St Aloysius College (Autonomous)

Mangaluru

Re-accredited by NAAC "A++" Grade

Course structure and syllabus of

B.Sc.
ZOOLOGY

Under NEP Regulations, 2021

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Re-accredited by NAAC with '**A++**' Grade with CGPA 3.67/4 (Cycle 4)
Recognised as Centre for Research Capacity Building under UGC-STRIDE Scheme
Recognised under DBT – BUILDER Scheme, Government of India
College with "STAR STATUS" Conferred by DBT, Government of India
Recognised by UGC as "College with Potential for Excellence"

Date: 21-02-2022

NOTIFICATION

Sub: Syllabus of **B.Sc. ZOOLOGY** under NEP Regulations, 2021.
(As per Mangalore University guidelines)

Ref: 1. Decision of the Academic Council meeting held on 18-12-2021 vide Agenda No: 6
2. Decision of the Academic Council meeting held on 09-07-2022 vide Agenda No: 14
3. Decision of the Academic Council meeting held on 02-09-2023 vide Agenda No. 3
4. Office Notification dated 21-02-2022
5. Office Notification dated 17-08-2022
6. Office Notification dated 26-09-2023

Pursuant to the above, the Syllabus of **B.Sc. ZOOLOGY** under NEP Regulations, 2021 which was approved by the Academic Council at its meeting held on 18-12-2021, 09-07-2022 & 02-09-2023 is hereby notified for implementation with effect from the academic year **2021-22**.

PRINCIPAL | ST ALOYSIUS COLLEGE MANGALORE 575 003 AUTONOMOUS | **REGISTRAR**

To:

1. The Chairman/Dean/HOD.
2. The Registrar Office
3. Library

BOS meeting of the Zoology department was held on **18th November 2021**

BOARD OF STUDIES IN ZOOLOGY

1. Chairperson : Dr. Hemachandra, Associate Professor

2. Members from the department : Mr. Hariprasad Shetty, Assistant Professor.
   Ms.Karen Trescilla D'Souza, Assistant Professor.
   Mr.Kiran Vati K, Lecturer.
   Dr.Rachana B Rai, Assistant Professor.
   Mr. Glavin Thomas Rodrigues, Lecturer.

3. External Members:

Subject Experts : Dr Siby Philip
Head of Zoology, Nirmalagiri College, Kuthuparamba, Kannur, Kerala, 670701.

Dr. Shamprasad Varija Raghu
R amalingaswami Fellow/Associate Professor,
Dept of Applied Zoology, Mangalore University.

Vice-Chancellor Nominee : Dr. Nagarathna K A
Department of Zoology Mangalore University College, Mangaluru

Representative from Industry / Corporate Sector/ Allied Area
Conrad Charles I P ,
Atlantis Aquaria, # 16-7-448, Muthu's Compound, Balmatta
Mangaluru-575002

Meritorious Alumnus : Dr Sudeep Ghate Post Doc fellow ,NUCSER, Paneer ,Deralkatte.

Board of Study in Biotechnology (UG) was held on 5th July 2022.

BOARD OF STUDIES IN ZOOLOGY

1. Chairperson : Dr Hemachandra, Associate Professor
2. Members from the department: Mr. Hariprasad Shetty, Assistant Professor.
   Mr. Kiran Vati K, Assistant Professor
   Mr. Glavin Thomas Rodrigues, Assistant Professor
   Ms. Savia Dsouza, Assistant Professor
   Ms. Michelle Sonali Rodrigues, Assistant Professor

External Members :

Sl No	Name	Address
Subject Experts		
1	Dr Siby Philip	Head of Zoology, Nirmalagiri College Kuthuparamba, Kannur
2	Dr Shamprasad Varija Raghu	Ramalingaswami Fellow/Associate Professor, Dept. of Applied Zoology, Mangalore University.
Vice-Chancellor Nominee		
	Dr Nagarathna K A	Department of Zoology, Mangalore University College, Mangaluru
5.	**Representative from Industry / Corporate Sector/Allied Area**	
	Conrad Charles I P	Atlantis Aquaria, #16-7-448, Muthu's Compound Balmatta,Mangaluru-575002
6.	**Meritorious Alumnus**	
	Dr Sudeep Ghate	Scientist, centre for Bioinformatics and Biostatistics, NITTE (Deemed to be University), Paneer Deralakatte.
7.	**Student**	
	Ian Castelino	Student, St. Aloysius College.

BOS meeting of the Zoology department was held on 7th February 2023

BOARD OF STUDIES IN ZOOLOGY

1. Chairperson: Dr Hemachandra, Associate Professor

2. Members of the department:

Mr Hariprasad Shetty, Assistant Professor

Mr Kiran Vati K, Assistant Professor

Mr Glavin Thomas Rodrigues, Assistant Professor

Ms Savia D'Souza, Assistant Professor

Ms Michelle Sonali Rodrigues, Assistant Professor

Ms Sriraksha, Reg No 2121715, Student representative

3. External Members

Sl. No.	Name of the members	Nature of representation	Address
1	**Dr Siby Philip**	Subject expert	Assistant Professor Head of Zoology Nirmalagiri College, Kuthuparamba, Kannur, Kerala-670701.
2	**Dr Ishwara Prasad K S**	Subject expert	Assistant Professor Head of Zoology Vivekananada College of arts, commerce and science, Puttur, Karnataka
3	**Dr Mohammed S Mustak**	University Nominee	Professor, Department of Applied Zoology, Mangalore University, Mangalagangothri-574199, Dakshina Kannada, Mangalore
4	**Dr Vineeth Kumar K**	Meritorious aluminous	Principal Department of Zoology CFAL, Bejai- Kapikad Road Kotekani, Mangaluru-574004
5	**Mr Ronald D Souza**	Industrial Nominee	Aquatic bio systems Bondantila Village, Vamajoor, Mangaluru

I Semester

Paper	Instructions hours/ week		Duration of exam hours	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G 508 DC 1.1 (Theory) Cytology, Genetics and Infectious Diseases	4	-	2	60	40	100	2
G 508. DC 1.1P (Practical) Cytology, Genetics and Infectious Diseases	-	4	4	40	10	50	1
G 508 OE 1.1 (Open Elective) Economic Zoology	**3**	**-**	**2**	**40**	**10**	**50**	**1**

II Semester

Paper	Instructions hours/ week		Duration of exam hour	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G 508.DC 2.1 (Theory) **Biochemistry and Physiology**	4	-	2	60	40	100	2
G 508.DC2.1 P (Practical) **Biochemistry and Physiology**	-	4	4	40	10	50	1
G 508 OE 2.1E (Open Elective) Parasitology	**3**	**-**	**2**	**40**	**10**	**50**	**1**

Scheme of credit based semester system for B.Sc.
Optional subject: Zoology
III Semester

Paper	Instructions hours/week		Duration of exam hours	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G508DC2.3 (Theory) Molecular Biology, Bioinstrumentation and Techniques in Biology	4	-	2	60	40	100	2
G 508.DC 2.3P (Practical) Molecular Biology, Bioinstrumentation and Techniques in Biology	-	4	4	40	10	50	1
G508OE 2.3E (Open Elective) Endocrinology	**3**	**-**	**2**	**40**	**10**	**50**	**1**

IV Semester

Paper	Instructions hours/week		Duration of exam hour	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G508.DC2.4 (Theory) Gene Technology , Immunology and Computational Biology	4	-	2	60	40	100	2
G508.DC2.4P (Practical) Gene Technology , Immunology and Computational Biology	-	4	4	40	10	50	1
G508OE 2.4E (Open Elective) Animal Behavior	**3**	**-**	**2**	**40**	**10**	**50**	**1**

Scheme of credit based semester system for B.Sc.
Optional subject: Zoology

V Semester

Paper	Instructions hours/week		Duration of exam hours	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G 508 DC1.5 (Theory) Non-Chordates and Economic Zoology	4	-	2	60	40	100	3
G 508 DC 2.5P (Practical) Non-Chordates and Economic Zoology	-	4	4	40	10	50	2
G 508 DC 3.5 (Theory) Chordates and Comparative Anatomy	4	-	2	60	40	100	3
G 508 DC 4.5P (Practical) Chordates and Comparative Anatomy	-	4	4	40	10	50	2
G 508 Voc1.5 **(Vocational)** Aquatic Biology	**3**	**-**	**2**	**40**	**10**	**50**	**3**

VI Semester

Paper	Instructions hours/week		Duration of exam hours	Marks		Total Marks	Credits
	Theory	Practical		Exam	IA		
G 508 DC 1.6 (Theory) Evolutionary and Developmental Biology	4	-	2	60	40	100	3
G 508 DC 2.6 (Theory) Environmental Biology, Wildlife management and Conservation	4	-	2	60	40	100	3
G 508 DC 3.6P (Practical) Evolutionary and Developmental Biology	-	4	4	40	10	50	2
G 508 DC 4.6P (Practical) Environmental Biology, Wildlife management and Conservation	-	4	4	40	10	50	2
G 508 Voc 1.6 **(Vocational)** Entomology	**3**	**-**	**2**	**40**	**10**	**50**	**3**

Proposed Course content under New Education Policy Year 2021-22 for

ISemester B.Sc. Zoology

Core Course Content

Course Title/Code: **Cytology, Genetics and Infectious Diseases**

Semester I- Zoology Core Course I Content:

Content	**Hours**
Unit I	**14**

Chapter 1. Structure and Function of Cell Organelles I in Animal cell

- Cell and its components: Basic types of cells- prokaryotic andeukaryotic, nature and comparison, Cell theory.
- Plasma membrane: chemical structure (fluid mosaic model)and function
- Endomembrane system: protein targeting and sorting, transport, endocytosis andexocytosis

Chapter 2. Structure and Function of Cell Organelles II in Animal Cell

- Cytoskeleton: microtubules, microfilaments, intermediate filaments
- Mitochondria: Structure, oxidative phosphorylation; electron transport system
- Peroxisome and Ribosome: structure and function

Unit II	**14**

Chapter 3. Nucleus and Chromatin Structure

- Structure and function of nucleus in eukaryotes
- Chromatin - euchromatin and heterochromatin, nucleosomes, unit fiber, solenoid fiber, and higher order of organization, condensation and coiling. Chromosome - the structure of a typical metaphase chromosome; giant chromosomes- polytene chromosomes, lamp brush chromosomes; endomitosis.
- Structure of DNA & RNA – Forms of DNA, Types of RNA. Watson and Crickmodel of DNA

Chapter 4. Cell cycle, Cell Division and Cell Signaling

- Cell division: mitosis and meiosis
- Introduction to Cell cycle and its regulation, apoptosis
- Signal transduction: intracellular 11 signaling and cell surface receptors, via G-proteinlinked receptors
- Cell-cell interaction: cell adhesion molecules, cellular junctions

Unit III **14**

Chapter 5. Mendelism and Sex Determination

- Basic principles of heredity: Mendel's laws- monohybrid cross and hybrid cross
- Complete and Incomplete Dominance
- Penetrance and expressivity
- Genetic Sex-Determining Systems, Environmental Sex Determination, Sex Determinationand mechanism in *Drosophila melanogaster.*
- Sex-linked characteristics in humans and dosage compensation

Chapter 6. Extensions of Mendelism, Genes and Environment

- Extensions of Mendelism: Multiple Alleles, Gene Interaction.
- The Interaction Between Sex and Heredity: Sex-Influenced and Sex-LimitedCharacteristics
- Cytoplasmic Inheritance, Genetic Maternal Effects.
- Interaction between Genes and Environment: Environmental Effects on Gene Expression,Inheritance of Continuous Characteristics.

Unit IV **14**

Chapter 7. Human Chromosomes and Patterns of Inheritance

- Patterns of inheritance: autosomal dominance, autosomal recessive, X-linked recessive,X-linked dominant.
- Chromosomal anomalies: Structural and numerical aberrations with examples.
- Human karyotyping and Pedigree analysis.

Chapter 8. Infectious Diseases

- Introduction to pathogenic organisms: viruses, bacteria, fungi, protozoa and worms.
- Structure, life cycle, pathogenicity, including diseases, causes, symptoms and control ofcommon parasites: *Trypanosoma ,Giardia and Wuchereria.*

Suggested Readings :

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA(2004).
2. Alberts et al: Molecular Biology of the Cell: Garland(2002).
3. Cooper: Cell: A Molecular Approach: ASM Press(2000).
4. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman(2004).
5. Lewin B. Genes VIII. Pearson (2004).
6. Watson et al. Molecular Biology of the Gene. Pearson(2004).
7. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby- Kuby Immunology. W H Freeman(2007).
8. Delves Peter J., Martin Seamus J., Burton Dennis R., Roitt Ivan M. Roitt's Essential Immunology, 13thEdition. Wiley Blackwell(2017).
9. Principles of Genetics by B. D. Singh
10. Cell-Biology by C. B. Pawar, Kalyani Publications
11. Economic Zoology by Shukla and Upadhyaya

Zoology Core Lab Course Content

Course Title: Cell Biology & Cytogenetics Lab

Lab Course Content

List of labs to be conducted **56 hrs.**

1. Understanding of simple and compound microscopes.
2. To study different cell types such as buccal epithelial cells, neurons, striated musclecells using 3. Methylene blue/any suitable stain (virtual/ slaughtered tissue).
3. Micrometry: Measurement of cell dimension using micrometry.
4. To study the different stages of Mitosis in root tip of *Allium cepa*.
5. To study the different stages of Meiosis in grasshopper testis (virtual).
6. To check the permeability of cells using salt solution of different concentrations.
7. Study of parasites in humans (e.g. Protozoans, Helminthes in compliance with examples being studied in theory) permanent microslides.
8. To learn the procedures of preparation of temporary and permanent stained slides,with available mounting material.
9. Study of mutant phenotypes of *Drosophila* sp. (from Cultures or Photographs).
10. Preparation of temporary stained mount to show the presence of Barr body in humanfemale blood cells/ cheek cells.
11. Preparation of polytene chromosomes (Chironomus larva or Drosophila larva).
12. Preparation of human karyotype and study the chromosomal structural and numerical aberrations from the pictures provided. (Virtual/optional).
13. To prepare family pedigrees.
14. https://www.vlab.co.in
15. https://zoologysan.blogspot.com
16. www.vlab.iitb.ac.in/vlab
17. www.onlinelabs.in
18. www.powershow.com
19. https://vlab.amrita.eduhttps://sites.dartmouth.edu/

Suggested Readings:

1. Lodish et al: Molecular Cell Biology: Freeman & Co, USA(2004).
2. Alberts et al: Molecular Biology of the Cell: Garland(2002).
3. Cooper: Cell: A Molecular Approach: ASM Press(2000).
4. Karp: Cell and Molecular Biology: Wiley (2002). Pierce B. Genetics. Freeman(2004).
5. Thomas J. Kindt, Richard A. Goldsby, Barbara A. Osborne, Janis Kuby-Kuby Immunology. W HFreeman(2007).
6. Kesar, Saroj and Vasishta N.2007 Experimental Physiology: Comprehensive Manual. Heritage Publishers,NewDelhi.

Open Elective Course Content

Course Title: Economic Zoology

Course Content

Content	Hrs
Unit I	**14**

Chapter 1. Sericulture:

- History and present status of sericulture in India
- Mulberry and non-mulberry species in Karnataka and India
- Mulberry cultivation
- Morphology and life cycle of *Bombyx mori*
- Silkworm rearing techniques: Processing of cocoon, reeling
- Silkworm diseases and pest control

Chapter 2. Apiculture:

- Introduction and present status of apiculture
- Species of honey bees in India, life cycle of *Apis indica*
- Colony organization, division of labor and communication
- Bee keeping as an agro based industry; methods and equipment's: indigenous methods,extraction appliances, extraction of honey from the comb and processing
- Bee pasturage, honey and bees wax and their uses
- Pests and diseases of bees and their management

Unit II	**14**

Chapter 3. Live Stock Management:

- **Dairy:** Introduction to common dairy animals and techniques of dairy management
- Types, loose housing system and conventional barn system; advantages and limitationsof dairy farming
- Establishment of dairy farm and choosing suitable dairy animals-cattle
- Cattle feeds, milk and milk products
- Cattle diseases
- **Poultry:** Types of breeds and their rearing methods
- Feed formulations for chicks
- Nutritive value of egg and meat
- Disease of poultry and control measures

Chapter 4. Aquaculture:

- Aquaculture in India: An overview and present status and scope of aquaculture
- Types of aquaculture: Pond culture: Construction, maintenance and management; carpculture, shrimp culture, shellfish culture, composite fish culture and pearl culture

Unit – 3 **14**

Chapter 5. Fish culture:

- Common fishes used for culture.
- Fishing crafts and gears.
- Ornamental fish culture: Fresh water ornamental fishes- biology, breeding techniques
- Construction and maintenance of aquarium: Construction of home aquarium, materials used, setting up of freshwater aquaria, aquarium plants, ornamental objects, cleaning the aquarium, maintenance of water quality. control of snail and algal growth.
- Modern techniques of fish seed production

Chapter 6. Prawn culture:

- Culture of fresh and marine water prawns.
- Preparation of farm.
- Preservation and processing of prawn, export of prawn.

Chapter 7. Vermiculture:

- Scope of vermiculture.
- Types of earthworms.
- Habit categories - epigeic, endogeic and anecic; indigenous and exotic species.
- Methodology of vermicomposting: containers for culturing, raw materials required, preparation of bed, environmental pre-requisites, feeding, harvesting andstorage of vermicompost.
- Advantages of vermicomposting.
- Diseases and pests of earthworms.

Chapter 8. Lac Culture:

- History of lac and its organization, lac production in India.
- Life cycle, host plants and strains of lac insect.
- Lac cultivation: Local practice, improved practice, propagation of lac insect, inoculationperiod, harvesting of lac.
- Lac composition, processing, products, uses and their pests.

Text Books

Suggested Readings:

1. Eikichi, H. (1999). Silkworm Breeding (Translated from Japanese). Oxford & IBH Publishing Co.Pvt. Ltd., New Delhi.
2. Ganga, G. (2003). Comprehensive Sericulture Vol-II: Silkworm Rearing and Silk Reeling.
3. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Mahadevappa, D., Halliyal, V.G., Shankar, D.G. and Bhandiwad, R., (2000). Mulberry Silk
5. Reeling Technology Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Roger, M (1990). The ABC and Xyz of Bee Culture: An Encyclopedia of Beekeeping, KindleEdition.
7. Shukla and Upadhyaya (2002). Economic Zoology, Rastogi Publishers
8. YadavManju (2003). Economic Zoology, Discovery Publishing House.
9. JabdePradip V (2005). Textbook of applied Zoology, Discovery Publishing House, New Delhi.
10. Cherian &Ramachandran Bee keeping in-South Indian Govt. Press, Madras.
11. Sathe, T.V. Vermiculture and Organic farming.
12. Bard. J (1986). Handbook of Tropical Aquaculture.
13. Santhanam, R. A. Manual of Aquaculture.
14. Zuka. R.1 and Hamiyn (1971). Aquarium fishes and plants
15. Jabde, P.V. (2005) Text Book of Applied Zoology: Vermiculture, Apiculture, Sericulture, Lacculture.
16. Animal Disease- Bairagi K. N. Anmol Publications Pvt.Ltd 2014
17. Economics Of Aquaculture - Singh(R.K.P) - Danika Publishing Company 2003
18. Applied and Economic Zoology (SWAYAM) web https://swayam.gov.in/nd2_cec20_ge23/preview

Proposed Course content under New Education Policy – Year 2021-22
For II Semester BSc Zoology Core Course Content

Course Title: Biochemistry and Physiology

Core Course content:

Content	Hrs
Unit I	**14**

Chapter 1. Structure and Function of Biomolecules:

- Structure and Biological importance of carbohydrates (Monosaccharides,Disaccharides, Polysaccharides and Glycoconjugates).
- Lipids (saturated and unsaturated Fatty acids, Tri-acylglycerols, Phospho lipids,Glycolipids and Steroids)
- Structure, Classification and General Properties of a-amino acids; Essential andnon-essential amino acids, Levels of organization in proteins; Simple and conjugate proteins.

Chapter 2. Enzyme Action and Regulation

- Nomenclature and classification of enzymes; Cofactors; Specificity of enzyme action.
- Isozymes; Mechanism of enzyme action
- Enzyme kinetics; Factors affecting rate of enzyme-catalyzed reactions ; Equation of Michaela‘s -Mendon, Concept of Km and V max, Enzymeinhibition
- Allosteric enzymes and their kinetics; Regulation of enzyme action.

Unit 2	**14**

Chapter 3. Metabolism of Carbohydrates and Lipids

- Metabolism of Carbohydrates: glycolysis, citric acid cycle, gluconeogenesis,phosphate pentose pathway Glycogenolysis andGlycogenesis Lipids- Biosynthesis of palmitic acid; Ketogenesis,
- β-oxidation and omega -oxidation of saturated fatty acids with even and oddnumber of carbon atoms

Chapter 4. Metabolism of Proteins and Nucleotides

- Catabolism of amino acids: Transamination, Deamination, Ureacycle, Nucleotides and vitamins
- Peptide linkages

Unit 3 **14**

Chapter 5. Digestion and Respiration in humans

- Structural organization and functions of gastrointestinal tract and associatedglands.
- Mechanical and chemical digestion of food; Absorptions of carbohydrates, lipids, proteins, water, minerals and vitamins; Metabolic disorders - obesity, Kwashiorkor, Marasmus.
- Physiology of trachea and Lung.
- Mechanism of respiration, Pulmonary ventilation; Respiratory volumes andcapacities; Transport of oxygen and carbon dioxide in blood, Respiratory pigments, Dissociation curves and the factors influencing it;
- Control of respiration. Respiratory disorders- asthma, pneumonia, occupation relatedlung diseases

Chapter 6. Circulation and Excretion in humans

- Components of blood and their functions; hemopoiesis
- Blood clotting: Blood clotting system, Blood groups: Rh-factor, ABO and MN
- Structure of mammalian heart
- Cardiac cycle; Cardiac output and its regulation, Electrocardiogram, Bloodpressure andits regulation. Circulatory disorders-Anaemia, atherosclerosis, myocardial infarction.
- ure of kidney and its functional unit; Mechanism of urine formation. Excretory disorders-Renal calculi, uremia, gout, nephritis, renal failure-acute and chronic.

Unit IV 14

Chapter 7. Nervous System and Endocrinology in humans

- Structure of neuron, resting membrane potential (RMP)
- n of action potential and its propagation across the myelinated andunmyelinated nervefibers. Types of synapses. Neuro disorders- Parkinson's and Alzheimer's diseases.
- Endocrine glands - pineal, pituitary, thyroid, parathyroid, pancreas and adrenal;hormones secreted by them.
- ification of hormones; Mechanism of Hormone action. Hypo and hypersecretion ofhormones and its effects

Chapter 8. Muscular System in humans

- Histology of different types of muscle; Ultra structure of skeletal muscle; Molecular and chemical basis of muscle contraction; Characteristics of muscletwitch; Motor unit, summation and tetanus

Suggested Readings:

1. Nelson & Cox: Leininger's Principles of Biochemistry: McMillan (2000)
2. Zubay et al: Principles of Biochemistry: WCB (1995)
3. Voet&Voet: Biochemistry Vols l & 2: Wiley (2004)
4. Murray et al: Harper's Illustrated Biochemistry: McGraw Hill (2003) Elliott and Elliott:Biochemistry and Molecular Biology: Oxford University Press
5. Guyton, A.C. & Hall, J.E. Textbook of Medical Physiology, Xl Edition, Hercourt Asia PTELtd. /W.B.Saunders Company. (2006).
6. Tortora, G.J. &Grabowski, S. Principles of Anatomy & Physiology. XI Edition John Wiley& sons (2006).
7. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rd Edition,Pearson Education (2016).
8. Hill, Richard W., et al. Anima l physiology. Vol. 2. Sunderland, MA: Sinauer Associates,(2004).
9. Chatterjee CC Human Physiology Volume l & 2, 11th edition, CBS Publishers (20 I 6).

Zoology Semester II Core Course Lab Content

Course Title/Code: **Biochemistry and Physiology**

Course Content

List of labs to be conducted	Hours
1. Preparation of models of nitrogenous bases- nucleosides and nucleotides.	20
2. Preparation of models of amino acids and dipeptides.	
3. Preparation of models of DNA and RNA.	15
4. Qualitative analysis of Carbohydrates, Proteins and Lipids.	
5. Qualitative analysis of Nitrogenous wastes – Ammonia, Urea and Uric acid.	
6. Separation of amino acids or proteins by paper chromatography.	15
7. Determination of the activity of enzyme (Urease)-Effect of [S] and determination ofKm and Vmax.	
8. Determination of the activity of enzyme (Urease) - Effect of temperature and time.	
9. Action of salivary amylase under optimum conditions.	
10. Quantitative estimation of Oxygen consumption by fresh water Crab.	
11. Quantitative estimation of salt gain and salt loss by fresh water.	
12. Estimation of Hemoglobin in human blood using Sahli's haemoglobinometer.	
13. Counting of RBC in blood using Hemocytometer.	
14. Counting of WBC in blood using Hemocytometer.	
15. Differential staining of human blood corpuscles using Leishman stain.	
16. Recording of blood glucose level by using glucometer.	
Virtual Labs (Suggestive sites) https://www.vlab.co.in https://zoologysan.blogspot.com www.vlab.iitb.ac.in/vlab www.onlinelabs.inwww.powershow.com https://vlab.amrita.edu https://sites.dartmouth.edu	06

Text Books

1. Nelson & Cox: Leininger‘s Principles of Biochemistry: McMillan (2000)
2. Zubay et al: Principles of Biochemistry: WCB (1995)
3. Voet&Voet: Biochemistry Vols l & 2: Wiley (2004)
4. Murray et al: Harper‘s Illustrated Biochemistry: McGraw Hill (2003) Elliott andElliott: Biochemistry and Molecular Biology: Oxford University Press
5. Guyton, A.C. & Hall, J.E. Textbook of Medical Physiology, Xl Edition, Hercourt Asia PTE Ltd. /W.B.Saunders Company. (2006).
6. Tortora, G.J. &Grabowski, S. Principles of Anatomy & Physiology. XI Edition JohnWiley & sons (2006).
7. Christopher D. Moyes, Patricia M. Schulte. Principles of Animal Physiology. 3rdEdition, Pearson Education (2016).
8. Hill, Richard W., et al. Anima l physiology. Vol. 2. Sunderland, MA: SinauerAssociates, (2004).
9. Chatterjee CC Human Physiology Volume l & 2, 11th edition, CBS Publishers (20 I6).

Web References:

- Mammalian Physiology– www.biopac.com

Pedagogy: Lectures, Presentations, videos, Virtual Labs, Assignments, Tests, Individual or group Field oriented Project Report on or visit to a research institute.

TOPICS RECOMMENDED FOR SEMINAR/PROJECT REPORT

1. Biochemical pathways, their evolutionary background and regulation.
2. Blood groups and their importance.
3. Vital enzymes for human body.
4. Essential and nonessential amino acids.
5. Important body lipids.
6. Significance of animal proteins.
7. Role of carbohydrates in animal body.
8. Nature of proteins and nurture of animal body.
9. Role of lipids in structural and functional organization of body.

Open Elective Course Content

Semester**: II Zoology**

Course Title: **Parasitology**

Course Content

Content **42Hrs**

Unit –1

Chapter 1. General Concepts **14**

- Introduction, Parasites, parasitoids, host, zoonosis
- Origin and evolution of parasites
- Basic concept of Parasitism, symbiosis, phoresis, commensalisms and mutualism
- Host-parasite interactions and adaptations
- Life cycle of human parasites
- Occurance, mode of infection and prophylaxis

Chapter 2. Parasitic Platyhelminthes

- Study of morphology, life cycle, pathogenicity, prophylaxis and control measures of
- *Fasciolopsis buski*
- *Schistosoma haematobium*
- *Taenia solium*
- *Hymenolepis nana*

Chapter 3. Parasitic Protists

- Study of morphology, life cycle, pathogenicity, prophylaxis and control *measures* of
- *Entamoeba histolytica*
- *Giardia intestinalis*
- *Trypanosoma gambiense*
- *Plasmodium vivax*

Unit – 2 **14**

Chapter 4. Parasitic Nematodes

- Study of morphology, life cycle, pathogenicity, prophylaxis and control measures of
    - *Ascaris lumbricoides*
    - *Ancylostoma duodenale*
    - *Wuchereria bancrofti*
    - *Trichinella spiralis*
- Nematode plant interaction ; Gall formation

Chapter 5. Parasitic Arthropods

- Biology, importance and control of
    - Ticks (Soft tick *Ornithodoros*, Hard tick *Ixodes*)
    - Mites (*Sarcoptes*)
    - Lice (*Pediculus*)
    - Flea (*Xenopsylla*)Bug (*Cimex*)
- Parasitoid

  (Beetles)

Chapter 6. Parasitic Vertebrates

- Cookicutter Shark
- Hood Mocking bird and

Vampire bat and their parasitic behavior and effect on host

Unit – 3 **14**

Chapter 7.Molecular diagnosis & clinical parasitology

- General concept of molecular diagnosis for parasitic infection
- Advantages and disadvantages of molecular diagnosis
- Fundamental techniques used in molecular diagnosis of endoparasites
- Immunoassay or serological techniques for laboratory diagnosis of endoparasites on the basis of marker molecules like G.intestinalis, B. coli, E. histolytica, L. donovani, Malarial parasite using
    - ELISA, RIA
    - Counter Current Immunoelectrophoresis (CCI)
    - Complement Fixation Test (CFT) PCR, DNA, RNA probe

Suggested Readings:

1. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications andDistributors.
2. E.R. Noble and G.A. Noble (1982) Parasitology: The biology of animal parasites. V Edition, Lea&Febiger.
3. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor and FrancisGroup.
4. Parija, S. C. Textbook of medical parasitology, protozoology & helminthology (Text and colour Atlas), II Edition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi.
5. Meyer, Olsen & Schmidt's Essentials of Parasitology, Murray, D. Dailey, W.C. Brown Publishers.
6. K. D. Chatterjee (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBSPublishers & Distributors (P) Ltd.
7. Gunn, A. and Pitt, S.J. (2012). Parasitology: an Integrated Approach. Wiley Blackwell.
8. Noble, E. R. and G.A.Noble (1982) Parasitology: The biology of animal parasites. V th Edition, Lea&Febiger.
9. Paniker, C.K.J., Ghosh, S. [Ed} (2013). Paniker‘s Text Book of Medical Parasitology. Jaypee, NewDelhi.
10. Parija,S.C.Textbookofmedicalparasitology,protozoology&helminthology(Textand color Atlas),IIEdition, All India Publishers & Distributers, Medical Books Publishers, Chennai, Delhi.
11. Roberts, L.S and Janovy, J. (2009). Smith & Robert‘s Foundation of Parasitology. 8th. Edn. McGrawHill.
12. Bogitsh, B. J. and Cheng, T. C. (2000). Human Parasitology. 2nd Ed. Academic Press, New York.
13. Chandler, A. C. and Read. C. P. (1961). Introduction to Parasitology, 10th ed. John Wiley andSonsInc.
14. Cheng, T. C. (1986). General Parasitology. 2nd ed. Academic Press, Inc. Orlando.U.S.A.
15. Schmidt, G. D. and Roberts, L. S. (2001). Foundation of Parasitology. 3rd ed. McGraw HillPublishers.
16. Schmidt, G. D. (1989). Essentials of Parasitology. Wm. C. Brown Publishers (Indian print1990,Universal Book Stall).
17. John Hyde (1996) Molecular Parasitology Open University Press.
18. J Joseph Marr and Miklos Muller (1995) Biochemistry and Molecular Biology of Parasites 2 ndEdnAcademic Press.

Core Course Content

Course Title/Code: Molecular Biology, Bioinstrumentation and Techniques in Biology

Semester III - Zoology Core Course III Content:

Content	Hours
Unit I	**14**
Chapter 1: Process of Transcription	**07**
• Fine structure of gene • RNA polymerases • Transcription factors and machinery • Formation of initiation complex • Initiation, elongation and termination of transcription in prokaryotes and eukaryotes	
Chapter 2: Process of Translation	**07**
• The genetic code • Ribosome • Factors involved in translation • Aminoacylation of tRNA, tRNA-identity, aminoacyl tRNA synthetase • Initiation, elongation and termination of translation in prokaryotes and eukaryotes	
Unit II	**14**
Chapter 3: Regulation of Gene Expression I	**07**
• Regulation of gene expression in prokaryotes: Lac and trp operons in *E. coli* • Regulation of gene expression in eukaryotes: Role of chromatin in gene expression • Regulation at transcriptional level, Post-transcriptional modifications: Capping, splicing, polyadenylation • RNA editing	
Chapter 4: Regulation of Gene Expression II	**07**
• Regulation of gene expression in eukaryotes • Regulation at translational level, Post-translational modifications: protein folding etc. • Intracellular protein degradation • Gene silencing, RNA interference (RNAi)	

Unit III **14**

Chapter 5: Principle and Types of Microscope **06**

- Principle of microscopy and applications
- Types of microscopes: light microscopy, dark field microscopy, phase-contrast microscopy.
- Fluorescence microscopy, confocal microscopy, electron microscopy

Chapter 6: Centrifugation and Chromatography

- Principle of centrifugation
- Types of Centrifuges: high speed and ultracentrifuge **08**
- Types of rotors: Vertical, swing-out, fixed-angle etc.
- Principle and Types of Chromatography: paper, thin layer, column-lon-exchange, gel filtration, GLC, HPLC, affinity chromatography

Unit IV **14**

Chapter 7: Spectrophotometry and Biochemical Techniques **06**

- Colorimetry and spectrophotometry: Beer-Lambert law, absorption spectrum
- Biochemical techniques: Measurement of pH,
- Preparation of buffers and solutions
- Measurement, applications and safety measures of radio-tracer techniques

Chapter 8: Molecular Techniques **08**

- Nucleic acid fractionation, detection by electrophoresis, Polymerase Chain Reaction (PCR), primer designing, site directed Mutagenesis, DNA sequencing.
- Molecular cloning, genomic libraries.
- Detection of proteins, PAGE, ELISA, Western blotting.

Suggested Readings:

- Lodish et al: Molecular Cell Biology: Freeman & Co, USA (2004).
- Alberts et al: Molecular Biology of the Cell: Garland (200Z).
- Cooper: Cell: A Molecular Approach: ASM Press (2000).
- Karp: Cell and Molecular Biology: Wiley (2002).
- Watson et at. Molecular Biology of the Gene. Pearson (2004).
- Lewin. Genes VIII. Pearson (2004).
- Pierce B. Genetics. Freeman (2004),
- B. Sambrook et al. Molecular Cloning Vols. I, II, III. CSH L T 2

Zoology Core Lab Course Content

Course Title: Molecular Biology, Bioinstrumentation and Techniques in Biology

Lab Course Content

List of labs to be conducted **56 hrs.**

1. To study the working principle of simple, compound and binocular microscopes.
2. To study the working principle of various lab equipments such as pH meter, electronic balance, vortex mixer, use of glass and micropipettes, laminar air flow, incubators, shaker, water bath, centrifuge, chromatography apparatus, etc.
3. To prepare solutions and buffers.
4. To learn the working of colorimeter and spectrophotometer.
5. Demonstration of differential centrifugation.
6. To prepare dilutions and verify the principle of spectrophotometry.
7. To identify different amino acids in a mixture using paper chromatography.
8. Demonstration of DNA extraction from blood or tissue samples.
9. To estimate amount of DNA using spectrophotometer.
10. **Virtual Labs**

    IIT Bombay Virtual Labs
    www.labinapp.com
    www.uwlax.edu
    www.labster.com
    www.onlinelabs.in
    www.powershow.in
    https://vlab.amrita.edu/?sub=3&brch=77

Suggested Readings:

1. Primrose & Twyman Principles of Genome Analysis and Genomics. Blackwell (2003).
2. Hartl & Jones. Genetics: Principles & Analysis of Genes & Genomes. Jones & Scartlett (1998).
3. Sambrook et al. Molecular Cloning Vols. I, II, III. CSHL (2001).
4. Primrose. Molecular Biotechnology. Panima (2001).
5. Clark & Swifter. Experimental Biochemistry. Freeman (2000)
6. Sudbery. Human Molecular Genetics. Prentice-Hall (2002).
7. Wilson. Clinical Genetics-A Short Course, Wiley (2000).
8. Pasternak. An Introduction to Molecular Human Genetics. Fritzgerald (2000).
9. Biostatistical Analysis (Fourth Edition) by Jerrold H. Zarr, Pearson Education Inc. Delhi.
10. Statistical Methods (Eighth Edition) by G.W. Snecdecor and W.G. Cochran, Willey Blackwell IG. Biostatistics (Tenth Edition) by W.W. Daniel and C.L. Cross, Wiley
11. Introductory Biological Statistics (Fourth Edition) by John E. Havel.

Open Elective Course Content

Course Title: Endocrinology

Course Content

Content	Hrs
Unit I	**08**
Chapter 1: Introduction to Endocrinology • History of endocrinology • Classification, characteristic and transport of hormones • Neurosecretions and neurohormones	
Unit II	**33**
Chapter 2: Epiphysis, Hypothalamohypophysial Axis • Structure of pineal gland, secretions and their functions in biological rhythms and reproduction. • Structure of hypothalamus, hypothalamic nuclei and their functions, • Regulation of neuroendocrine glands, feedback mechanisms • Structure of pituitary gland • Hormones and their functions, hypothalamohyposial portal system, • Disorders of pituitary gland **Chapter 3: Peripheral Endocrine Glands** • Structure, hormones, functions and regulation of thyroid gland, parathyroid, adrenal, pancreas, ovary and testis hormones in homeostasis • Disorders of endocrine glands	**18** **15**
Unit III	**15**
Chapter 4: Regulation of Hormone Action • Hormone action at cellular level: Hormone receptors, transduction and regulation • Hormone action at molecular level: Molecular mediators • Genetic control of hormone action	
Suggested Readings: **Text Books** 1. Zubay et al: Principles of Biochemistry: WCB (1995) 2. Nelson & Cox: Leininger's Principles of Biochemistry: McMillan (2000) 3. Voet & Voet: Biochemistry Vols. 1 & 2: Wiley (2004) 4. Murray et al: Harper's Illustrated Biochemistry: McGraw Hill (2003) 5. Elliott and Elliott: Biochemistry and Molecular Biology: Oxford University Press **6.** Chatterjee C C Human Physiology Volume l & 2, 11th edition, CBS Publishers (20I6).	

Proposed Course content under New Education Policy–Year 2022-23

For IV Semester B.Sc. Zoology Core Course Content

Course Title: Gene Technology, Immunology and Computational Biology

Core Course content:

Content	Hours
Unit I	**14**
Chapter 1: Principles of Gene Manipulation	**07**
• Recombinant DNA technology • Restriction enzymes, DNA modifying enzymes, cloning vectors, ligation • Gene transfer techniques, gene therapy • Selection and identification of recombinant cells • CRISPR- Cas	
Chapter 2: Applications of Genetic Engineering	**07**
• Single cell proteins • Biosensors, Biochips • Crop and livestock improvement, development of transgenes • Development of DNA drugs and vaccines	
Unit II	**14**
Chapter 3: Enzyme Technology	**07**
• Microbial culture • Methods of enzyme production • Immobilization of enzymes • Applications of antibiotics	
Chapter 4 : DNA Diagnostics	**07**
• Genetic analysis of human diseases, detection of known and unknown mutations • DNA fingerprinting • Concept of pharmacogenomics and pharmacogenetics • Personalized medicine optimizing drug therapy	
Unit III	**14**
Chapter 5: Biostatictics	**06**
• Calculations of mean, median, mode, variance, standard deviation • Concepts of coefficient of variation, Skewness, Kurtosis	

- Elementary idea of probability and application
- Data summarizing: frequency distribution, graphical presentation—bar, pie diagram, histogram
- Tests of significance: one and two sample tests, t-test and Chi-square test

Chapter 6: Basics of Computers **2**

- Basics (CPU, GPU, RAM, threads, parallel computing), operating systems (Windows, Linux) and languages (R and python)
- Work stations, servers and networking

Chapter 7: Bioinformatics **6**

- Databases and search engines: nucleicacids, genomes, protein sequences and structures.
- Sequence analysis (homology): pairwise and multiple sequence alignments - BLAST, CLUSTAL W
- Tools for phylogenetic analysis

Unit IV **14**

Chapter 8. Immunology

Immune system

- Immunity: innate and acquired immunity, passive and active immunity.
- Organs of immune system - Primary lymphoid organs (thymus, bone marrow, Bursa of fabricius). Secondary lymphoid organs (spleen, lymph nodes, Peyers patches).
- Cells of immune system (B cells, T cells, natural killer cells, macrophages). Antigens and antigenecity.
- Immunoglobulins - structure of IgG, functions of immunoglobulins. Immunological memory.
- Antibody diversity.
- Major histocompatibility complex
- Complement system

Immunodeficiency diseases

- AIDS - causative agent, mode of transmission, effects and preventive measures
- Vaccines- bacterial- viral- toxoid- III generation vaccines
- Autoimmunity

Suggested Readings:

1. N. Primrose & Twyman. Principles of Genome Analysis and Genomics. Blackwell (2003).
2. Hartl & Jones. Genetics: principles & Analsysis of Genes & Genomes. Jones & Bartlett (1998).
3. Sarnbrook et al Molecular Cloning vols. I, II, III. CSHL (2001).
4. Primrose. Molecular Biotechnology. Panima (2001)
5. N. Gurumani (2004) An introduction to Biostatistics, MJP publishers, Chennai
6. Ivan M. Roin - Essential Immunology, Low Price Edn. VI.ELBS Publisher, 1988.
7. K.R. Joshi, N.O. Osama - immunology, 4th Edition, Agro Botanica IV E 176, J.N.Vyas Nagar, Bikaner, 1998
8. Nandini Shetty - Immunology - Introductory T.B. - Wiley Estern Ltd., New Delhi, 1993

Zoology Semester IV Core Course Lab Content

Course Title/Code: Gene Technology, Immunology and Computational Biology

Course Content

List of labs to be conducted	Hours
	56
• Measure the pre and post clitellar lengths of earthworms and calculate mean, median, mode, standard deviation etc. • Measure the height and weight of all students in the class and apply statistical measures.	08
• To perform bacterial culture and calculate generation time of bacteria. • To study restriction enzyme digestion using teaching kits. • To study Polymerase Chain Reaction (PCR) using teaching kits. • Demonstration of agarose gel electrophoresis for detection of DNA. • Demonstration of polyacrylamide gel electrophoresis (PAGE) for detection of proteins. • To calculate molecular weight of unknown DNA and protein fragments from gel pictures	16
• To learn the basics of computer applications • To learn sequence analysis using BLAST • To learn Multiple sequence alignment using CLUSTALW	16

- To learn about Phylogenetic analysis using any suitable program.
- Identification of cells and organs of immune system

Virtual Labs **16**

1. To learn how to perform Primer designing for PCR
2. Gel documentation system
3. PCR – www.youtube.com
4. DNA isolation
5. Spectrophotometer

Suggestive sites

https://vlab.amrita.edu/?sub=3&brch=77

Suggested Readings:

1. N Primrose & Twyman. Principles of Genome Analysis and Genomics. Blackwell (2003).
2. Hartl & Jones. Genetics: principles & Analsysis of Genes & Genomes. Jones & Bartlett (1998).
3. Sarnbrook et al Molecular Cloning vols. I, II, III. CSHL (2001).
4. Primrose. Molecular Biotechnology. Panima (2001)
5. N. Gurumani (2004) An introduction to Biostatistics, MJP publishers, Chennai
6. Ivan M. Roin - Essential Immunology, Low Price Edn. VI.ELBS Publisher, 1988.
7. K.R. Joshi, N.O. Osama - immunology, 4th Edition, Agro Botanica IV E 176,
   J.N. Vyas Nagar, Bikaner, 1998
8. Nandini Shetty - Immunology - Introductory T.B. - Wiley Estern Ltd., New Delhi, 1993

Open Elective Course Content
Semester**: IV Zoology**

Course Title: **Animal Behaviour**

Course Content

Content	**42Hrs**
Unit I	**14**
Chapter 1: Animal behaviour • Definition and types of animal behaviour: • Innate behaviour- taxes, reflexes, instincts and motivation; • Learnt behaviour - habituation, imprinting, conditioned reflexes and insight learning. Biological clock- circadian rhythm	**05**
Chapter 2: Communication in Animals • Significance of communication • Components of communication • Types: Tactile, visual, acoustic, chemical	**05**
Chapter3. Social organisation in animals • Social behaviour • Society /colony in ants, termites and monkey troops.	**04**
Unit II	**14**
Chapter 4: Behaviour in solving ecological obstacles • Foraging behavior • territorial behavior • antipredatory behavior • aggressive behavior • play behaviour	**06**
Chapter 5 : Animal Migration • Migration in fishes. Catadromous and anadromous. • Migration in birds - causes, types of migration, origin of migration, preparation for migration, orientation and navigation. • Advantages of migration - methods of studying bird migration (suitable examples are to be cited.)	**08**

Unit–3 **14**

Chapter 6:Reproductive behaviours **07**

- Sexual selection
- Reproductive strategies
- Diversity in mating system monogamy, polygamy- types, polyandry types.
- Courtship in spiders, frogs and birds.

Chapter 7: Nesting behavior and Parental Care **07**

- Nesting and parental care in birds (suitable examples are to be cited).
- Nesting behaviour in wasps.
- Parental care in fishes (*Hippocampus, Ophiocephalus, Tilapia, Arius*)
- Parental care in Amphibians (*Racchophorus, Salamander, Hyla, Pipa,* and *Ichthyophis*).

Suggested Readings:

- Norman T. J. Bailey (1994) Statistical methods in biology, 3rd edition, Cambridge University Press.
- Ron Freethy – Secrets of Bird Life (A guide to Bird Biology), Blandford, London, 1982, 1990.
- T. M. Caro – Behavioural Ecology & Conservation Biology, Oxford University Press, 1998.
- Drickamer et al – Animal Behaviour, W.C. Brown Publisher, London, 1996.

Kejoshi Aoki, Susuma et al., - Animal Behaviour, Springer Verlag, Newyork, 1984

SEMESTER V

G 508 DC 1.5 NON-CHORDATES AND ECONOMIC ZOOLOGY

Course Outcomes

At the end of the course students will be able to understand:

1. The identification and classification of Non-Chordates based on their general characters.
2. The diversity and evolutionary relationship among non-chordates.
3. The economic importance of Non-Chordates.
4. The entrepreneurship/ self-employment possibilities in various sectors of Zoology.

Course Contents **Hours**

UNIT 1: Lower Non-Chordates **12**

Chapter 1: Protozoa and Porifera

- **Protozoa**: General characters of the phylum Protozoa and classification upto classes giving suitable examples. Economic importance of Protozoa.
- **Porifera** : General characters of the phylum Porifera and classification up to classes giving suitable examples. Water canal system. Economic importance of sponges.
- **Chapter 2: Cnidaria and Ctenophora**
- **Cnidarian**: General characters of the phylum Cnidaria and classification up to classes giving suitable examples. Polymorphism in *Physalia.* Coral formation and types of coral reefs. Economic importance of Cnidaria.
- **Ctenophora :** General characters of the phylum Ctenophora and affinities of the phylum.

UNIT 2: Lower Non-Chordates **12**

Chapter 3: Platyhelminthes and Nemathelminths.

- **Platyhelminthes**: General characters of the phylum Platyhelminthes and classification up to classes giving suitable examples.
- **Nemathelminths** : General characters of the phylum Nemathelminths and classification up to classes giving suitable examples.
- Parasitic adaptations of Platyhelminthes and Nemathelminths.

Chapter 4: Annelida

- General characters of the phylum Annelida and classification up to classes giving suitable examples.
- Metamerisim and parasitic adaptations in Annelids with suitable examples.

- Economic importance of Annelida.

UNIT 3: Higher Non-Chordates **12**

Chapter 5: Arthropoda and Onychophora

- **Arthropoda** : General characters of the phylum Arthropoda and classification up to classes giving suitable examples.
- Economic importance of beneficial and harmful insects.
- **Onychophora** : General characters of the phylum Onychophora and affinities of the phylum.

Chapter 6: Mollusca, Echinodermata and Hemichordata

- **Mollusca**: General characters of the phylum Mollusca and classification up to classes giving suitable examples. Economic importance of molluscs.
- **Echinodermata**: General characters of the phylum Echinodermata and classification up to classes giving suitable examples. Economic importance of Echinodermata.
- **Hemichordata :**General characters of the subphylum Hemichordata and affinities of the subphylum.

UNIT 4: Economic Zoology **12**

Chapter 7: Sericulture, Apiculture and Vermitechnology.

- **Sericulture:** Life cycle of silkworm, modern rearing methods of silkworm. Silk production and its management.
- **Apiculture:** Economically important species of honey bees. Bee keeping and management. By products of apiculture and their uses.
- **Vermitechnology:** Introduction and importance of vermiculture, application of earthworms in waste management; Vermicompost, vermiwash.

Chapter 8: Aquaculture, Poultry and Dairy.

- **Aquaculture:** Freshwater and marine fish culture in India. Fish byproducts and their economic importance. Techniques of culturing shrimps and pearl.
- **Poultry:** Importance and scope of poultry. Poultry for egg and meat production and its management.
- **Dairy:** Importance and scope of dairy and its management. Dairy byproducts, preservation and uses.

SEMESTER V

G 508 DC 3.5 P

NON-CHORDATES AND ECONOMIC ZOOLOGY

PRACTICALS 56 Hrs

1. **List of museum specimens and slides:** Commonly available specimens cited in the list of examples are to be selected for practicals.

a) **Protozoa:***Elphidium, Euglena, Plasmodium, Paramecium* and *Vorticella.*

b) **Porifera :** *Leucosolenia, Euplectella* and *Euspongia*.

c) **Ctenophora :***Obelia, Physalia, Porpita, Aurelia, Adamsia* and *Fungia.*

d) **Platyhelminthes:** *Planaria, Fasciola hepatica* and *Taeniasolium.*

e) **Nemathelminthes:** *Ascaris* (Male & female) and *Wuchereriabancrofti.*

f) **Annelida:***Neries, Aphrodite, Arenicola, Cheatopterus, Sabella, Pheretima* and *Hirudinaria.*

g) **Arthropoda:***Penaeus, Carcinus*, , *Lepas, Scolopendra, Limulus* and *Palamnaeus.*

h) **Onychophora:** *Peripatus.*

i) **Mollusca:***Chiton, Dentalium, Cypraea, Xancus, Aplysia, Pila, Mytilus, Oyster, Nautilus, Sepia* and *Octopus.*

j) **Echinodermata:***Asterias*,*Ophiothrix*, *Echinus* and *Antedon*.

k) **Hemichordata:** *Balanoglossus*.

2. To prepare temporary slide of setae of earthworm.

3. Commercially important inland and marine fishes (at least 10).

4. Edible prawns (at least 03)

5. Edible shell fishes

6. Study of life cycle of *Bombyx mori.*

7. .Animal product and secretion

   a) Honey and bees wax,

   b) Pearl, molluscan shells

   c) Feathers of birds

   d) Dairy products.

   e) Egg

   f) Fish products.

8. Life history of honeybee and lac insect.

9. Vermicomposting

10. Ornamental fish culture techniques

11. Virtual Labs (Suggestive sites)

- https://www.vlab.co.in
- https://zoologysan.blogspot.com
- www.vlab.iitb.ac.in/vlab

REFERENCES

- Adam Sedgwick - A Students Text book of Zoology, Low Price Publications, Delhi, Vol. I , II &Vol.III, 1990.
- Ayyar, E.K. and T.N. Ananthakrishnan, 1992. Manual of Zoology Vol. I(Invertebrata), Parts I & II. S. Viswanathan (Printers and Publishers) Pvt Ltd., Madras, 991p.
- Banerjee, G.C. (2015), Animal Husbandry, Navyug Book International Publications
- Jawaid, A. and Sinha, S. P. (2008) A Handbook of Economic Zoology. S. Chand Group Publishers, New Delhi.
- Jordan, E.K. and P.S. Verma, 1993. Invertebrate Zoology, 12th Edition, S. Chand & Co Ltd., Ram Nagar, New Delhi, 1050 pp.
- Khan, A. A. (2007) Encyclopedia of Economic Zoology. 2 vols. Anmol Publications Pvt. Ltd., New Delhi.
- Kotpal, R.L., 1988-1992. (All Series) Protozoa, Porifera, Coelenterata, Annelida, Arthropoda, Mollusca, Echinodermata, Aves - Rastogi Publications, Meerut - 250 002.
- Parker and Haswell, 1964. Text Book of Zoology, Vol I (Invertebrata), A.Z.T, B.S. Publishers and Distributors, New Delhi - 110 051, 874 pp

SEMESTER V

G 508 DC 3.5 B

Paper 6 DIVERSITY OF CHORDATES AND COMPARITIVE ANATOMY

Course outcomes:

At the end of the course the student should be able to:

1. Learn the structural biology of Chordates through their adaptive features.
2. Study the functional biology of Chordates through their body organization and functions.
3. To explore and establish the correspondences between body parts of organisms from different species.
4. To understand the importance of anatomical structures to assess comparative study from lower to higher vertebrates.

Course contents: **HOURS**

UNIT I: Lower chordates **12**

Chapter 1: **General characters and classification of chordata**

- General characteristics of Chordata and outline classification upto subphyla.
- Protochordata- Characters of Urochordata and Cephalochordata with examples; External features of *Herdmania* and *Branchiostoma*.

Chapter 2: Vertebrata and Cyclostomata

- Vertebrata - General characters of Vertebrata; Outline classification up to classes.
- Cyclostomata - General characters; External features and differences between Lamprey (*Petromyzon)* and Hag fish (*Myxine)*.

UNIT II: Higher Chordates **12**

Chapter 3: Pisces and Amphibia:

- Pisces - General characteristics of fishes and aquatic adaptations of fishes- Chondrichthyes and Osteichthyes with examples
- Amphibia - General characters and classification up to orders; Distinguishing features of Anura, Apoda and Urodela with suitable examples.

Chapter 4: Reptilia, Aves and mammals:

- Reptilia -General characters and classification up to orders (living orders only) with suitable examples, Indian snakes – Examples of poisonous and Non-poisonous snakes
- Aves- General characters and classification, Flight Adaptations in birds.
- Mammalia - General characters and classification up to subclasses; Distinctive features of Prototheria, Metatheria and Eutheria with important examples.

UNIT III:Comparative anatomy 12

Chapter 5: Basics of Comparative anatomy:

- General concepts of Comparative Anatomy, Body plan of animals-evolutionary perspectives.
- Methods and tools used to study animal body
- Integumentary system- Structure, function and derivatives of integument.

Chapter 6: Skeletal system and Digestive system

- Skeletal system- Overview of axial and appendicular skeleton, Jaw suspension and visceral arches.
- Digestive system- Alimentary canal and associated glands. Dentition.

UNIT IV: Comparative anatomy continuation 12

Chapter 7: Respiratory and Circulatory system:

- Respiratory system- Skin, gills, lungs and air sacs Internal gills; External gills; Lungs and gas bladder of fishes; Evolution of lungs.
- Circulatory system- General plan of circulation, Evolution of heart and aortic arches.

Chapter 8: Urinogenital system and nervous system:

- Urinogenital system-Succession of kidney, Evolution of urinogenital ducts, types of mammalian uteri.
- Nervous system- Comparative account of brain, Autonomic nervous system, spinal cord, cranial nerves in mammals. Sense organs- Eye, ear, olfactory organs, Lateral line.

SEMESTER V

G 508 DC 3.5 P DIVERSITY OF CHORDATES AND COMPARITIVE ANATOMY

PRACTICALS 56 Hrs

1. Study of animal specimens: any 1 example from each class
2. Study on use and ethical handling of model organisms (Mice, rats, rabbit and pig).
3. To prepare a slide of different types of scales.
4. Comparative study of mouth parts (preserved specimen / diagrams only); House fly, female Mosquito, Cockroach, Butterfly / moth, Bug, beetle
5. Comparative study of bones of different vertebrates.
6. Comparative study of histological slides of different tissues of vertebrates.
7. Dissections: through multimedia/models or study of specimens Cockroach: Central nervous system Wollogo Afferent and efferent branchial vessels, Cranial nerves, Weberian ossicles.
8. Mounting (virtual or demonstration or permanent slides):
    - Prawn : Appendages.
    - Cockroach : Mouth parts and leg

9. DISSECTIONS virtual:
    - Shark : Cranial nerves V, VII, IX and X
    - Shark : Afferent branchial system.
    - Shark : Brain.
    - Mouse/Rat : Digestive system and urinogenital systems
    - Leech : Digestive and Reproductive system
    - Cockroach : Digestive and Nervous System

10. Virtual Labs (Suggestive sites)
    - https://www.vlab.co.in
    - https://zoologysan.blogspot.com
    - www.vlab.iitb.ac.in/vlab

REFERENCES

- Hyman L. H. (2004) Anatomy of Comparative Vertebrates. Reprint. Satish Serial Publishing, Delhi.
- Kenneth, V. K. (2006) Vertebrates: Comparative Anatomy, Function, Evolution. 4th edition, McGraw-Hill, New York, NY.

- Kulshrestha,S. K. (2004) Comparative Anatomy of Vertebrates
- Milton, H. (1995) Analysis of vertebrate structure. John Niley& Sons Inc, New York.
- Romer, A.S and Parsons T. S. (1978) The Vertebrate body, 5thedition, W.B. Saunders Co & Toppan Co, Ltd
- Saxena, R.K. and Sumitra S. (2008) Comparative Anatomy of Vertebrates. New Delhi.

SEMESTER V

G 508 DC 3.5 Voc AQUATIC BIOLOGY

Vocational Course

Course Outcomes

At the end of the course students will be able to understand:

1. The significance of aquatic ecosystems and its role.
2. The diversity and adaptations of aquatic fauna in different aquatic biomes.
3. The Physio-Chemical properties of aquatic habitats.
4. The sources and effect of aquatic pollution and eco-restoration of aquatic systems.

Course contents **HOURS**

UNIT 1: Aquatic Biomes and associated organism **12**

- Brief introduction of the aquatic biomes: Freshwater ecosystem, estuaries, intertidal zones, oceanic pelagic zone, marine benthic zone and coral reefs.
- Classification of organisms - Freshwater and Marine forms - Plankton, nekton, neuston, periphyton and benthos.
- Organism classification based on zones – Littoral/riparian, limnetic and profundal. Classification based on nutrition: Autotrophs, heterotrophs and saprotrophs.

UNIT 2: Freshwater Biology **12**

- Classification of freshwater habitats - Lotic and lentic ecosystems, lakes and rivers.
- Physico–chemical Characteristics: Light, Temperature, Thermal stratification, Dissolved Solids, Carbonate, Bicarbonates, Phosphates and Nitrates, Turbidity; dissolved gases (Oxygen, Carbon dioxide).
- Adaptation in freshwater organisms.

UNIT 3: Marine Biology **12**

- Oceanography - general features, waves, tides, current and upwelling.
- Salinity and density of Sea water, Continental shelf, Adaptations of deep-sea organisms, formation of Coral reefs.
- Physico-chemical properties of estuary – Salinity and temperature. Mangrove ecosystems.

UNIT 4: Management of Aquatic Resources **12**

- Major pollutants, sources, dynamics, transport paths and agents. Sewage, industrial and agricultural discharges, composition, disposal systems.
- Nutrients- detergents, heavy metals and pesticides composition and fate in the marine environment, biological concern, and toxicity and treatment methods.
- Thermal pollution: effects of thermal pollution and management of heat. Radioactive pollution.
- Oil pollution - biological effects biodegradation, biomonitoring, bacterial pollution and seafood poisoning

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SEMESTER VI

G 508 DC 3.6A EVOLUTIONARY AND DEVELOPMENTAL BIOLOGY - Paper 7

Course Outcomes:

1. To learn about the origin of life, organic evolution hypotheses, and evolution evidence.
2. To highlight the importance of understanding evolution, speciation, and extinction.
3. It emphasizes the oogenesis and gametogenesis processes and research on the early stages of fish, frogs, chickens, humans and also the focus is on birth abnormalities, the function of different stem cells in growth.
4. Review of ageing and late developmental processes

Course contents **HOURS**

UNIT 1: Evolution **12**

Chapter 1: Origin of life and theories of organic evolution

- Theories of origin of life- (special creation- cosmozoic – abiogensis –biogensis- theory of Chemical evolution) - evidences from metabolism-biochemical pathways- precambian rocks.
- Lamarkism and Neo-Lamarkism, Darwin-Wallace theory, Synthetic theory of Evolution- Neo-Darwinism- Hardy-Weinberg Equilibrium. Forces of evolution: Gene mutation, gene flow, genetic drift, natural selection and isolation.

Chapter 2: Evidences of evolution, concept of species and extinction

- Types of fossils, incomplete of fossil record, dating of fossils. Brief account of *Dinosaurs* and *Confusciusornis sanctus.* Phylogeny of horse and man.
- Concept of species and mode of speciation- Microevolution and macroevolution. Extinction of species types and causative factors- habitat destruction, predation, disease and competition- intra and interspecific competition- catastrophic events. Mass extinction.

UNIT 2: Early developmental biology **12**

Chapter 3: Gametogenesis and parthenogenesis

- Spermatogenesis - stages – Structure of human sperm. Oogenesis- Previtellogenesis, vitellogenesis. Comparison of spermatogenesis and oogenesis. Sexual cycles: Estrous cycle in rodents and menstrual cycle in humans.

- Types of parthenogenesis – Natural and artificial parthenogenesis. Significance of Parthenogenesis. Hermaphroditism.

Chapter 4: Reproductive system, fertilization and fertility control

- Male and female reproductive systems, accessory sex organs, secondary sexual characters in humans. Gonadal hormones. Kinds of fertilization, Mechanism of fertilization. Monospermy and polyspermy- significance of fertilization.
- Fertility control-need for fertility control- family planning method- temporary permanent barriers-IUDs-hormonal and biological and terminal method. Assisted reproductive techniques: in vitro fertilization-embryo transfer (IVF-ET), gamete intrafallopian transfer (GIFT), zygote intrafallopian transfer (ZIFT), and frozen embryo transfer (FET).

UNIT 3: Developmental Biology **12**

Chapter 5: Early development of frog and extra embryonic membranes.

- Structure of ovum- cleavage-blastula-fate map - Gastrulation- mesogenesis-notogenesis and neurulation.
- Development, structure and functions of yolk sac, amnion, chorion and allantois.

Chapter 6: Early development of chick and human.

- Structure of hen's egg- cleavage- blastula-fate map- gastrula- origin and structure of primitive streak- 18, 24, 48 hrs chick embryos.
- Structure of Graafian follicle-ovulation-fertilization-morula- blastocyst-implantation- gastrulation. Twins and multiple births.

UNIT 4: Developmental Biology **12**

Chapter 7: Placenta, metamorphosis and regeneration

- Yolk sac placenta- allantoic placenta- structure and functions of placenta. Morphological and histological classification of placenta with examples. Placental hormones.
- Metamorphosis regeneration and stem cells. Stem cells. Environmental regulation of development

Chapter 8: Late developmental processes and aging

- The dynamics of organ development: Development of eye, kidney, limb.
- Metamorphosis: the hormonal reactivation of development in amphibians, insects.
- Regeneration: salamander limbs, mammalian liver, hydras.
- Aging: The biology of senescence.

G 508 DC 3.6AP

EVOLUTIONARY AND DEVELOPMENTAL BIOLOGY

PRACTICALS **56 Hrs**

1. Study of the histological structure of following mammalian organs: Ovary, Testis.
2. Study of different types of eggs-Graafian follicle,frog's egg, hen's egg and insect egg.
3. Study of Grashopper's , Frog's and mammalian sperms.
4. Stages of development of frog: The study of cleavage stages, blastula, gastrula and neurula (sections).
5. Various stages of tadpole.
6. Study of permanent slides of chick embryo: 18 hr, 24hrs, 36hrs and 48hrs (WM).
7. Study of permanent slides of chick embryos: T.S. of 18 hrs and 24 hrs.
8. Demonstration of development of chick embryo by window technique.
9. Study of permanent slides of any two types of placenta.
10. Study of various stages of human foetus.
11. Study of homologous organs - fore limbs of frog and bird; mouth parts of cockroach, mosquito and butterfly.
12. Serial homology in Crustacea (appendages).
13. Study of analogous organs - vertebrate and cephalopod eye, wing of bird and insect.
14. Study of vestigial organs - appendix, coccyx and molar teeth in man.
15. Darwin's Finches: Beak adaptation in birds
16. Virtual Labs (Suggestive sites)
    - https://www.vlab.co.in
    - https://zoologysan.blogspot.com
    - www.vlab.iitb.ac.in/vlab.

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SEMESTER VI

G 508 DC 3.6 B Paper 8

ENVIRONMENTAL BIOLOGY, WILDLIFE MANAGEMENT AND CONSERVATION

Course contents **HOURS**

1. Enhance understanding of students on the general principles of ecology as how it related to terrestrial and aquatic plant and animal conservation and management.
2. Impart field based training to students how it will be applicable to solve problems related to wildlife conservation and management.
3. Enhance the ability of students to identify species, characteristics, habitat requirements and life cycles of birds, fish and mammalian wildlife species.
4. Encourage the students to carry out the research works in frontier areas of Wildlife and Biodiversity Conservation.

UNIT 1: Environmental Biology **12**

Chapter 1:

- Introduction: biotic factors: Light-effects of light on plants and animals. Temperature-thermal stratification-extreme temperature - cyclomorphosis.
- Biotic factors: Animal relationships-mutualism, parasitism, commensalism, predation and competition with relevant examples.

Chapter 2:

- Ecosystem Types of ecosystems with examples- natural ecosystem-man engineered ecosystem and micro ecosystem. Aquarium ecosystem and its maintenance. Biosphere and ecotone.
- Food chains and energy flow, types of food chains with examples. Food webs with examples. Ecological pyramids with examples - energy flow and laws of thermo9dynamics

UNIT 2: Environmental Biology cont- **12**

Chapter 3:

- Habitats- Aquatic habitats: Marine habitat - Zonation of the sea and ecological classification of marine biota, coastal ecology, estuarine ecology and mangroves.
- Fresh water habitat - lentic and lotic systems. Ecological classification of fresh water animals. Terrestrial habitats - A brief account of biomes and terrestrial habitats.

Chapter 4:

- Community Ecology Community structure - ecological determinants - ecological stratification- Ecological niches - ecological succession - climax community.
- Population Ecology Population density - natality and mortality - age distribution - population growth rate – population growth curves. Biotic potential - Allee's principle and Gause's principle

UNIT – 3: Wildlife Conservation and Management 12

Chapter 5:

- Introduction, importance of wild life conservation – Economic, ecological, aesthetic, Scientific, Recreational, Medicinal. Wild life categories: Endangered, Threatened, Vulnerable, rare; data deficient categories, Red data book.
- Causes of wildlife depletion: Degradation and destruction of natural habitats, Exploitation for commercial purposes, Deforestation, Agricultural expansion and grazing, Urbanization and industrialization, Forest fires.

Chapter 6:

- National parks, Wildlife sanctuaries, wildlife reserves, privately owned wildlife reserves & Biosphere reserves.
- Single species / single habitat-based conservation programmes (e.g. Project tiger, Project Elephant, Project Rhino, Great Indian bustard project)

UNIT – 4 Wildlife conservation and legal aspects 12

Chapter 7:

- International conventions on conservation; Important International conventions &treaties on nature & conservation, India's role & contribution, Ex- situ & in-situ conservation, Conservation Breeding (e.g., Vulture, Pygmy hog, Gharial etc.),
- Institutions and their role in conservation; Zoos, Natural history museums & collections, Zoological survey of India, Botanical survey of India, Forest research Institute, Survey of India, Central Marine Fisheries research Institute

Chapter 8:

- Threats to wildlife-Need for wildlife conservation - agencies engaged in wildlife conservation. Government organization and non-government organizations (NGOs),
- Wildlife (Protection) Act 1972. CITES, endangered species of India. Red data book. Biosphere reserves- Important National parks and Wildlife sanctuaries of India.

SEMESTER VI

G 508 DC 3.6 BP

ENVIRONMENTAL BIOLOGY, WILDLIFE MANAGEMENT AND CONSERVATION

PRACTICALS 56 Hrs

1. Study of tropical pond as an ecosystem - study of fauna and flora and interaction between the various constituents (notes and Figure).
2. Study of aquarium as an ecosystem - Study of fauna and flora and interaction between the various constituents (notes and figures).
3. Biostatistics problems: Tabulation of data- Bar Diagram-Histogram-Frequency distribution-mean, median and mode. Standard deviation-standard error-Chi-square test.
4. Location of species of zoological interest on the Indian map and world map. Flightless birds, Tigers, Lions, Gorilla, Hippopotamus, Rhinoceros.
5. Location of Tiger reserves, national parks, Biosphere reserves, Wildlife sanctuaries of India on map.
6. Study of threatened animals of India (by Pictures/charts) Tiger, Lion, One-horned Rhinoceros, Gaur, the Golden Languor, Lion Tailed Monkey, Musk Deer, Mouse Deer, Hangul (Kashmir stag), the Great Indian hornbill and Indian rock python.
7. Indian population data: based on census record and plotting a graph to show growth rate.
8. Study of community: By quadrate method to determine frequency, density and abundance of different species present in the community. Alpha diversity.
9. Study of biomass of consumers of a particular area by quadrate method - by determining the dry weight of living organisms - both animals and plants per unit area.
10. Preparation of a small inventory of important local invertebrate and vertebrate species, their common name, zoological name, vernacular name, salient features, classification etc.
11. Study of ecological adaptations and morphological peculiarities - Hermit crab, Leaf insect, Stick-insect, Glowworm, Stink bug, Puffer fish, Angler fish, Exocoetes, Phrynosoma, Draco, Chaemeleon and Bat.
12. Study of biotic relationships - Leguminous plants, Termites, Liver fluke, Tapeworm, flying fish, Sucker fish, Insectivorous plants.

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SEMESTER VI
G 508 DC 3.6 Voc ENTOMOLOGY
Vocational Course

Course outcome

1. Students are trained in the basics of insect classifications and preservation of collected samples in the laboratory condition for future studies.
2. The behaviour, insect physiology and biological applications of various insects are studied in detail.
3. Plant-insect interactions are discussed to understand the biological significance of insects in controlling pests and pollination.
4. Taxonomical training in identification and classification of insects helps students get job opportunities as entomologists or in related fields.

Course contents **HOURS**

Unit I Introduction to Entomology **12**

Chapter 1:

- History of Entomology in India, dominance of Insecta in Animal kingdom, Classification of phylum Arthropoda up to classes.
- Morphology: Structure and functions of insect cuticle and molting. Body segmentation. Structure of Head, thorax and abdomen. Structure and modifications of insect antennae, mouth parts, legs, Wing venation, modifications and wing coupling apparatus.

Chapter 2:

- Metamorphosis and diapause in insects. Types of larvae and pupae. Structure and functions of digestive, circulatory, excretory, respiratory, nervous, and reproductive system, in insects.
- Structure of male and female genital organ. Types of reproduction in insects. Major sensory organs like simple and compound eyes, chemoreceptor.

Unit II – Insect Ecology **12**

Chapter 3:

- Introduction, Environment and its components. Effect of abiotic factors– temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents.
- Effect of biotic factors – food competition, natural and environmental resistance.

Chapter 4:

- Concepts of Balance of life in nature, biotic potential and environmental resistance and causes for outbreak of pests in agro-ecosystem.

Unit III – Insects Orders **12**

Chapter 5:

- Classification of important class of Insecta upto Orders, basic groups of present day insects with special emphasis to orders and families of Agricultural importance like
- Orthoptera: Mantidae, Blattidae; Odonata;
- Isoptera; Hemiptera; Aphididae, Coccidae,;

Chapter 6:

- Neuroptera: Chrysopidae; Lepidoptera: Pieridae, Papiloinidae, Noctuidae, Coleoptera: Bruchidae, Scarabaeidae;
- Hymenoptera: Apidae, Vespidae, lchneumonidae, Braconidae, Chalcididae; Diptera: Culicidae, Muscidae, Tephritidae.

Unit IV – Chemical and Biological pest control 12

Chapter 7:

- Categories of pests. Host plant resistance, Chemical control and importance, hazards and limitations.
- Classification of insecticides, toxicity of insecticides.

Chapter 8:

- Beneficial insects: parasites and predators used in pest control and their mass multiplication techniques.
- Important species of pollinators, weed killers and scavengers, their importance.

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Question Paper Pattern

Time : 2 hours **Max. Marks :60**

Note:

1. **Answer any TEN questions from Part –A -Assorted questions from all four units**
2. **Answer any EIGHT questions from Part- B- Assorted questions from all four units**
3. **Answer any FOUR questions from Part- C -Assorted questions from all four units**

Part-A

I. Answer any TEN OUT OF TWELVE questions of the following 2x10=20

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

Part B

II. Answer any FOUR OUT OF SIX questions - Assorted questions from all four units (5x4=20)

a.
b.
c.
d.
e.
f.

Part- C

III. Answer any TWO OUT OF FOUR questions -Assorted questions from all four units 10x 2=20

a.
b.
c.
d.

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