

PROPOSED SYLLABUS
FOR
M. Sc. COURSE IN ZOOLOGY
2020
(CBCS SYSTEM)



DEPARTMENT OF ZOOLOGY
DIAMOND HARBOUR WOMEN'S UNIVERSITY

STRUCTURE OF SYLLABUS UNDER CBCS

SEMESTER WISE DIVISION OF MARKS AND CREDITS

| SEMESTER | Theoretical (Core) | Practical (Core) | Discipline Centric Elective | | Open Elective (Theory) | Total Marks | Total Credits |
|--------------|-----------------------|---------------------|--------------------------------|-----------------|------------------------------|----------------|------------------|
| | | | Theory | Practical | | | |
| SEMESTER-I | 200 (20) | 50 (4) | - | - | - | 250 | 24 |
| SEMESTER-II | 200 (20) | 50 (4) | - | - | - | 250 | 24 |
| SEMESTER-III | 100 (10) | 50 (4) | 50 (5) | - | 100 (10) | 300 | 29 |
| SEMESTER-IV | 100 (10) | - | 50 (5) | 100 (8) | | 250 | 23 |
| Total | 600 (60) | 150 (12) | 100 (10) | 100 (08) | 100 (10) | 1050 | 100 |

N.B. – figures in parenthesis indicate the number of credits

SEMESTER-I

Duration: July to December

| Course Code | Paper name | Paper Type | Module | Marks | | | Credit | Class hours/ week | Total Class hours |
|---------------|--|------------|--------|--------------------------|---------------------|-------------|-----------|-------------------|-------------------|
| | | | | Semester-end Examination | Internal Assessment | Total Marks | | | |
| ZOO/CC/TH/101 | Non-chordate and Chordates | Theory | 101 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/102 | Taxonomy, Systematics, and Biostatistics | Theory | 102 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/103 | Ecology | Theory | 103 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/104 | Cell and Molecular Biology | Theory | 104 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/105 | Practical | Practical | 105 | 40 | 10 | 50 | 4 | 8 | 120 |
| | | | | Total Marks - 250 | | | 24 | 28 | 420 |

Note: All papers would contain 40 marks for written exam and 10 marks for internal assessment. Internal assessment can be made in the form of term paper, laboratory work, viva, assignments, seminar presentation, field work, outreach activities and mid-semester test.

SEMESTER-II

Duration: January to June

| Course Code | Paper name | Paper Type | Module | Marks | | | Credit | Class hours/ week | Total Class Hours |
|---------------|--------------------------------|------------|--------|--------------------------|---------------------|-------------|--------|-------------------|-------------------|
| | | | | Semester-end Examination | Internal Assessment | Total Marks | | | |
| ZOO/CC/TH/201 | Evolution and Animal Behaviour | Theory | 201 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/202 | Biochemistry and Biophysics | Theory | 202 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/203 | Genetics | Theory | 203 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/204 | Parasitology and Immunology | Theory | 204 | 40 | 10 | 50 | 5 | 5 | 75 |

| | | | | | | | | | |
|---------------------------|------------------|-----------|--------------------------|----|----|----|-----------|-----------|------------|
| ZOO/CC/ PR/205 | Practical | Practical | 205 | 40 | 10 | 50 | 4 | 8 | 120 |
| | | | Total Marks - 250 | | | | 24 | 28 | 420 |

Note: All papers would contain 40 marks for written exam and 10 marks for internal assessment. Internal assessment can be made in the form of term paper, laboratory work, viva, assignments, seminar presentation, field work, outreach activities and mid-semester test.

SEMESTER-III

Duration: July to December

| Course Code | Paper name | Paper Type | Module | Marks | | | Credit | Class hours/week | Total Class hours |
|---|--|------------------------|--------------------------|--------------------------|---------------------|-------------|-----------|------------------|-------------------|
| | | | | Semester-end Examination | Internal Assessment | Total Marks | | | |
| ZOO/CC/ TH/301 | Animal Physiology & Endocrinology | Theory | 301 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/ TH/302 | Biodiversity, Conservation and Wildlife Biology | Theory | 302 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/DC E/TH/303 | DISCIPLINE SPECIFIC Special paper Theory-I * | Theory | 303 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/ PR/304 | Practical | Practical | 304 | 40 | 10 | 50 | 4 | 8 | 120 |
| Open Elective Paper (CBCS, For other discipline) | | | | | | | | | |
| ZOO/OE/ TH/305 | Open Elective paper# Vision of zoological studies [CBCS] | Theory (Open Elective) | 305 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/OE/ TH/306 | Open Elective paper# Molecular and applied biology [CBCS] | Theory (Open Elective) | 306 | 40 | 10 | 50 | 5 | 5 | 75 |
| | | | Total Marks - 300 | | | | 29 | 33 | 495 |

Note: All papers would contain 40 marks for written exam and 10 marks for internal assessment. Internal assessment can be made in the form of term paper, laboratory work, viva, assignments, seminar presentation, field work, outreach activities and mid-semester test.

SEMESTER-IV
Duration: January to July

| Course Code | Paper name | Paper Type | Module | Marks | | | Credit | Class hours/week | Total Class hours |
|----------------|---|------------|--------|--------------------------|---------------------|-------------|-----------|------------------|-------------------|
| | | | | Semester-end Examination | Internal Assessment | Total Marks | | | |
| ZOO/CC/TH/401 | Animal Physiology & Endocrinology | Theory | 401 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/CC/TH/402 | Biodiversity, Conservation and Wildlife Biology | Theory | 402 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/DCE/TH/403 | DISCIPLINE SPECIFIC Special paper Theory-II* | Theory | 403 | 40 | 10 | 50 | 5 | 5 | 75 |
| ZOO/DCE/PR/404 | Special paper Practical-I* | Practical | 404 | 40 | 10 | 50 | 4 | 8 | 120 |
| ZOO/DCE/PR/405 | Special paper Practical-II* | Practical | 405 | 40 | 10 | 50 | 4 | 8 | 120 |
| | | | | Total Marks - 250 | | | 23 | 31 | 465 |

Note: All papers would contain 40 marks for written exam and 10 marks for internal assessment. Internal assessment can be made in the form of term paper, laboratory work, viva, assignments, seminar presentation, field work, outreach activities and mid-semester test.

DEPARTMENT OF ZOOLOGY
Structure of syllabus under CBCS 2020

| Semester | Paper Name | Module No. | Course Code | Type of Course | Marks | Credits | |
|---------------------|---|------------|----------------|----------------|-------------|------------|--|
| Semester-I | | | | | | | |
| I | Non-chordate and Chordates | 101 | ZOO/CC/TH/101 | Theory | 50 | 5 | |
| | Taxonomy, Systematics, and Biostatistics | 102 | ZOO/CC/TH/102 | Theory | 50 | 5 | |
| | Ecology | 103 | ZOO/CC/TH/103 | Theory | 50 | 5 | |
| | Cell and Molecular Biology | 104 | ZOO/CC/TH/104 | Theory | 50 | 5 | |
| | Practical | 105 | ZOO/CC/PR/105 | Practical | 50 | 4 | |
| Semester-II | | | | | | | |
| II | Evolution and Animal Behaviour | 201 | ZOO/CC/TH/201 | Theory | 50 | 5 | |
| | Biochemistry and Biophysics | 202 | ZOO/CC/TH/202 | Theory | 50 | 5 | |
| | Genetics | 203 | ZOO/CC/TH/203 | Theory | 50 | 5 | |
| | Parasitology and Immunology | 204 | ZOO/CC/TH/204 | Theory | 50 | 5 | |
| | Practical | 205 | ZOO/CC/PR/205 | Practical | 50 | 4 | |
| Semester-III | | | | | | | |
| III | Animal Physiology & Endocrinology | 301 | ZOO/CC/TH/301 | Theory | 50 | 5 | |
| | Biodiversity, Conservation and Wildlife Biology | 302 | ZOO/CC/TH/302 | Theory | 50 | 5 | |
| | Discipline Centric Elective paper Theory-I * | 303 | ZOO/DCE/TH/303 | Theory | 50 | 5 | |
| | Practical | 304 | ZOO/CC/PR/304 | Practical | 50 | 4 | |
| | Open Elective Paper (CBCS, For other discipline) | | | | | | |
| | Open Elective Vision of Zoological Studies [CBCS] | 305 | ZOO/OE/TH/305 | Theory | 50 | 5 | |
| | Open Elective Molecular and applied biology [CBCS] | 306 | ZOO/OE/TH/306 | Theory | 50 | 5 | |
| Semester-IV | | | | | | | |
| IV | Developmental Biology | 401 | ZOO/CC/TH/401 | Theory | 50 | 5 | |
| | Applied Biology | 402 | ZOO/CC/TH/402 | Theory | 50 | 5 | |
| | Discipline Centric Elective paper Theory II * | 403 | ZOO/DCE/TH/403 | Theory | 50 | 5 | |
| | Discipline Centric Elective paper Practical-I* | 404 | ZOO/DCE/PR/404 | Practical | 50 | 4 | |
| | Discipline Centric Elective paper Practical-II* | 405 | ZOO/DCE/PR/405 | Practical | 50 | 4 | |
| | | | | | 1050 | 100 | |

Note: All theoretical papers would contain 40 marks for written exam and 10 marks for internal assessment. Internal assessment can be made in the form of term paper, laboratory work, viva, assignments, seminar presentation, field work, outreach activities and mid-semester test. Practical paper contains 40 marks for written exam and 10 marks for laboratory note book and viva-voce.

[**ZOO-Zoology; OE-Open Elective; DCE-Discipline Centric Elective; CC-Core Course; Th-Theory; PR-Practical**].

* Discipline Centric Elective papers will be offered as follows-

- 1) Molecular Biology (ZOO/DCE/TH/CMB/303, ZOO/DCE/CMB/403, ZOO/DCE/PR/CMB/404, ZOO/DCE/PR/CMB/405)
- 2) Genetics (ZOO/DCE/TH/GEN/303, ZOO/DCE/TH/GEN/403, ZOO/DCE/PR/GEN/404, ZOO/PR/GEN/405)
- 3) Parasitology and Immunology (ZOO/DCE/TH/PI/303, ZOO/DCE/TH/PI/403, ZOO/DCE/PR/PI/404, ZOO/DCE/PR/PI/405)
- 4) Ecology and Environment (ZOO/DCE/TH/EE/303, ZOO/DCE/TH/EE/403, ZOO/DCE/PR/EE/404, ZOO/DCE/PR/EE/405)

Students will choose one special paper subject before the beginning of the 3rd Semester.

Option once exercised is final and binding. No change shall be permitted. Special papers will be offered as per the existing infrastructure.

Non-Chordate and Chordates

Paper – ZOO/CC/TH/101

Marks – 50 (25+25)

Unit A - Non-Chordate (25)

1. Different organelles in Protozoa
2. Locomotory mechanisms in non-chordates
3. Feeding and digestion - Ciliary and filter feeding
4. Respiration and circulation in invertebrates
5. Specialized excretory organs
 - Structure and function
 - Osmoregulation
6. Reproduction – mechanisms, Larval forms, Insects Metamorphosis
7. Regeneration in invertebrates.
8. Chemical coordination
 - Hormones and neurohormones
 - Pheromones and allelochemicals
9. Bioluminescence

Unit B - Chordate (25)

1. Protochordates
 - Relationship between Amphioxus and vertebrates
 - Origin of Craniates
2. Specialization of the integuments (claw, nail, scales, horns, antlers etc.)
3. Locomotion and movement
 - Different forms and kinetics of locomotory organs in vertebrates
 - Aerodynamics-general requirements of flyers: lift, drag, flight and control
4. Circulation
 - Evolution of heart
 - Circulatory system in foetal and neonatal mammals
 - Portal system
5. Respiration - Structure and evolution.
6. Nervous system
 - Types of cells within the nervous system
 - Overview of peripheral nervous system
 - Central nervous system and its function
7. Vertebrate sensory system
 - General and specialized sensory organs

Suggested readings-

1. Invertebrates-G. J. Brusca and R. C. Brusca, 3rd edition, Sinauer Associates
2. Invertebrate Zoology-Robert D. Barnes, Edward E. Ruppert, 6th edition, International edition.
3. Anderson – Invertebrate Zoology
4. Invertebrate Zoology-Meglisch & Schram.
5. Biology of the Invertebrates- J.A.Pechenik-
6. The Life of Vertebrates-J. Z. Young, 3rd edition, Oxford University Press
7. Vertebrates Comparative Anatomy Function Evolution-Kenneth Kardong, 4th edition
8. Klugg - Chordate Structure and function
9. Kent - Comparative Anatomy of the vertebrates, 9th Edition.
10. Hilderbrand M- Analysis of vertebrate structure, 5th edition.
11. McFarland, W N Pough, F.H. and Cade, T - Vertebrate life, L 4th Edition, 1996

Taxonomy, Systematics and Biostatistics

Paper – ZOO/CC/TH/102

Marks – 50 (25+25)

Unit A - Taxonomy and Systematics (25)

1. Principle and methods of taxonomy
 - Biological nomenclature and rules of ICZN
 - Phenetics
 - Cladistics
 - Evolutionary taxonomy
2. Taxon and species concept
3. Character and character state
 - Types of character
 - Character state transition
4. Theories of Biological Classification
 - Classification and phylogeny
 - Types of classification, hierarchic classification
5. Modern methods of systematic
 - DNA bar-coding.
 - Construction of phylogenetic tree

Unit B – Biostatistics (25)

1. Measures of central tendencies and dispersion
2. Probability- Probability models: Bernoulli, Binomial, Poisson, Normal (without deviation), Mean variation), Mean, Variance (without variation). Applications of the models using zoological data
3. Sampling method, Hypothesis testing (t-test, other non-parametric test, chi square test, ANOVA)
4. Regression and correlation
5. Representation of data

Suggested readings-

- 1) Principles of systematic zoology-Mayr and Ashlock, McGraw-Hill Inc.
- 2) Systematics and the Origin of Species from the Viewpoint of a Zoologist-Mayr, Harvard University Press
- 3) Principles of Animal Taxonomy- Simpson, G. G, 1961, Columbia University Press. New York.
- 4) Biostatistical Analysis-Jerrold H. Zar, 5th Edition, Pearson
- 5) Statistics for Biologists – Richard Colin Campbell, 1989. Cambridge University Press
- 6) Sampling design and statistical methods for environmental biologist- R H Green.
- 7) Introduction to Biostatistics- Robert R. Sokal and F. James Rohlf Dover Publications Inc.; 2nd edition

Ecology

Paper – ZOO/CC/TH/103

Marks - 50

1. Population Ecology
 - Population growth models
 - Life history strategies (r and K selection)
 - Population dynamics - Dispersal, patterns of survival, age structure
2. Metapopulation ecology
3. Community Ecology
 - Species abundance and diversity – diversity indices
 - Community structure and features, Keystone species, ecotones, edge effect
 - Coexistence and resource partitioning
4. Species Interactions
 - Types of interactions
 - Interspecific competition – competitive exclusion, Lotka-Volterra equations,
 - Exploitative interactions - Predation, herbivory, parasitism
 - Mutualism
5. Ecosystem Ecology
 - Energy flow
 - Patterns of primary and secondary productivity
 - Nutrient cycles – carbon, nitrogen, phosphorus, effect of climate change on nutrient cycles
Decomposition rates
6. Environment and ecosystem services
7. Global ecology
8. Coastal Ecosystem and Resources:
 - Physico- chemical features,
 - Tidal Energy,
 - Nutrient over-enrichment;
 - Exploitable and potential biological resources
9. Mangrove Ecosystem
 - Importance,
 - Role as coastal buffer zone and as breeding habitats for shellfish and finfish;
 - Conservation and Management of Mangrove ecosystem.
10. Coral Reef Ecosystem
 - Living resources,
 - Exploitation and its impact,
 - Sustainability and Conservation measures.

11. Human Impact on Coastal Fisheries Resources

- Threats and sources of pollution;
- Tools of conservation; Coastal Aquaculture Regulations and CRZ (coastal regulation zone);
- Integrated coastal zone management;
- Application of remote sensing and GIS to Coastal fisheries and aquaculture.

Suggested readings:

1. Ecology - William D. Bowman, Sally D. Hacker, et al., 4th edition, , 2017, Sinauer Associates is an imprint of Oxford University Press
2. Ecology: Concepts and Applications - Manuel C Molles, Anna Sher, 8th Edition, 2018, McGraw-Hill Education
3. Ecology: The Experimental Analysis of Distribution and Abundance, Charles J. Krebs, 6th edition, 2008, Pearson
4. Fundamentals of Ecology- Eugene P. Odum, 5th edition, 2005, Brooks-Cole
5. Ecology- Robert E. Ricklefs, Gary Leon Miller, 4th edition, 2000, W. H. Freeman Publishers
6. Ecology: From Individuals to Ecosystems - Michael Begon , Colin R. Townsend, et al. 4th edition, 2006, Wiley-Blackwell
7. Introduction to Population Ecology - Larry L. Rockwood, 2nd edition, 2015, Wiley-Blackwell

Cell and Molecular Biology

First Semester

Paper - ZOO/CC/TH/104

Marks - 50

1. Cell Membrane
 - Molecular Organization and functions
 - Membrane transport: Protein diffusion, osmosis, active transport, ion channels active transport, membrane pumps & electrical Properties of membrane
2. Cellular trafficking- GERL system on cellular dynamics and transport
3. Structure & function of cytoskeleton and its role in motility
4. Organization of genes and chromosomes
 - Nuclear membrane- organization and function
 - Nucleolus: Molecular organization and function
5. Cell cycle and Cell death
 - Regulation and control of cell cycle
 - Apoptosis and necrosis
 - Autophagy
 - Cellular senescence
6. Central Dogma
 - Prokaryotic and eukaryotic DNA replication
 - Transcription in prokaryotes and eukaryotes and RNA processing and turn over
 - Translation in prokaryotes and eukaryotes and Processing and regulation
7. Cellular communication and Cell signaling
 - Cell adhesion, integrin, gap junctions, desmosomes
 - Extracellular matrix
 - Hormone receptors, Cell surface receptor, G-protein coupled receptors, second messengers
 - Signal transduction pathways and crosstalk: MAPK-ERK, MEK
8. Cancer
 - Oncogenes and tumor suppressor genes
 - Characteristics and hallmarks of cancer (angiogenesis, EMT, MET)
 - Oncogenesis
9. Methods in Molecular Cell Biology
 - Isolation, Purification and Characterization of proteins RNA, DNA and proteins
 - Chromatography
 - RNA isolation and real-time RT-PCR
 - Electrophoresis, Isoelectric focusing
 - Immunohistochemistry / Immunocytochemistry
 - Fluorescence-activated cell sorting
 - Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.

Suggested readings-

1. The Cell: A Molecular Approach - Geoffrey M. Cooper and Robert E. Hausman, 7th edition, Sinauer Associates Inc
2. Cell and Molecular Biology: Concepts and Experiments - Gerald Karp and Nancy L Pruitt, 8th edition, 2016, John Wiley & Sons Inc
3. Molecular Biology of the Cell- Bruce Alberts et al., 6th edition, 2015, Garland Publishing Inc
4. Molecular cell biology- Harvey Lodish, et al., 8th edition, 2016, WH Freeman
5. Becker's World of the Cell Technology Update-Jeff Hardin, Global Edition.

Practical

Paper – ZOO/CC/PR/105

Marks - 50

1. Identification of Scale (fish), cilia (Paramecium), Flagella (Euglena), feather (bird), corpora cardiaca/allata (cockroach), Olfactory lobe (Tilapia), Webberian Ossicles(fish).
2. Dendrogram and cladogram
3. Graphical representation of data
4. Correlation and regression analysis
5. Estimation of dissolved oxygen, CO₂, hardness, BOD
6. Study of biotic community
7. Trypan blue exclusion test for identification of live from dead cells
8. DNA isolation from liver
9. Gel electrophoresis
10. Laboratory notebook
11. Viva-voce

Evolution and Animal Behaviour

Paper – ZOO/CC/TH/201

Marks – 50 (25+25)

Unit A – Evolution (25)

1. Evolutionary ideas and evolutionary theories
2. Natural Selection and Adaptation
 - Neutral theory of evolution and neutralist-selectionist controversy
3. Gene Frequencies in Population
 - The Hardy- Weinberg principle and analysis of gene frequencies in natural population.
 - Major factors influencing frequencies (migration, inbreeding), effects of selection and mutation on frequencies. Gene flow between subpopulations, genetic drift
4. Patterns and trends in evolution
 - Constructing evolutionary trees, measure of genetic relationship among organisms
 - Molecular clock of evolution
 - Molecular phylogeny
5. The Origin and Evolution of Primates
 - Evolution of Anthropoid Primates
 - The first hominids and origin of modern man
 - Human migration patterns

Unit B - Animal Behaviour (25)

1. Gene, Environment and Behaviour/Levels of Selection:
Kin selection concept
 - Fundamental of Behaviour Genetics and molecular tools
 - Genotype and Environment Interaction, Phenotypic plasticity
2. Cooperation and conflict:
 - sexual selection – modern perspectives, Elaborate ornaments: Fisher's hypothesis and Handicap hypothesis
 - Parent-offspring conflict
 - Range of cooperative behaviours and prisoner's dilemma
3. Foraging:
 - Optimal foraging theory
 - Foraging and predation risk: defense strategies against predators
 - Territoriality and Group Foraging
4. Agonistic behaviour:
 - Game theory models and strategies
5. Learning, imprinting and memory
6. Communication and its types:
 - Signal content and structure

- Orientation and cues

Suggested readings:

Evolution –

1. Evolution - Douglas J. Futuyma and Mark Kirkpatrick, 4th edition, 2017, Sinauer Associates (an imprint of Oxford University Press)
2. Evolution – Carl T. Bergstrom & Lee Alan Dugatkin, 2nd edition, 2016, W. W. Norton & Company
3. Strickberger's Evolution - Hallgrímsson, 5th edition, 2013, Jones Bartlett India

Animal behaviour –

1. Principles of Animal Behavior - Lee Alan Dugatkin, 3rd edition, 2013, W. W. Norton & Company
2. Animal Behavior - Dustin R. Rubenstein & John Alcock, 11th edition, 2018, Sinauer Associates (an imprint of Oxford University Press)
3. An Introduction to Animal Behaviour - Aubrey Manning & Marian Stamp Dawkins, 6th edition, 2012, Cambridge University Press

Biochemistry and Biophysics

Paper- ZOO/CC/TH/202

Marks – 50 (35+15)

1. Biochemical structures and Interactions
 - Structure of atoms, molecules
 - Chemical bonds (Hydrogen bonding, electrostatic, hydrophobic interaction, Van der Waals etc.)
2. Structure, classification and function of biomolecules
 - Amino acid (classification, properties; peptides: primary, secondary, tertiary and quaternary structures, conformation of proteins (Ramachandran plot, domains, motif and folds)
 - Carbohydrate (structure, classification and properties of monosaccharides; examples of di-, oligo & polysaccharides)
 - Lipid (basic structure & properties of membrane lipids)
 - Outline of metabolic pathways of various major biomolecules with mention of rate limiting steps
 - Few important bioactive molecules and important catabolites, Metabolic disorders
3. Conformation of nucleic acids
4. Enzymes
 - Classification, kinetics, enzyme regulation
 - Types of inhibitions & inhibitors; modulations
 - Isozymes
5. Regulation of carbohydrate metabolism
 - Glycolysis
 - TCA cycle
 - Glycogen metabolism
6. Bioenergetics
 - Anaerobic and aerobic respiration
 - Oxidative and substrate level phosphorylation, biological energy transducers
 - Electron Transport Chain and ATP synthesis
7. Vitamins and minerals
 - Use of vitamins as coenzymes and co factors with the relevant reaction involved
 - Deficiencies
8. Biophysical chemistry
 - pH, buffer, reaction kinetics
 - Thermodynamics, colligative properties etc.
9. Centrifugation.
10. Spectroscopic methods- UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy
Infrared spectroscopy, Raman spectroscopy, Mass spectrometry, surface plasma resonance methods and their biological applications.

11. Microscopy and imaging (light, fluorescence/confocal, SEM, TEM)

Suggested readings-

Biochemistry-

1. Lehninger Principles of Biochemistry-Nelson and Cox,7th edition,W H Freeman & Co
2. Biochemistry-Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, 5th Edn..
3. Harper's Illustrated Biochemistry-Robert K. Murray, Daryl K. Granner, Victor W. Rodwell,2006, 27th EdnThe McGraw-Hill
4. Biochemistry of Lipids, Lipoproteins and Membranes- Dennis E. Vance and Jean E. Vance,5th Edn.,2008 Elsevier.
5. Biochemistry-Voet & Voet. 4th edition, John Wiley & Sons Inc
6. Biochemistry-Berg, Stryer ,9th edition, WH Freeman

Biophysics

1. Physical biochemistry- D Freifelder, 2nd Edition, Freeman company.
2. Principles and Techniques of Biochemistry and Molecular Biology-Wilson K & Walker J, 6th ed., 2005, Cambridge University Press.
3. Physical Biochemistry: Principles and Applications- David Sheehan, 2009, John Wiley & Sons Ltd, Chichester, England,
4. Biophysical chemistry-Upadhyay, upadhyay & Nath.
5. Introductory Practical Biochemistry- Sawhney SK & Singh R, 1996, Narosa Publishing House Pvt Ltd, New Delhi.
6. Principles of Instrumental Analysis-Skoog, Holler &Nieman, 7th Edition, 2017.

Genetics

Paper – ZOO/CC/TH/203

Marks - 50

1. Mendelian principles of inheritance and Extensions of Mendelian principles
 - Principles of dominance and segregation, principles of independent assortment
 - Multiple alleles, incomplete and pseudo dominance, gene interactions, Epistasis, penetrance and expressivity
2. Chromosomal basis of inheritance
 - Chromosome theory of inheritance: Sex chromosomes, sex linkage and sex influenced characters
 - Sex determination and dosage compensation in *C. elegans*, *Drosophila* and Human
3. Concept of Gene and Chromatin dynamics:
 - Gene, allele, pseudoallele, multiple alleles, complementation tests
 - Organization of DNA in prokaryotes
 - Organization of DNA in eukaryotes, Nucleosome
4. Gene mapping in Eukaryotes:
 - Linkage and Crossing over,
 - Chromosome mapping with two- and three-point testcross
 - Methods of gene mapping
5. Mutation, Recombination and DNA repair:
 - Types of mutation and the molecular mechanism of development of mutation
 - Homologous and non-homologous recombination, Transposable elements
 - DNA repair mechanisms
6. Microbial genetics: Conjugation, Transformation, Transduction, Gene mapping in prokaryotes, regulation of gene expression in bacteria (*lac* operon, *trp* operon) and bacteriophages (lysogenic and lytic pathways)
7. Cloning, RFLP, RAPD and AFLP techniques, Gene knock out, etc.
8. Recombinant DNA technology, Application of RDT in agriculture, medicine and industry; Gene therapy

Suggested readings:

1. iGenetics : A Molecular Approach - Peter J. Russell, 4th edition, 1996, Addison-Wesley
2. Principles of Genetics- D. Peter Snustad and Michael J. Simmons, 7th edition, 2016, John Wiley & Sons Inc
3. Genetics- Monroe W Strickberger, 3rd edition, 1990, McMillan
4. Introduction to Genetics: A Molecular Approach; T A Brown, Garland Science (2011)
5. Principles of gene manipulation and genomics- S. B. Primrose and R. M. Twyman, Oxford publication

Parasitology and Immunology

Paper - ZOO/CC/TH/204

Marks – 50 (25+25)

Unit A – Parasitology (25)

1. Types of Animal association
2. Host parasitic interaction
3. Immune reactions to parasitic infections
4. Life cycle, pathogenesis, epidemiology, prophylaxis and treatment of some important protozoan (Malaria, Leishmaniasis, Trypanosomiasis, Amoebiasis) and helminthic parasites (Filariasis, Ascariasis, Taeniasis, Schistosomiasis)
5. Vectors and its importance in transmission of parasites
6. Common pests and management
 - Different types, biology, bionomics and management
 - Theory and practice
 - Biological and Integrated pest management

Unit B – Immunology (25)

1. Phylogeny of immune system- evolution of invertebrate immune system
2. Innate Immunity and its components–
 - Different Barriers.
 - Neutrophil and Macrophage Function.
 - Defense mechanism to Infection (Migration, Inflammation and Phagocytosis),
 - NK cell.
 - Relationship with Adaptive Immune system
 - Complement system
3. Concept of APC
 - Antigen processing and presentation,
 - Structure and Function of MHC molecule.
4. Antigens and antigen recognition
 - Types, antigenicity and immunogenicity
 - B and T cell epitopes
5. Structure and function of antibody molecules
 - Generation of antibody diversity
 - Monoclonal antibodies
 - Antibody engineering
 - Antigen-antibody interactions
6. Activation and differentiation of B and T cells
 - B and T cell receptors
 - Humoral and cell-mediated immune responses

- Primary and secondary immune modulation
 - Class switching
7. Techniques in immunology
- ELISA, flowcytometry and immunofluorescence microscopy, detection of molecules in living cells, in situ localization by techniques such as FISH and GISH.

Suggested readings:

Parasitology-

- 1) Foundations of Parasitology-Roberts and Janovy, 9th McGraw, Hill Education
- 2) General Parasitology, Cheng, 2nd edition, Academic Press Inc.
- 3) Parasitology – An Integrated Approach, Alan Gunn & Sarah J. Pitt, Wiley-Blackwell publishers
- 4) Parasitology – A Conceptual Approach, Locker & Hofkin, Garland Science
- 5) Paniker’s Textbook of Medical Parasitology, C.K. Jayaram Paniker and Sougata Ghosh, 8th edition

Immunology-

- 1) Kuby Immunology- Owen, Punt, Stanford, 7th edition WH Freeman.
- 2) Cellular and Molecular Immunology- Abbas A, Andrew H. H. Lichtman, Shiv Pillai, 9th edition, Elsevier India
- 3) Roitt's Essential Immunology-Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 13th Edition, Wiley-Blackwell

Practical

Paper – ZOO/CC/PR/205

50

1. Pedigree analysis, t-test and chi-square analysis
2. Preparation of polytene chromosome, Karyotyping
3. Demonstration of Primary and secondary lymphoid organ
4. Measuring and drawing of parasites with camera-lucida and identification
5. Identification of parasites
6. Staining and mounting of protozoan and Helminth parasites
7. Identification of histological slides of spleen, lymph node, thymus
8. Immunization Protocol
9. Behavioral studies in Animals
10. Laboratory notebook
11. Viva-voce

Animal physiology and Endocrinology

Paper – ZOO/CC/TH/301

Marks – 50 (25+25)

Unit A- Animal Physiology (25)

1. Principles of environmental physiology and homeostasis
2. Digestive system: Digestive glands, Gastro-Intestinal Hormones, Digestion and Absorption
3. Cardiovascular System and circulation:
 - Peripheral circulation, Heart, Cardiac cycle, Regulation of the Cardiovascular system, ECG
 - Composition of Blood, Other body fluids, ABO system and Rh system, Coagulation
4. Respiratory system: Functional anatomy, Pulmonary and Alveolar ventilation, Mechanism of respiration, Gas exchange in the lungs, Transport of gases in blood, Regulation of respiration
5. Sensory system: Neurons, Conduction of nerve impulse, Action potential, Synaptic transmission, Neuromuscular transmission
6. Excretory system
 - Kidney: Structural and functional anatomy
 - Nephron: Types of nephron, Structure of nephron
 - Formation of urine: glomerular filtration, tubular function, Medullary concentration gradient, excretion of H⁺ and acidification of Urine
7. Thermal physiology

Unit B- Endocrinology (25)

1. Hormones, neurohormones and pheromones
 - Classification of Hormones, Mechanism of Hormone action
2. Endocrine glands (Hypothalamus, Pituitary, Thyroid, Suprarenal, Endocrine Pancreas (The islets of Langerhans)) and their secreted hormones
3. Bone physiology: Parathormone, Calcitriol and Calcitonin
4. Male and Female Reproductive biology:
 - Hormonal regulation in gametogenesis
 - Male sex hormones and their function, Female sex hormones and their function
 - Regulation of secretion of estrogen and progesterone
 - Female reproductive cycle, Menstrual cycle
5. Staining & different types of dyes in identification of specific tissues, Mordants, metachromasia

Suggested readings-

Animal physiology-

1. CC Chatterjee's Human Physiology- C.C. Chatterjee, Nitin Ashok John, 12th edition, 2018, CBS Publishers and Distributors PVT.LTD
2. Animal Physiology: From Genes to Organisms- Sherwood, Cengage Learning, 2nd edition
3. Ganong's Review of Medical Physiology- Barrett, Barman, McGraw-Hill Education, 26th edition

6. Guyton and Hall Textbook of Medical Physiology-Hall, Saunders, 13th edition
7. Eckert Animal Physiology, Randall, W. H. Freeman,5th edition

Endocrinology

1. Endocrinology- Mac E. Hadley and Jon E. Levine, 6th edition, 2009, Pearson Education India
2. Vertebrate Endocrinology- David O. Norris and James A. Carr, 13th edition, 2013, Academic Press
3. Basic Medical Endocrinology- H. Maurice Goodman, 4th edition, 2009, Academic Press

Biodiversity, Conservation and Wildlife Biology

Paper – ZOO/CC/TH/ 302

Marks - 50

1. Utility and concept
2. Threats to biodiversity
3. Levels and measures of biodiversity. Estimating biodiversity, biodiversity indices.
4. IUCN Red List Category Version – wildlife categories of Protected Areas- National Parks, Sanctuaries, Biosphere Reserve. Biodiversity convention, criteria for measuring conservation value of areas.
5. Strategies of conservation
6. Concept of Biodiversity hotspots
7. Problem of invasive alien species
8. Wildlife and wild life habitat in India-Concept of protected area
9. Social forestry: Joint Forest management- Arabari concept.
10. Management of wildlife: Distribution, status. Habitat utilization pattern, threats to survival with reference to Indian context.
11. Climate change and its effect on wildlife and their habitat.
12. Biodiversity and ecosystem services
13. Human and wildlife conflict
14. National and international efforts of conservation- Wild life trade and legislation

Suggested readings:

1. Wildlife Ecology, Conservation, and Management - John M. Fryxell, Anthony R. E. Sinclair, et al. 3rd edition, 2014, Wiley-Blackwell
2. An Introduction to Conservation Biology - Richard B. Primack and Anna Sher, 1st edition, 2016, Sinauer Associates (an imprint of Oxford University Press)
3. Conservation of Wildlife Populations: Demography, Genetics, and Management - L. Scott Mills, 2nd edition, 2012, Wiley-Blackwell

Discipline Centric Elective Paper

ZOO/DCE/TH/303

Marks – 50

(Refer to syllabi of Discipline Centric Elective papers)

Practical

Paper – ZOO/ CC/PR/304

Marks - 50

1. T.C. and D.C.
2. Blood group Analysis
3. Identification of endocrine glands in mammalian system
4. Tissue fixation, microtomy and double staining of tissue sections
5. Identification of mammalian tissue sections
6. Biodiversity measurement and study of biodiversity
7. Identification of histological slides of spleen, lymph node, thymus
8. Pug-mark analysis
9. Excursion and field report
10. Laboratory notebook
11. Viva-voce

Developmental Biology
Paper - ZOO/CC/TH/401
Marks - 50

1. Basic concepts of development
 - Potency, commitment, specification, induction, competence
 - Determination and differentiation; morphogenetic gradients; cell fate and cell lineages
 - Genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development
2. Gametogenesis, fertilization and early development
 - Primordial germ cells and development of sex organs
 - Production of gametes, sperm-egg recognition in animals and fertilization
 - Zygote, cleavage and blastula formation
 - Embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis
3. Morphogenesis and organogenesis in animals
 - Axes and pattern formation in *Drosophila*, HOX gene and their regulation
 - Vulva formation in *Caenorhabditis elegans*
 - Organizer formation and mesoderm specification in *Xenopus*
 - Eye lens induction, limb development and regeneration in vertebrates
 - Differentiation of neurons, post embryonic development- larval formation, metamorphosis
4. Sex determination
 - Process of sex determination in *Drosophila*, *Caenorhabditis elegans* and human
 - Y chromosome in male sexual phenotype development
 - Brain sex determination pathway in vertebrates.
 - Temperature and hormonal regulation of sex determination
5. Regenerative Biology and Stem cells
 - Cellular and molecular aspects, Genomic equivalence and cytoplasmic determinants
 - Stem cell (embryonic, adult, and occurrence in the organs)
 - Self-renewal, pluripotency, characterization
 - Niche and its role in differentiation of stem cells
 - Stem cell and new organ development
6. Aging and senescence
7. Environmental control of development
 - Environmental control of gene regulation

Suggested reading:

1. Developmental Biology- Scott F. Gilbert, 12th edition, Sinauer Associates Inc
2. Principles of Development- Lewis Wolpert, et al., 6th edition, OUP Oxford
3. Essentials of Stem Cell Biology- Robert Lanza and Anthony Atala, 3rd edition, 2014, Academic press

APPLIED BIOLOGY

Paper - ZOO/CC/TH/402

Marks - 50

1. Aquaculture: Ornamental fish culture and management, mariculture, pearl culture
2. Sericulture: Types of silk moth, Disease and pests of mulberry silkworm, Biotechnology in sericulture and future of sericulture in India.
3. Apiculture- Types of honey bees, Modern methods of apiary management, Diseases and pest of honey bees, Problems and prospects of apiculture particular in Sundarban area.
4. Vermiculture: Types of earthworms used in vermiculture, Vermiculture techniques, Utility and prospects of vermiculture
5. Lac Culture: Types, rearing methods, diseases and control measures
6. Agroecology- Animals in agro-ecosystem management
7. Cell culture techniques, different types of culture media, Different types of culture
8. Genetic engineering- Application of transgenic animals, Genetically modified organisms and its impact on environment
9. Generation of Antibody, Detection of molecules using ELISA, RIA, western blot,
10. Data base and search tools: Computational tools and biological data base, National Centre for Biotechnology Information (NCBI)
11. Sequence alignment: Types of sequence alignment, Methods of sequence analysis: BLAST, FASTA)
12. Animal handling and ethics

Suggested readings-

1. Introduction to bioinformatics -Attwood, T.K. & D.J.Parry-Smith, 1999, Pearson Education Asia, New Delhi.
2. Bioinformatics computing- Bergeron, 2005, Pearson Education.
3. Principles of gene manipulation- Old & Primrose, 1994, Blackwell Scientific Publications.
4. Gene Cloning and DNA Analysis: An Introduction- T. A. Brown, 7th edition, Wiley-Blackwell

Discipline Centric Elective Paper

ZOO/DCE/TH/403

Marks - 50

Discipline Centric Elective Paper Practical

ZOO/DCE/PR/404

Marks – 50

Discipline Centric Elective Paper Practical

ZOO/DCE/PR/405

Project/ Review/ Dissertation

Cell and Molecular Biology

Discipline Centric Elective Paper– ZOO/DCE/TH/CMB/303

Marks - 50

8. Cell Membrane, Cell Organelles and trafficking

- A. Molecular Organization of membrane, functions and membrane transport
- B. Structural organization and functions of cell organelles
- C. ER translocation of polypeptides,
- D. Vesicular trafficking: ER to Golgi transport, Lysosomal biogenesis, endocytosis, exocytosis, Proteosomal degradation
- E. Nucleo-cytoplasmic protein transport; Protein transport to Mitochondria, Chloroplast and Peroxisomes

9. The Cytoskeleton and Cell Movement

- A. Structural organization of actin, myosin, intermediate filament and microtubules
- B. Cellular movement

10. The Extracellular Matrix

- A. Structural organization Extracellular Matrix
- B. Cell-Matrix Interactions

11. Organization of genes and chromosomes

- A. Structure of chromatin and chromosomes and nucleosome concept
- B. Operon concept, unique and repetitive DNA, interrupted genes, gene families, transposons

12. DNA replication and regulation

- A. Prokaryotic and eukaryotic DNA replication
- B. Role of Non-coding RNA

13. Regulation of gene expression

- A. Transcription in eukaryotes: Initiation, elongation & termination
- B. Genetic imprinting and Gene silencing

14. Translation & Post Translational events

- A. Translation in eukaryotes: Initiation, Elongation and termination
- B. Post translational modifications, Protein splicing, chaperones and protein folding.

Cell and Molecular Biology

Discipline Centric Elective Paper – ZOO/DCE/TH/CMB/403

Marks - 50

1. Cellular communication and Cell signaling

- A. Cell adhesion, integrin, gap junctions, desmosomes, plasmodesmata
- B. Role of calcium and NO in signal transduction
- C. Cell determination by morphogen gradients
- D. Signal transduction pathways and crosstalk: RTK, JAK-STAT, TGF- β , Hedgehog, Wnt and Notch etc.

2. Cellular energetics

- A. Structural and functional organization of mitochondria
- B. Mechanism of oxidative phosphorylation

Cell cycle and Cell Death mechanisms

- A. Mechanism, Regulation and control of cell cycle
- B. Apoptosis, Autophagy and Anoikis
- C. Cellular senescence

3. Stem Cell Biology

- A. Concept, types, self-renewal, pluripotency, differentiation
- B. Isolation and characterization of stem cells
- C. Application of stem cells in modern techniques

4. Cancer

- A. Oncogenes, proto-oncogenes and tumor suppressor genes
- B. Characteristics and hallmarks of cancer (angiogenesis, EMT, MET)
- C. Cancer stem cells
- D. Cancer niche and immunology
- E. Cancer-critical genes and epigenetic mechanisms
- F. Treatment strategies, Drug resistance and therapeutic challenges

5. Methods in Molecular Cell Biology

- A. Basic molecular biology techniques : DNA and RNA isolation, real-time RT-PCR,
- B. Electrophoresis and Western blotting
- C. Microscopy and imaging
- D. Immunohistochemistry, immunocytochemistry
- E. Protein purification methods
- F. Flow cytometry
- G. Cell culture techniques, transfection and infection of cells
- H. Transgenics and Knock-outs

Suggested readings:

- 1. The Cell: A Molecular Approach - Geoffrey M. Cooper and Robert E. Hausman, 7th edition, Sinauer Associates Inc
- 2. Cell and Molecular Biology: Concepts and Experiments - Gerald Karp and Nancy L Pruitt, 8th edition, 2016, John Wiley & Sons Inc
- 3. Molecular cell biology- Harvey Lodish, et al., 8th edition, 2016, WH Freeman
- 4. Molecular Biology of the Cell- Bruce Alberts et al., 6th edition, 2015, Garland Publishing Inc

Discipline Centric Elective Practical Paper I (ZOO/DCE/PR/CMB/404)

50

- 1. Chromatographic separation of protein
- 2. RNA and DNA isolation
- 3. Cloning by PCR
- 4. Gel Electrophoresis
- 5. Western blotting
- 6. Cell culture
- 7. Viva

Discipline Centric Elective Practical Paper II (ZOO/DCE/PR/CMB/405)

Marks - 50

- 1. Immunocytochemistry/ immunohistochemistry
- 2. FACS
- 3. Review/ Project preparation
- 4. Seminar presentation
- 5. Grand Viva

Genetics

Discipline Centric Elective Paper– ZOO/DCE/TH/GEN/303

Marks - 50

1. Mendelian principles of inheritance and Extensions of Mendelian principles

- A. Principles of dominance and segregation, principles of independent assortment
- B. Multiple alleles, incomplete and pseudo dominance, gene interactions, Epistasis, penetrance and expressivity
- C. Extra-chromosomal inheritance: Mitochondrial and Chloroplast genome, Maternal effect

2. Chromosome structure and function

- A. Chromatin variation, Position effect and gene silencing
- B. Mechanism of X chromosome inactivation in mammalian females and hyperactivation of X chromosome in Drosophila male
- C. Structure of telomere and centromere
- D. Special type of chromosomes: polytene and lamp brush chromosome,

3. Concept of Gene

- A. Gene, allele, pseudoallele, multiple alleles, complementation tests, Polygene and quantitative inheritance
- B. Organizational variation of genes : split gene, pseudogene, overlapping gene and multigene families
- C. Gene-character relationship, one gene one enzyme concept, one gene one polypeptide concept, other views on genic feature
- D. Gene interactions, epigenetics, gene environment interaction

4. Gene action

- A. DNA as genetic material, Structural variations of DNA, Properties of DNA, C-value paradox, Central dogma, RNA types and properties
- B. DNA markers : VNTR, STR, minisatellites & SNP, RFLP, RAPD, AFLP etc.
- C. Genetic codon and deciphering of the genetic codon, wobble hypothesis

5. Gene expression and its regulation

- A. Operon model in explaining regulation of gene expression in prokaryotes
- B. Regulation of gene expression in eukaryotes, RNA pol. And transcription factors, splicing, capping and polyadenylation of mRNA, RNA editing, post transcriptional control of gene expression.

6. Genes in development with special reference to Drosophila

- A. Gradients in early development
- B. Cell fate and signaling pathway

7. Chromosomal basis of inheritance

- A. Chromosome theory of inheritance: Sex chromosomes, sex linkage and sex influenced characters
- B. Sex determination and dosage compensation in *C. elegans*, *Drosophila* and Human

8. Gene mapping in Eukaryotes

- A. Linkage, Recombination and Crossing over,
- B. Chromosome mapping with two and three point testcross
- C. Methods of gene mapping

9. Mutation, Recombination and DNA repair

- A. Types of mutation and the molecular mechanism of development of mutation
- B. Homologous and non-homologous recombination, Transposable elements
- C. DNA repair mechanisms and Recombinant DNA technology and its application

Genetics

Discipline Centric Elective Paper– ZOO/DCE/TH/GEN/403

Marks - 50

1. Human Genetics

- A. Pedigree analysis, Karyotypes, Lod score
- B. Genetic disorders in human

2. Population genetics

- A. Gene and genotypic frequency distribution in a population according to Hardy Weinberg principle
- B. Genotypic frequency in population for multiple alleles and sex linked alleles
- C. Random mating vs assortative mating
- D. Gene frequency change in population with respect to different evolutionary forces, variation among populations: causal analysis, anagenesis vs cladogenesis
- E. Change of gene frequency and evolution, Neutral theory of mutation and evolution.

3. Neoplastic growth and carcinogenesis

- A. Meaning of neoplastic growth, malignancy and metastasis, angiogenesis, carcinogens and tumorigenesis, tumour suppressor genes, oncogenes and proto-oncogene, retroviral oncogene
- B. Relation between cell cycle and cancer formation, chromosomal aberrations and malignancy, relation between telomere length and cancer, cancer and heredity.

4. Microbial genetics

- A. Conjugation, Transformation, Transduction
- B. Gene mapping in prokaryotes

5. Genetic engineering and its basic Principles

- A. Aims and objective of genetic engineering or recombinant DNA technology, Major discoveries related to genetic engineering
- B. Basic principles, Organisms mostly used in gene manipulation, overview of the genetic system of prokaryotes and eukaryotes

- C. Basic steps of recombinant DNA technology
- D. Some products of genetic engineering

6. Molecular techniques used in recombinant DNA

- A. DNA sequencing : Sanger's method, Maxam and Gilbert's Method, Artificial synthesis of DNA, Chromosome walking
- B. In situ hybridization, site directed mutagenesis, restriction mapping
- C. Gel electrophoresis for separation of DNA, RNA and proteins, Gel retardation assay, Rnase protection assay.
- D. Transfection of cells-principle and methods
- E. Germline transformation in Drosophila and other eukaryotes, Production of transgenic animals,
- F. Gene knockout and silencing, Nuclear transplantation and animal cloning

7. Gene therapy

- A. Types of genetherapy: Somatic cell genetherapy and germline gene therapy
- B. Methods of genetherapy
- C. Success and Future need of genetherapy in India

8. Medical genetics

- A. Identification of single gene disorders-conventional and contemporary approach
- B. Positional/structural and functional cloning
- C. Bioinformatic analysis, mutation detection, multifactorial disorders, familial forms-linkage analysis, genetic polymorphism and disease susceptibility.
- D. Cytogenetics/Molecular cytogenetics/Biochemical methods of screening for mutation,
- E. Forensic testing- DNA finger printing for paternity testing and individual identification.

9. Genetic counselling

- A. Eugenics, Types eugenics- positive and negative eugenics,
- B. Screening of families for hereditary disease, case studies,
- C. Counselling of the parents, counsellor's duty, prenatal diagnosis, risk assessment and advice to the parents, Genetic load for some hereditary diseases in population, prospect of genetic counselling.

Suggested readings-

- 1. iGenetics : A Molecular Approach - Peter J. Russell, 4th edition, 1996, Addison-Wesley

2. Principles of Genetics- D. Peter Snustad and Michael J. Simmons, 7th edition, 2016, John Wiley & Sons Inc
3. Lewin's GENES XII- Jocelyn E. Krebs, Stephen T. Kilpatrick, Elliott S. Goldstein, 12th edition, 2017, Jones and Bartlett Publishers, Inc
4. Molecular Biology of the Gene- James D. Watson, et al., 7th edition, 2014, Pearson Education (US)
5. Genetics- Monroe W Strickberger, 3rd edition, 1990, McMillan
6. Introduction to Genetics: A Molecular Approach; T A Brown, 2011, Garland Science

Discipline Centric Elective Paper Practical Paper (Genetics)
(ZOO/DCE/PR/GEN/404)

50

1. Pedigree analysis for recessive and dominant disorders
2. *Drosophila* genetic cross and chi-square test
3. RNA and DNA isolation
4. Cloning by PCR
5. Gel separation of digested DNA
6. Blotting techniques
7. Counseling for single gene disorders and multi-factorial disorders
8. Analysis of Polytene chromosome
9. Viva

Discipline Centric Elective Paper Practical Paper (Genetics)
(ZOO/DCE/PR/GEN/405)

Marks - 50

1. Primer designing
2. Analysis of Biological Sequences: Basic Blast and Specialized Blast
3. Review/ Project preparation
4. Seminar presentation
5. Grand Viva

Discipline Centric Elective Paper

Parasitology and Immunology

Paper I: ZOO/DCE/TH/PI/303

Marks - 50

Unit-A: Parasitology

1. Pathobiology of parasitic protozoa

- An introduction to parasitism
- Parasitic diversity
- General consideration of Amoeba in man
- Malarial parasites of human
- Leishmaniasis – various clinical manifestations, drug resistance, host-pathogen interaction.
- Pathobiology of *Toxoplasma gondii*
- Structure and biology of *Trichomonas vaginalis*, *Trypanosoma cruzi*

2. Helminthology

- Classification of helminth
- Origin and evolution of parasitic helminth
- Life cycle, biology, pathogenesis, epidemiology and control of important human and veterinary helminthes- *Wuchereria bancrofti*, *Trichinella spiralis*, *Ascaris lumbricoides*, *Diphyllobothrium latum*, *Paragonimus westermani*
- Taeniasis, Schistosomiasis and Ancylostomiasis - causative agents, life cycles, pathogenesis and treatments

Unit-B: Immunology

1. Overview of Inflammation, Global regulator of inflammation: IL-10, IL-1 and Th17 subset. Cytokine storm, sepsis shock and inflammatory cascade
2. Hypersensitivity - Type I, Type II, Type III, Type IV with examples
3. Autoimmunity and Immunological Tolerance- General features and mechanisms, different autoimmune disease
4. APC and T-cell interaction – Modulation of T-cell function by APCs. T-cell plasticity
5. Chemokines
6. Mucosal immunity
7. Various types of Immunodeficiencies
8. Tumor Immunology
9. Various strategies of tumor cell to evade Immune system, Anti-tumor Immune response, Immunotherapy of Cancer

Discipline Centric Elective Paper

Parasitology and Immunology

Paper - ZOO/DCE/TH/PI/403

Marks - 50

Unit- A: Parasitology

1. Conceptual approach in Parasitology

- Host defense and parasite evasion.
- Ecology of parasitism.
- Evolution of parasitism
- Future challenges of parasite control
- Epidemiological surveillance tools

2. Vector biology

- Vector biology with special reference to malaria and leishmaniasis
- Structure, biology and control of sand fly, tick, Anopheles
- Zoonosis with special reference to toxoplasmosis and Japanese encephalitis
- Vector parasite interaction
- Climate change, expansion and redistribution of vectors

Unit-B: Immunology

1. Immunologic memory
2. Immunologic tolerance
3. Vaccinology
4. Transplantation Immunology- Acute, Hyperacute and chronic Graft rejection
5. Translational immunology
6. Immunotherapies - Si RNA and sh RNA: Application in immunological research, Immunotherapies to combat various diseases
7. Concept and applications of flowcytometry and FACS
8. Concept and applications of immunohistochemistry
9. Immunoprecipitation

Suggested readings-

- 1) Kuby Immunology- Owen, Punt, Stanford, 8th edition WH Freeman.
- 2) Cellular and Molecular Immunology- Abbas A, Andrew H. H. Lichtman , Shiv Pillai, 9th edition, Elsevier India
- 3) Lippincott's Illustrated Reviews Immunology -T Doan, R Melvold, S Viselli, C Waltenbaugh, 2012.
- 4) Roitt's Essential Immunology-Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt, 13th Edition, Wiley-Blackwell
- 5) Foundations of Parasitology-Roberts and Janovy, 9th McGraw, Hill Education
- 6) General Parasitology, Cheng, 2nd edition, Academic Press Inc.
- 7) Introduction to animal parasitology, J. D. Smyth , Third edition Edition
- 8) Paniker's Textbook of Medical Parasitology , C.K. Jayaram Paniker and Sougata Ghosh, 8th edition
- 9) Parasitology: Concomitant Infections- F. E. G. Cox, 2001

Discipline Centric Elective Practical Paper I

Parasitology and Immunology

ZOO/DCE/PR/PI/404

Marks -50

1. Identification of parasites
2. Staining and mounting of protozoan and Helminth parasites
3. Parasite culture, counting, infection
4. Study of gut parasites
5. Demonstration of locations of primary and secondary lymphoid organs.
6. Isolation of WBCs – from peripheral blood, spleen.
7. Lymphocyte proliferation assay
8. Isolation of peritoneal macrophages.
9. Demonstration of western blotting
10. Viva

Discipline Centric Elective Practical Paper II

Parasitology and Immunology

ZOO/DCE/PR/PI/405

Marks - 50

6. Identification of medically important vectors
7. Staining and mounting of Helminth parasites
8. ELISA
9. Assay of apoptosis
10. FACS
11. Review/ Project preparation
12. Seminar presentation
13. Grand Viva

Discipline Centric Elective Paper

Ecology and Environment

(ZOO/DCE/TH/EE/303)

Marks - 50

Ecotoxicology:

- Effect of toxins at different organizational level – individual, population, communities and ecosystems.
- Biochemistry and mechanism of action of toxicants - Route of Entry, DNA modification, stress proteins and proteotoxicity, Oxidative Stress, Enzyme Dysfunction, Heme Biosynthesis Inhibition, Oxidative Phosphorylation Inhibition, Narcosis, secondary actions, metal shift
- Detoxification - Detoxification of organic compounds - Phase I, phase II reactions, Metal Detoxification, Regulation, and Sequestration, Microbial Degradation, Bioremediation
- Toxicity testing - Classification of Toxicity Tests, LC50, LD50, Dose response curve, Thresholds and Hormesis
- Transport of Contaminants in Ecosystems - Bioconcentration, Bioaccumulation, Biomagnification, and Food Chain Transfer
- Effects and actions of Organochlorine, Organophosphorous, Carbamate, Pyrethroid and Neonicotinoid Insecticides, Organometallic Compounds, PCBs, Dioxins
- Endocrine Disruptors
- Introduction to immunotoxicology
- Introduction to genotoxicology

Ecological modelling:

- Basic concept of ecological modeling; Overview of Different Model Types;
- Theoretical model and analytical solution.
- Patterns of Spatial distribution - Random, contagious and regular, coefficient of dispersion. Index of similarity and index of association.
- Modelling Population Dynamics, Ecotoxicological Models

Molecular ecology:

- Overview of molecular genetics in ecology
- Molecular marker in ecology
- Phylogeography -molecular clocks, bifurcating trees, the coalescent
- Genetically modified organisms and its impact on environment.
- DNA finger printing and its role in wildlife conservation. Molecular marker, different types and their role in conservation ecology.
- Semiochemistry: Plant: animal interaction in the natural environment

Evolutionary and Behavioural Ecology:

- Ecological specialization and generalization
- Natural selection and social behaviour, territorial behaviour and habitat selection
- Evolution of sex and sex ratio, sexual conflict and sexual selection
- Animal signals and mating, colonizing ability, distant movement and dispersal
- Parent – offspring conflict
- Altruism and reciprocal altruism, cooperation, kin selection, eusociality, colouration and mimicry, crypsis
- Phylogenetic foundation of behavioural ecology

Discipline Centric Elective Paper

Ecology and Environment

(ZOO/DCE/TH/EE/403)

Marks - 50

Microbial ecology:

- Interactions among microbial populations
- Microbes and geo-chemical cycling
- Microbes and bioremediation
- Microbes and soil processing
- Microbes in mineral and energy recovery, fuel and biomass production

Conservation ecology:

- Conservation challenges from climate change, habitat loss and habitat Fragmentation
- Theory and analysis of conservation of population
- Conservation of habitats, landscapes
- Conservation genetics
- Invasive species

Restoration ecology:

- Definition, Philosophy and rationale for ecorestoration,
- Ecological restoration and sustainability
- Process of ecorestoration – from landscape to species level
- Strategy and implementation procedure - In Coastal Environment, In Island Environment, In mainland Environment

Ecotourism:

- Foundation of ecotourism,
- Sustainable development and ecotourism,
- Ecotourism and conservation

- Economics and management issues, merits and demerits.

Ecological economics:

- Economy and the Environment interdependence
- Ethics, economics and the environment
- The Economics of Environmental Quality – economics of pollution control
- Criteria for Evaluating Environmental Policies
- Environmental economics and climate change
- Concept of carbon trading

Human ecology:

- The human population
- Climate change – Causes, modelling future climate change, consequence of climate change, climate change and public health
- Ozone layer depletion
- Atmospheric pollution
- Carbon sequestration
- Water pollution
- Solid and hazardous waste management
- The urban environment
- Environmental Impact Assessment

Discipline Centric Elective Practical Paper I

Ecology and Environment

(ZOO/DCE/PR/EE/404)

Marks - 50

1. Dose response curve, Lethal dose estimation, LD50, MATC
2. Light, illumination and intensity, transparency, TSS, TDS, conductivity of water.
3. Estimation of temporary and permanent hardness, salinity and alkalinity of water.
4. Measurement of dissolved oxygen, chloride, phosphorus and silica in waters
5. Moisture content of the soil and stored grain samples
6. Primary productivity in an aquatic ecosystem
7. Basic principles for the estimation of heavy metals.
8. Viva

Discipline Centric Elective Practical Paper II

Ecology and Environment

(ZOO/DCE/PR/EE/405)

Marks - 50

1. BOD and COD estimation.
2. Estimation of N, P, K content of water/ soil.
3. Study of biotic community: Abundance, Relative abundance, Species diversity and Dominance indices; Shannon-Weiner diversity index and Importance Value Index
4. Life table construction and population projection
5. Air pollution monitoring: demonstration of Air sampler
6. Applicability of GPS/GIS in recording bioresources and mapping of landscape
7. Review/ Project preparation
8. Seminar presentation
9. Grand Viva

Suggested readings:

Ecotoxicology –

1. Ecotoxicology: A comprehensive treatment – Michael C Newman & William H Clements, 2008, CRC press
2. Ecotoxicology: Effects of Pollutants on the Natural Environment - Colin Walker, 2014, CRC press
3. Principles of Ecotoxicology – CH Walker et al, 4th edition, 2012, CRC press
4. Casarett and Doull's Toxicology: The Basic Science of Poisons – edited by Curtis Klaassen, 9th edition, 2018, McGraw-Hill Education

Ecological modelling –

1. Fundamentals of Ecological Modelling: Applications in Environmental Management and Research - Sven Erik Jorgensen & Brian D. Fath, 4th edition, 2011, Elsevier
2. An Introduction to Mathematical Models in Ecology and Evolution: Time and Space - Michael Gillman, 2nd edition, 2009, Wiley-Blackwell

Molecular Ecology –

1. Molecular Ecology - Joanna R. Freeland, Stephen D. Petersen, et al. 2nd edition, 2011, Wiley-Blackwell
2. An Introduction to Molecular Ecology - Graham Rowe, Michael Sweet, Trevor Beebee, 3rd edition, 2017, Oxford University Press

Evolutionary and Behavioural Ecology –

4. Evolutionary Ecology - Eric R. Pianka, 6th edition, 1999, Benjamin Cummings
5. Evolutionary Behavioral Ecology - David Westneat, Charles Fox, 1st edition, 2010, Oxford University Press
6. An Introduction to Behavioural Ecology - Nicholas B. Davies, John R. Krebs, et al. 4th edition, 2012, Wiley-Blackwell
7. Behavioural Ecology: An Evolutionary Approach – edited by John R. Krebs & Nicholas B. Davies, 4th edition, 1997, Blackwell publishing

Microbial ecology –

1. Environmental Microbiology and Microbial Ecology - Larry L. Barton, Robert J. C. McLean, 1st edition, 2019, Wiley-Blackwell
2. Environmental Microbiology - Ian L. Pepper, Charles P. Gerba, et al. 3rd edition, 2014, Academic Press
3. Microbial Ecology: Fundamentals and Applications - Ronald M. Atlas and Richard Bartha, 4th edition, 1997, Benjamin Cummings

Conservation ecology –

4. Wildlife Ecology, Conservation, and Management - John M. Fryxell, Anthony R. E. Sinclair, et al. 3rd edition, 2014, Wiley-Blackwell
5. An Introduction to Conservation Biology - Richard B. Primack and Anna Sher, 1st edition, 2016, Sinauer Associates (an imprint of Oxford University Press)

Restoration ecology –

1. Foundations of Restoration Ecology - Edited by Margaret A. Palmer, Joy B. Zedler, and Donald A. Falk, 2nd edition, 2016, Island press
2. Restoration Ecology: The New Frontier - Edited by Jelte van Andel and James Aronson, 2nd edition, 2012, Blackwell Publishing Ltd.

Ecotourism –

1. Ecotourism - David Weaver, 2nd edition, 2008, Wiley
2. Ecotourism - David A. Fennell, 4th edition, 2014, Routledge

Environmental Economics –

1. Principles of Environmental Economics - Ahmed M. Hussen, 2nd edition, 2004, Routledge
2. Environmental Economics: An Introduction - Barry C. Field & Martha K. Field, 7th edition, 2017, McGraw-Hill

Human ecology –

1. Environment – Peter H Raven et al. 9th edition, 2015, Wiley
2. Environmental Science: Towards A Sustainable Future - Richard T. Wright & Dorothy F. Boorse, 13th edition, 2017, Pearson
3. Environmental Pollution and Control - J. Jeffrey Peirce, 4th edition, 1997, Butterworth-Heinemann
4. Global Warming and Biological Diversity - Edited by Robert L. Peters and Thomas E. Lovejoy, 1994, Yale University Press
5. The Science of Environmental Pollution - Frank R. Spellman, 3rd edition, 2017, CRC press
6. Environmental and Pollution Science - Mark L. Brusseau, Ian L. Pepper, Charles Gerba, 3rd edition, 2019, Academic Press

Open Elective Papers (CBCS, For other discipline)

Vision of Zoological Studies

ZOO/TH/OE/305

Marks - 50

1) Diversity of Animals

- a) Outline of animal classification
- b) Animal migration
- c) Animal echolocation

2) Evolutionary biology

- a) Darwinian concept of evolution
- b) Natural selection
- c) Genetic basis of evolution
- d) Molecular clock and Zoo-geological timescale

3) Wildlife and Biodiversity

- a) Importance & Threats of Biodiversity
- b) Policies/acts regarding environment and wildlife protection
- c) Zoogeographical realms

4) Principles of animal development

- a) Basic principles of developmental biology
- b) Gametogenesis, fertilization and early development
- c) Concept of stem cell

5) Immunology and Medical Parasitology

- a) Basic concept of Immunology
- b) Cells and organs of immune system
- c) Common parasites - Tropical diseases and prevention

Molecular and applied biology

ZOO/TH/OE/306

Marks -50

1) Biochemistry and molecular biology

- a) Biological macromolecules
- b) Biocatalyst
- c) Central dogma

2) Applied biology

- a) Aquaculture
- b) Apiculture
- c) Sericulture
- d) Vermiculture

3) Environmental biology

- d) Environmental pollution
- e) Impact of environmental pollution in animals
- f) Climate change

4) Ecology

- g) Concept of ecosystem
- h) Concept of sustainability
- i) Animals in sustainable agroecosystem management
- j) Coastal resource management

5) Biotechnology and its application

- a) Recombinant DNA technology
- b) Genetic engineering
- c) Current Application of biotechnology