (Group A) **Evolution** **Marks 25 Credit 02**

1. **Origin and early history of life:**
   - Origin of basic biological molecules, Abiotic synthesis of organic monomers and polymers
   - Evolution of Prokaryotes and unicellular Eukaryotes; Origin of multicellular organisms, RNA world.
2. **Molecular evolution:**
   - Concepts of neutral evolution
   - Molecular divergence and molecular clocks
   - Protein & Gene evolution, Evolution of Multigene Family
   - Acquisition of new genes: Mechanisms and Exon Theory
3. **Paleontology and evolutionary history**:
   - The evolutionary time scale, Major events in the evolutionary time scale and extinction
   - Stages of Hominid evolution
   - Tools of studying evolution
4. **Population genetics:**
   - Origin of Genetic variation in the natural population
   - Hardy-Weinberg law Assumption, Derivation & application in population genetics,
   - Destabilizing forces influencing allele frequencies: Mutation, Natural Selection, Migration and Genetic drift.
   - Inbreeding: Measure of inbreeding, inbreeding depression, Heterosis
5. **Speciation:**
   - Patterns and Mechanisms of reproductive isolation; genetic basis of reproductive isolation.
   - Modes of Speciation
   - Evolution of interaction among species

PG-ZOO-CC-202: (Group B) **Animal behaviour** **Marks 25 Credit 02**

1. **Introduction and history of behavioural ecology.**
2. **Development of behaviour:**
   - Genetic, Environmental and Neural influences.
   - Imprinting, food choices.
   - Bird song.
   - Play behaviour.
3. **Social behaviour:**
   - Sexual selection, Altruism, Kin selection, social structures in primates, territoriality; Mating systems, conflicts.
4. **Biological rhythms:**
   - Basic components, types, centers (suprachiasmatic nuclei, pineal gland, optic lobes), factors influencing biological rhythms (environmental, photoperiod, temperature, other Zeitgebers), molecular basis of circadian rhythms.

5. **Learning behaviour:**
   - Classical conditioning, Instrumental conditioning, Acquisition, Extinction and Habituation, Sensitization, Generalization, Reinforcement.
6. **Communication:**
   - Signals and Channels of communication.
7. **Orientation and navigation:**
   - Migration in birds and mammals.
   - Compass orientation – Sun, star, moon, olfactory cues, magnetic field, ambient pressure, infrasound.
   - Homing behaviour, pilotage, true navigation.

Learning outcome: On completion of the course, the students have the understanding of the history of life. They are knowledgeable about the major events earth has encountered in its geological time period. The course has offered a wide array of knowledge and insights about the evolution of species and animal behaviour. The deeper understanding about the animal behaviour and origin of life will inspire the students to pursue further studies in these fields.

Course objectives: The objective of the curriculum in biochemistry and animal physiology is to extend the knowledge of the students about these courses which they have learned in their UG courses. The biochemistry part of the paper includes the basic molecular and chemical properties of biological organisms and their components. It also includes the structures, properties and metabolism of different biological macromolecules. The objective of the curriculum in Animal physiology is to explain the fundamental mechanisms of different systems including digestive, circulatory- respiratory, excretory, nervous and muscular system that operate in a living organism.

PG-ZOO-CC-203: (Group A) **Biochemistry** **Marks 25 Credit 02**

1. **Structure of atoms, molecules and chemical bonds.**
2. **pH and Buffers:** Concept of acids and bases, buffers, biological buffer systems: the phosphate buffer system, the bicarbonate buffer system.
3. **Carbohydrates and metabolism:** Overview of classification, structure and functions; Glycolysis and its regulation, Citric acid cycle and its regulation, Oxidative and substrate level phosphorylation, Basic concept of Electron-transfer reaction in mitochondria and ATP synthesis; Gluconeogenesis; Hexose monophosphate Shunt; Glycogenesis and Glycogenolysis.
4. **Protein and metabolism:** Overview of classification, structure and functions of Amino acids; Conformation of proteins structure and function; General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids; Acetyl CoA, alpha ketogutarate, acetoacetyl CoA, succinate, fumarate and oxaloaccetate pathway; Urea cycle and its regulation; Ammonia excretion.
5. **Lipids and metabolism**: Storage lipids, Structural lipids in membranes, Lipids as signals, cofactors and pigments; Hydrolysis of tri-acylglycerols; α-, β-, ω- oxidation of fatty acids; Energetics of beta oxidation
6. **Enzymes:** Classification, kinetics, function, examples of inhibitions & inhibitors; Ribozymes and deoxyribozymes.

PG-ZOO-CC-203: (Group B) **Animal physiology** **Marks 25 Credit 02**

1. **Digestive system**:
   - Digestion and absorption. Neuroendocrine regulation of gastro – intestinal movements and secretions. Energy balance, BMR

- Neural regulation of thirst and hunger, Events of absorptive and post absorptive states and their neural and endocrine regulation
- Physiology of starvation and obesity

2. **Circulation:**
   - Concepts of haemodynamics, blood volume and its regulation
   - Cardiac cycle and cardiac output, Neural and chemical regulation of cardiac activity, blood pressure and its regulation, ECG - its principle and significance.

3. **Respiration:**
   - Lung ventilation, lung volumes in human, pulmonary surfactants
   - Neural and hormonal control of breathing. Respiratory acidosis and alkalosis and regulation of blood PH.
   - Respiration in unusual environment – foetal and neonatal respiration, high altitude, diving.

4. **Excretion:**
   - Urine formation, urine concentration and its hormonal regulation, micturition, Role of kidney in maintaining homeostasis.
   - Osmolar Clearances and Free Water Clearances, regulation of water balance, electrolyte balance and acid-base balance.
   - Formation of nitrogenous excretory products NH3, Urea & Uric acid.

5. **Sensory system:**
   - Neurotransmitters: Classification, distribution and functions.
   - Genesis of membrane potential, transmission through synapse, excitatory and inhibitory post-synaptic potential
   - Classification of somatic senses and somatic receptors
   - Mechanoreceptors: Mechanism of hearing and Equilibrium, Photo receptors: Structure of vertebrate eye. Physiology of vision, Pain receptors: Headache, pain suppression (analgesia), Tactile receptors: Mechanism of transmission of signals.

6. **Muscular system:**
   - Skeletal muscle- ultra structure and molecular organization. Red and white muscles
   - Mechanism of muscle contraction and relaxation. Energetics of muscle contraction.
   - Neural control of muscle tone and posture.

7. **Stress and adaptation:**
   - Basic concept of environmental stress and strain, concepts of elastic and plastic strain, stress resistance, stress avoidance and stress tolerance.
   - Adaptation: The nature and levels of adaptation, Fundamental mechanisms of adaptation.

Learning outcome: The course helps to understand how separate biochemical pathways and physiological systems interact among themselves to perform different chemical reactions and to yield integrated physiological responses to challenges and stresses. Along with that this curriculum also gives the opportunity to develop some practical biological knowledge and skills which is included in the practical part of the course.

PG-ZOO-CC-204(P): **Marks 50 Credit 04**

Biostatistics, Taxonomy, Evolution and Biochemistry practical

1. Preparation and interpretation of line diagram, bar diagram, pie charts and histogram from hypothetical/real data in computer software.
2. Basic knowledge and use of SPSS software for statistical analysis.
3. Chi square, Unpaired and paired t-test and one way ANOVA.
4. Specimen collection and preservation techniques.
5. Preparation of key-dichotomous key based on invertebrates (insects).
6. Sampling methods (including diversity assessment) for invertebrates (insects) and vertebrates (birds).
7. Statistical assessment of morphological features (morphometry) using software.
8. Problems based on gene frequency – Hardy-Weinberg Law; Calculating gene frequencies and genotype frequencies.
9. Polygenic inheritance – height in men.
10. Problems based on multiple alleles – Blood groups, Rh factor.
11. Multifactor inheritance – Fingerprint analysis.
12. Study of fossils from models/ picture.
13. Preparation of standard curve and estimation of glucose and protein concentration from unknown samples.
14. Estimation of saponification Values of Oils and Fats.
15. Preparation of extract for enzyme assay and study of the enzyme (LDH/Alkaline phosphatase/Amylase) activity
16. Electrophoretic analysis of protein by SDS–PAGE.

PG-ZOO-CC-205(P): **Marks 50 Credit 04**

Animal behaviour, animal physiology practical & seminar presentation

1. Behaviour sampling methods.
2. Study of different stresses in humans.
3. Territoriality in dogs.
4. Estimation of fasting and PP blood Sugar in human by GOD-POD method.
5. Biochemical estimation of blood Cholesterol.
6. Action of digestive enzymes.
7. Oxygen consumption and estimation in an aquatic or terrestrial animal.
8. Demonstration of the unconditioned reflex action.
9. BMI estimation.
10. Body fat percentage calculation.
11. Pulse rate and Blood pressure measurement.

Seminar presentation on any topic from the 2nd semester syllabus.

3rd Semester

Course objective: The course aims to provide students with a thorough understanding of key concepts in developmental biology and endocrinology. In developmental biology, students will explore fundamental processes such as potency, induction, differentiation, and morphogenetic gradients, along with early embryonic development, axis formation, organogenesis, and the role of stem cells. They will also examine post-embryonic development, cell fate determination, and the molecular regulation of stem cells, including their clinical applications. Additionally, topics on ageing and senescence will be discussed. In endocrinology, students will study the mechanisms of hormone action, feedback systems, and the regulation of hormone synthesis and secretion by glands such as the thyroid, pancreas, and adrenal glands. The course also covers neuroendocrine control, reproductive endocrinology, and the hormonal regulation of processes such as spermatogenesis, oogenesis, menstrual cycles, gestation, and lactation, as well as the impact of hormones on macromolecule metabolism.

PG-ZOO-CC-301: (Group A) **Developmental Biology** **Marks 25 Credit 02**

1. Basic concept of development: Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; imprinting.
2. Early embryonic development, cleavage, gastrulation and formation of germ layers in animals; embryogenesis, Placenta.
3. Axes and pattern formation in *Drosophila*, amphibia; organogenesis – vulva formation in *Caenorhabditis elegans*, limb development in vertebrates; post embryonic development- larval formation, metamorphosis.
4. Cell fate and cell lineages, stem cell-types, genesis and differentiation in animals. Molecular biology of stem cell and its regulatory molecules, Placenta as a source of stem cells and its importance in stem cell research, emerging trend and clinical applications.
5. Ageing and senescence.

PG-ZOO-CC-301: (Group B) **Endocrinology** **Marks 25 Credit 02**

1. Chemical messengers, Hormones and their feedback systems. Mechanisms of hormone action.
2. Hypothalamic control of adenohypophysial function, Neuroendocrine system and neuro secretion Clinical aspects of the hypothalamo-hypophysial system.
3. Thyroid, Endocrine pancreas, Adrenal gland: biosynthesis and function of hormones and control of secretion.
4. Reproductive endocrinology: Endocrine regulation of spermatogenesis and oogenesis, Hormonal regulation of Estrous and Menstrual cycle, ovulation, gestation, parturition and lactation.
5. General idea about hormones influencing metabolism of macromolecules.

Learning outcomes: By the end of the course, students will have a deep understanding of developmental processes such as the determination of cell fate, tissue formation, and early organismal development, including key stages like cleavage, gastrulation, and germ layer formation. They will be able to explain the formation of body axes in various model organisms and the role of key molecular factors in these processes. Students will also grasp the significance of stem cells, including their sources, differentiation pathways, and applications in regenerative medicine. Furthermore, they will understand the biology of ageing and its underlying mechanisms. In endocrinology, students will be able to explain how the body regulates and balances hormone levels, describe the roles of major endocrine glands, and understand how hormones control reproductive processes such as gametogenesis, menstrual cycles, pregnancy, and lactation. Finally, students will recognize how hormones influence the breakdown and synthesis of carbohydrates, proteins, and fats, integrating metabolic functions with endocrine signals.

Course objective: The course aims to provide students with a foundational understanding of both immunology and molecular biology. In immunology, students will explore the mechanisms of innate and adaptive immunity, including antigen presentation, immune cell signalling, and the roles of PAMPs and DAMPs. Additionally, the course covers immunological tolerance, autoimmune disorders, immunodeficiencies, and transplantation immunology. In molecular biology, the focus will be on the processes of DNA replication, transcription, translation, and gene regulation in both prokaryotes and eukaryotes. Students will also study epigenetic mechanisms and post-transcriptional modifications, providing a comprehensive understanding of how genes are expressed and regulated at the molecular level.

PG-ZOO-CC-302: (Group A) **Immunology** **Marks 25 Credit 02**

1. Innate immunity – Epithelial Barrier, Inflammation, Function of Neutrophil, Macrophage and NK cell, PAMP and DAMP, Toll like Receptors (TLRs), Collaboration between innate and adaptive immunity.

2. Antigen capture and presentation, APCs, MHC molecules.

3. Humoral Immunity: Antigen Recognition: B cell and T cell receptor complex. Generation of immunoglobulin diversity, clonal selection, neutralization and opsonisation, Class switching, B cell signalling.

4. Cell Mediated Immunity: APC- T cell interaction, Th1, Th2 response. Cytotoxic T cell function, T- regulatory cells, T cell signalling.

5. Immunologic tolerance and Autoimmune disorders – Rheumatoid arthritis, Systemic lupus erythematosus (SLE)

6. Immunodeficiencies- Congenital Immunodeficiencies, Acquired Immunodeficiencies.

7. Transplantation Immunology- Different types grafting, Graft rejection.

PG-ZOO-CC-302: (Group B) **Molecular Biology** **Marks 25 Credit 02**

1. **DNA Replication:**

   - Mechanism of DNA replication: semi-conservative replication
   - Enzymes involved in replication: DNA polymerase, helicase, ligase
   - Differences between prokaryotic and eukaryotic replication

2. **Transcription and Translation:**

   - RNA transcription in prokaryotes and eukaryotes
   - Post-transcriptional modifications (capping, polyadenylation, splicing)
   - Genetic code: Properties and significance
   - Protein synthesis (translation): Mechanism, initiation, elongation, and termination

3. **Gene Regulation:**

   - Regulation of gene expression in prokaryotes: Operon models.
   - Regulation of gene expression in eukaryotes: Role of transcription factors, enhancers, silencers
   - Epigenetics: DNA methylation, histone modification, chromatin remodeling.

Learning outcomes: Upon completing the course, students will gain the ability to explain how the body defends against infections through innate and adaptive immune responses. They will understand key processes involved in antigen recognition, immune cell interactions, and the regulation of immune tolerance, as well as recognize the causes and implications of immune disorders like autoimmunity and immunodeficiency. Additionally, students will be equipped with a strong grasp of the molecular mechanisms behind DNA replication, RNA synthesis, and

protein production, along with the complex regulation of genes in both simple and complex organisms. They will also appreciate the role of epigenetic modifications and post-transcriptional changes in controlling gene expression.

PG-ZOO-CC-303(P): Marks 50 Credit 04

Developmental Biology, Endocrinology, Immunology and Molecular biology Practical

List of Practical:

1. Preparation, fixation, staining and identification of chick embryo after incubation of the eggs for different hours.
2. Study of different section of placenta through photomicrograph.
3. Identification of stages of estrous cycle by vaginal smear preparation in rat
4. Identification and collection of endocrine glands from mice, tissue fixation, embedding, microtomy, slide preparation and double staining of prepared histological slides of mammalian endocrine gland.
5. Macrophage isolation and observation from blood of white mouse.
6. Genomic DNA isolation from mammalian tissues and its quantification.
7. Study of serum protein by PAGE.

Course objective: The course provides students with a foundational understanding of ecosystem functions, energy flow, nutrient cycling, and population dynamics in various ecosystems. In System Ecology, students will explore both terrestrial and aquatic ecosystems, focusing on productivity, energy transfer, and the role of microbial communities. In Wildlife and Conservation Biology, students will learn about wildlife conservation, habitat management, and the effects of human activities on biodiversity. They will also be introduced to the use of remote sensing (RS) and Geographic Information Systems (GIS) in conservation efforts, along with studying key national and international conservation organizations and initiatives.

PG-ZOO-DSE-304(A): System ecology Marks 25 Credit 02

Ecosystem Ecology: Ecosystem structure; ecosystem function; structure and function of some Indian ecosystems: terrestrial (forest, grassland), Vertical stratification of plants and animals. Leaf litter decomposition. Types of humus and aquatic (fresh water, marine, eustarine) stratification, distributions and mixing patterns. Dynamics of light, oxygen and nutrient content.

Ecological Energetics: The entropy law, energy transfer across trophic links, energy budget, chemolithoautotrophs and hydrothermal vents.

Mineral cycling: Patterns and basic types of biogeochemical cycles, global cycling of carbon, nitrogen, phosphorus and water, watershed studies, nutrient cycling in the tropics, recycling pathways and recycling index.

Concept of Productivity: Biomass, Primary and secondary productivity patterns, tropic structure and ecological pyramids, ecological efficiencies.

Population and Community Ecology: Population fluctuations and cyclic oscillation, Pattern of dispersion and Population regulation. Metacommunity dynamics.

Microbial ecology: Microbial communities and ecosystems; Positive and negative interaction

between microorganisms and ecological implication; Microbes in nitrogen and carbon cycling; Microbes in fuel and biogas production.

PG-ZOO-DSE-304(A): Wildlife and Conservation Biology Marks: 25 Credit: 02

Basic concepts of wildlife and conservation: Definition and basic concepts of wildlife, scope of wildlife, importance of wildlife, values of wildlife, Biogeographic classification of India, Forest types of India according to Champion and Seth classification, concept of protected areas.

Concepts of Habitat and habitat management: Wildlife habitat and species management. Strategies and guidelines for management planning of protected areas; Use of fire as a tool in habitat management; livestock grazing and its impact on wildlife habitats; introduction and spread of exotic and invasive species in India; waterhole management; effect of habitat loss, habitat disturbance and habitat fragmentation; ecosystem restoration. Fundamentals of remote sensing and GIS. Application of RS and GIS in habitat management.

National and International organization for biodiversity and conservation: Biodiversity legislations and conventions, convention on biological diversity (CBD), Man and Biosphere (MAB), Ramsar convention, Kyoto protocol, role of protected areas and zoos in wildlife conservation, red data book.

International and national organizations in wildlife conservation: CITES, Global Tiger Forum (GTF); Wildlife Crime Control Bureau (WCCB), National Tiger Conservation Authority (NTCA), Worldwide Fund for Nature (WWF), Wildlife Trust of India (WTI), Trade Records Analysis of Flora and Fauna in Commerce (TRAFFIC), Bombay Natural History Society (BNHS), National Board for Wildlife (NBWL), Compensatory Afforestation Fund Management and Planning Authority (CAMPA); International Union for Conservation of Nature (IUCN), Conservation Breeding Specialist Group (CBSG), Species Survival Commission (SSC).

Learning outcomes: Upon completing the course, students will be equipped to assess the characteristics and roles of diverse ecosystems, detailing how energy and nutrients circulate within them. They will critically examine ecological principles related to productivity and gain insights into the dynamics of populations and community relationships, including patterns of variation and distribution. Additionally, students will propose and implement effective management strategies for wildlife habitats, taking into account the consequences of habitat degradation, disturbances, and the introduction of non-native species, as well as exploring restoration approaches. They will leverage remote sensing and Geographic Information Systems (GIS) for conservation strategies and articulate significant national and international initiatives aimed at preserving biodiversity, acknowledging the necessity of wildlife preservation and the significance of sustaining ecological integrity and species diversity.

Course objective: The course provides students with an in-depth understanding of entomology, focusing on insect classification, structural organization, and key physiological processes. Students will explore the general characteristics and external morphology of insects, as well as their digestive, circulatory, and reproductive systems. The course also addresses hormonal regulation and communication methods in insects. Additionally, students will study medical entomology, including the role of insect vectors in disease transmission and the use of forensic entomology in determining post-mortem intervals.

PG-ZOO-DSE-304(B): Entomology Marks: 50 Credit: 04

1. **Classification and Structural Organization:**
    - General characteristics of insects

- Classification up to order (Basic taxonomy and nomenclature) and Characteristics of insect families of economic importance.
- External morphology (body segmentation, appendages, wings, antennae)

2. **Insect Physiology and Development:**
    - Digestive system and feeding mechanisms
    - Circulatory system (haemolymph, haemocytes and immune response)
    - Reproductive system (Different types of reproduction and accessory reproductive organs)
    - Post-embryonic development (Hormonal control of growth and development; Degree-Day Methods)
    - Chemical communication (pheromones, allomones, kairomones) and Mechanical communication (sound production, vibrational communication)
3. **Medical Entomology**
    - Vector biology (Transmission mechanisms of insect vectors for pathogens affecting crops, humans, and livestock)
    - Forensic entomology (Insects associated with cadavers and their role in post-mortem interval estimation)

Learning outcomes: Upon completing the PG-ZOO-DSE-T-305 course, students will be able to identify and categorize insects up to the order level, recognizing key traits of families that have economic significance. They will describe the external anatomical features of insects, including body segmentation and appendages, while elucidating the primary physiological systems such as digestion, circulation, and reproduction. Students will evaluate the various forms of communication in insects, including chemical signals and sound production methods. They will investigate the behaviour and biology of insect vectors and their roles in the spread of pathogens affecting humans, plants, and animals, and utilize principles of forensic entomology to assess post-mortem intervals based on insect activity. Ultimately, students will recognize the ecological and economic relevance of insects in areas such as agriculture, medicine, and forensic investigations.

Course Objective: The course aims to equip students with practical knowledge and skills in applied zoology and entrepreneurship within various sectors. Students will explore sericulture, focusing on types of silkworms, their lifecycle, rearing techniques, and silk extraction processes, while also addressing silkworm diseases and pest control. In apiculture, they will study the social structure of honeybees and effective beekeeping practices, including honey extraction and the management of bee diseases. The course covers vermiculture and the methodology of vermicomposting, highlighting its advantages and challenges. Additionally, students will delve into aquaculture, including pearl and prawn culture, understanding hatchery techniques and fish farming practices. The course will introduce dairy farming, encompassing cattle breeds, breeding techniques, feeding, and management of dairy products and pathology. Students will also learn about poultry farming, including breed characteristics, rearing methods, feed formulation, and disease control. Finally, they will examine agricultural pests, their life cycles, and management strategies, including integrated pest management approaches to enhance sustainable practices in agriculture.

PG-ZOO-GE-327: Applied Zoology & Entrepreneurship Marks: 50 Credit: 04

1. Sericulture: Types of Silkworms with special reference to their scientific name, geographical distribution and host plants; Bombyx mori: Silk gland, Composition of silk, Uses of silk; Lifecycle; Rearing, Extraction and Reeling of mulberry silk; Silkworm diseases, pests and their control.

2. Apiculture: Various domesticated species of Honeybee; Social organization of Honeybee; Bee keeping: Langstroth Box for rearing of honey bee, Extraction and processing of honey; Composition of honey, apiculture by products and their uses; Pests and Diseases of bees and their control measures

3. Vermicomposting: Scope of Vermiculture; Habit categories of earthworms; methodology of vermicomposting, Advantages of vermicomposting; Diseases and pests of earthworms.

4. Aquaculture: Pearl culture: Hatchery techniques for seed production, pearl oyster farming, pearl formation, pre and post operative management of mussels, harvesting and processing of pearl. Prawn culture: Penaeid and Palaemonid features with examples; Semi-intensive method of prawn culture; Application of prawn culture; Fisheries: Difference between major and minor carps with examples; Composite fish farming: General concepts, advantages and disadvantages; Induced breeding: method and advantages; Integrated fish farming.

6. Dairy: Introduction to common dairy animals: Types of Cattle breeds and their distribution in India; Exotic cattle breeds; Artificial insemination and MOET in breeding; Cattle feed: Roughage and Concentrate; dairy by products, preservation and uses. Dairy pathology and vaccination programme.

7. Poultry: Types of breeds (fowl) with features and examples; Rearing method: Deep litter system; feed formulation for chicks; poultry by products with economic importance; Diseases of poultry and their control measures.

8. Agricultural Pests and their management: Pest- definition and types (major and minor pests with example); Lifecycle, nature of damage and control of Pests: *Scirpophaga incertulus* of paddy, *Anomis sabulifera* of Jute, Bandicoota– stored grain and house pest; Insect Pest control: Chemical, Mechanical, Cultural and Biological control measures; Integrated Pest Management (IPM).

Learning outcomes: Upon completing the course, students will be able to identify and classify various silkworm species, understand their life cycles, and implement effective rearing and silk extraction techniques while managing associated diseases and pests. They will recognize the social dynamics of honeybee colonies and apply appropriate beekeeping practices, including honey extraction and disease prevention strategies. Students will demonstrate knowledge of vermiculture and the process of vermicomposting, highlighting its ecological benefits. They will explore aquaculture, specifically pearl and prawn farming, understanding seed production, farming techniques, and integrated fish farming practices. In dairy production, students will distinguish between different cattle breeds, grasp breeding methodologies, and manage nutritional and health aspects of dairy animals. They will also evaluate poultry management, including breed characteristics, rearing systems, and disease control strategies. Lastly, students will analyze agricultural pest management techniques, including lifecycle assessment and integrated pest management approaches to enhance sustainable farming practices.