THE UNIVERSITY OF BURDWAN

SYLLABUS FOR 2-YEAR M.SC.
IN ZOOLOGY
UNDER CURRICULUM AND CREDIT FRAMEWORK FOR POSTGRADUATE PROGRAMMES (CCFPP) AS PER NEP 2020
WITH EFFECT FROM 2026–2027

SCHEME AND SYLLABUS FOR SEMESTER-WISE AND COURSEWISE CREDITS AND MARKS DISTRIBUTION STRUCTURE UNDER CCFPP AS PER NATIONAL EDUCATION POLICY 2020 FOR 2-YEAR M.Sc. IN ZOOLOGY

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Int. Ass.
I	Major/ Core Course	PG2ZOOL1011 (400–499)	Research Methodology and Ethics	6	4	0	2	75	40	20	15
		PG2ZOOL1012 (400–499)	Techniques in Biology	6	4	0	2	75	40	20	15
		PG2ZOOL1013 (400–499)	Parasitology and Microbiology	6	4	0	2	75	40	20	15
		PG2ZOOL1014 (400–499)	Immunology	6	4	0	2	75	40	20	15
	Minor Course	PG2ZOOL1021 (300–399)	Fundamentals of Zoology I	4	3	0	1	75	40	20	15
Total				**28**				**375**			

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Int. Ass.
II	Major/ Core Course	PG2ZOOL2011 (400–499)	Environmental Biology and Toxicology	6	4	0	2	75	40	20	15
		PG2ZOOL2012 (400–499)	Entomology	4	3	0	1	75	40	20	15
		PG2ZOOL2013 (400–499)	Fish Biology and Fisheries	4	3	0	1	75	40	20	15
		PG2ZOOL2014 (400–499)	Indian Knowledge System	4	3	0	1	75	40	20	15
	Minor Course	PG2ZOOL2021 (300–399)	Fundamentals of Zoology II	4	3	0	1	75	40	20	15
Total				**22**				**375**			

Option- I: Coursework in the 3rd Semester and Research Thesis/ Project in the 4th Semester

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Int. Ass.
III	Major/ Core Course	PG2ZOOL3011 (500–599)	Biosystematics and Population Genetics	4	3	0	1	50	20	20	10
		PG2ZOOL3012 (500–599)	Omics Study	4	3	0	1	50	20	20	10
		PG2ZOOL3013 (500–599)	Elective I	4	3	0	1	50	20	20	10
		PG2ZOOL3014 (500–599)	Elective II	4	3	0	1	50	20	20	10
		PG2ZOOL3015: (500–599)	Elective III	4	3	0	1	50	20	20	10
Total				**20**				**250**	0	0	250
IV	Research Thesis/ Project	PG2ZOOL4031 (500–599)	Research Thesis/ Project	**20**	–	–	20	**250**	Submission of Research project/ Dissertation, Seminar presentation and Interaction (Viva-voce) (150+75+25)		

OR

Option-II: Coursework only in 3rd and 4th Semesters

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Int. Ass.
III	Major/ Core Course	PG2ZOOL3011 (500–599)	Biosystematics and Population Genetics	4	3	0	1	50	20	20	10
		PG2ZOOL3012 (500–599)	Omics Study	4	3	0	1	50	20	20	10
		PG2ZOOL3013 (500–599)	Elective I	4	3	0	1	50	20	20	10
		PG2ZOOL3014 (500–599)	Elective II	4	3	0	1	50	20	20	10
		PG2ZOOL3015 (500–599)	Elective III	4	3	0	1	50	20	20	10
Total				**20**				**250**			

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks		
									Theory	Pract./ Viva-voce	Int. Ass.
IV	Major/ Core Course	PG2ZOOL4011 (500–599)	System Ecology	4	3	0	1	50	25	20	05
		PG2ZOOL4012 (500–599)	Comparative Animal Physiology	4	3	0	1	50	25	20	05
		PG2ZOOL4013 (500–599)	Neurobiology	4	3	0	1	50	25	20	05
		PG2ZOOL4014 (500–599)	Stem Cell Biology and Molecular diagnostics	4	3	0	1	50	25	20	05
		PG2ZOOL4015 (500–599)	Term paper	4	–	–	–	50			
Total				**20**				**250**			

OR

Option-III: **Only Research Thesis/Project in 3rd and 4th Semesters**

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks
III	Research Thesis/ Project	PG2ZOOL3031 (500–599)	Research Thesis/ Project	20	_	_	20	250	Seminar Presentation, Preparation and Submission of Research Thesis/ Project Document - 150 + Viva - 100
Total				**20**				**250**	

Semester	Course Type	Code and Level	Name of the Course	Credits	Lect.	Tuto.	Pract.	Full Marks	Distribution of Marks
IV	Research Thesis/ Project	PG2ZOOL4031 (500–599)	Research Thesis/ Project	20	_	_	20	250	Seminar Presentation, Preparation and Submission of Research Thesis/ Project Document - 150 + Viva - 100
Total				**20**				**250**	
Grand Total: Semesters I–IV				**90**				**1250**	

Explanation:

PG2ZOOL1014 stands for:
PG2: 2-year PG
Subject Code: ZOOL
1: Semester – I
0: Common digit to all courses
1: Major/ Core Course
4: Number of Course offered

PG2ZOOL2021 stands for:
PG2: 2-year PG
Subject Code: ZOOL
2: Semester – II
0: Common digit to all courses
2: Minor Course
1: Number of Course offered

PG2ZOOL2012 stands for:
PG2: 2-year PG
Subject Code: ZOOL
2: Semester – II
0: Common digit to all courses
1: Major/ Core Course
2: Number of Course offered

PG2ZOOL3015 stands for:
PG2: 2-year PG
Subject Code: ZOOL
3: Semester – III
0: Common digit to all courses
1: Major/ Core Course
5: Number of Course offered

PG2ZOOL3031 stands for:
PG2: 2-year PG
Subject Code: ZOOL
3: Semester – III
0: Common digit to all courses
3: Research Thesis/ Project
1: Number of Course offered

PG2ZOOL4031 stands for:
PG2: 2-year PG
Subject Code: ZOOL
4: Semester – IV
0: Common digit to all courses
3: Research Thesis/ Project
1: Number of Course offered

SEMESTER – I

MAJOR COURSE
PG2ZOOL1011: Research Methodology and Ethics
Credits – 6 (Theory: 4, Practical: 2)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- To acquaint students with fundamental principles and processes of scientific research
- To develop skills for designing, conducting, and analysing biological research systematically
- To introduce computational tools and databases essential for modern biological research
- To provide knowledge of statistical concepts and methods for data analysis and interpretation
- To promote ethical research practices and scientific communication skills
- To enable integration of computational and statistical approaches in experimental biology

UNIT I: Research Methodology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Model Organisms** Introduction to model organisms, definition, types, characteristics of model organisms. Importance of model organisms in biological research Major Model organisms in biological research: *Dictyostelium discoideum*, Yeast (*Saccharomyces cerevisiae*), *Hydra*, *Caenorhabditis elegans*, *Drosophila*, Zebra fish (*Danio rerio*), and Mouse (*Mus musculus*)	05
2	**Unit 2: Sampling, Data Collection and Descriptive Statistics** Sampling methods; Types of data: Experimental data, Field data and Survey data; Estimation of sample size; Frequency distribution; Measures of central tendency: Mean, median and mode; Quartiles and Percentiles; Parameters and Statistics Types of statistical distribution; Measures of dispersion: Standard deviation and standard error; Coefficient of variation; Skewness and Kurtosis	05
3	**Unit 3: Hypothesis Testing and Analysis of Variance** Concept of hypothesis testing, parametric and non-parametric tests, one sample hypothesis, two sample hypothesis, multi-sample hypothesis: analysis of variance (ANOVA), single factor analysis of variance, confidence limits for population mean; power and sample size, homogeneity of variances	06
4	**Unit 4: Correlation and Linear Regression** Concept of correlation, correlation coefficient, Pearson and Spearman correlation, Regression, simple linear regression equation, testing the significance of relation (r^2)	05
5	**Unit 5: Chi-Square Tests and Goodness of Fit** Chi-Square goodness-of-fit test; Chi-Square test for heterogeneity; Chi-Square analysis of contingency tables; Odds ratio and its interpretation	05
6	**Unit 6: Survival Analysis** Concept of life tables, censored data, estimation of survival function, Kaplan–Meier analysis	04

UNIT II: Computational Biology and Research Ethics **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Computer Applications** Computer networks and internet, search engines, network concepts, computer clusters supercomputers, remote computation platforms, cloud computing	03
2	**Unit 2: Bioinformatics** Concept and types of databases, nucleic acid sequences databases, snp database, genome database, protein databases, structures and interacting proteins databases, protein motifs, folds and domains, databases Sequence alignments (BLAST and ClustalW) Structural prediction tools, AI applications in biology	05
3	**Unit 3: Intellectual Property Rights** Concept of IPR, brief outline of Indian Patent rule, patent procedure, international patent system – PCT, patent database and searching – in PASS, EPO, USPTO	05
4	**Unit 4: Philosophy and Ethics** Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: Definition, moral philosophy, nature of moral judgments and reactions	04
5	**Unit 5: Scientific Conduct** Ethics with respect to science and research, Intellectual honesty and research integrity Scientific misconducts: falsification, fabrication and plagiarism (FFP) Redundant publications: duplicate and overlapping publications, salami slicing Selective reporting and misrepresentation of data	06
6	**Unit 6: Publication Ethics** Definition, introduction and importance Best practices/standards setting initiatives and guidelines: COPE, WAME etc. Conflicts of interest; Publication misconduct: Definition, concept, problems that lead to unethical behaviour and vice versa, types Violation of publication ethics, authorship and contributorship Identification of publication misconduct, complaints and appeals Predatory publishers and journals	07

Suggested readings

Bailey, N. T. J. (1995). *Statistical Methods in Biology*. 3rd Ed. ELBS.

Boyer, R. (2000). *Modern Experimental Biology*. Pearson Education. English Universities Cambridge Low-price Ed.

Das, S. (2006). *Unix – Concepts and Applications*. 4th Ed. Tata McGraw-Hill.

DBT (1990). *Recombinant DNA Safety Guidelines and Regulation*.

DBT (2011). *Guidelines and Handbook for Institutional Biosafety Committee* (IBSC).

Forthofer, N. and Lee, E. S. (2006). *Introduction to Biostatistics: A Guide to Design, Analysis and Discovery*. Academic Press.

Gun, A. M., Gupta, N. K. and Dasgupta, B. (2013). *Fundamentals of Statistics*. Volume 1. World Press Private Ltd.

Kanetkar, Y. P. (2008). *Let Us C.* 8th Ed. Infinity Science Press.

Kothari, C. R. (2004). *Research Methodology. Methods and Techniques*. New Age International (P) Limited.

Lipschutz, S. (2011). *Data structure with C.* 1st Ed. McGraw Hill Education (India) Private Limited.

Manual of Patent office practice and Procedure (2011). *The office of controller general of patents, designs & trademarks*.

Rastogi, V. B. (2015). *Biostatistics.* Scientific International Pvt. Ltd.
Ronald, N. F., Eun, S. E. and Michael, H. (2007). *Biostatistics. A guide to Design, Analysis, and Discovery.* Academic Press.
Selvin, S. (2004). *Biostatistics: How it works*? Pearson Education.
Sinha, P. K. and Sinha, P. (2011). *Computer Fundamentals*. 6th Ed. BPB Publications.
Sokal, R. R. and Rohlf, F. J. (1995). *Biometry: The Principles and Practice of Statistics in Biological Research*. 4th Ed. W. H. Freeman and Company, New York.
Tenenbaum, A. S. and Wetherhall, D. J. (2013). *Computer Networks.* Pearson.
WHO (2003). *Laboratory Biosafety Manual.*
Zar, J. H. (1999). *Biostatistical Analysis*. Pearson Education Inc., New Delhi, India.

Practical components

Full marks: 20

1. Open Access Publishing: Open access publications and initiatives; SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies; Software tool to identify predatory publications developed by SPPU; Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.
2. Publication Misconduct: A. Group discussions–Subject specific ethical issues, FFP, authorship; Conflicts of interest; Complaints and appeals: examples and fraud from India and abroad; B. Software tools – Use of plagiarism-detection software like Ouriginal, Turnitin, Drillbit and other open-source software tools
3. Databases and Research Metrics: A. Databases– Indexing databases; Citation databases: Web of Science, Scopus etc.; B. Research Metrics–Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, CiteScore; Metrics: h-index, g-index, i-10 index, altmetrics
4. Handling of DOS, Unix commands and Windows operation: File management, Network commands and configuration
5. Sequence retrieval – nucleotide and protein
6. Sequence alignment, BLAST search, BLAT search
7. Protein pattern search, Motif search
8. Statistical analysis using: paired *t*-test or Goodness-of-fit - Chi-square (χ^2) test or Analysis of Variance (ANOVA) or Correlation and Regression
9. Laboratory records
10. Viva-voce

Examination pattern

Full Marks: 20

1. Sequence retrieval	4
2. Sequence alignment and similarity search	5
3. BLAT / Motif / Pattern Search	6
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

After successful completion of the course, students will be able to:

- Design and formulate a clear and testable research problem or hypothesis
- Apply appropriate research methods for data collection, sampling, and experimentation
- Use computational tools and biological databases for data retrieval, analysis, and visualisation
- Perform statistical analyses (descriptive and inferential) using software tools such as R, SPSS, or Python
- Interpret biological data quantitatively and draw meaningful scientific conclusions
- Prepare research proposals, reports, and scientific manuscripts following ethical and professional standards
- Critically evaluate scientific literature and integrate findings into research contexts
- Collaborate effectively in interdisciplinary research involving computational, biological, and statistical approaches

MAJOR COURSE
PG2ZOOL1012: Techniques in Biology
Credits – 6 (Theory: 4, Practical: 2)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- To impart theoretical understanding of core and advanced biological techniques
- To develop laboratory skills and analytical competence
- To familiarise students with interdisciplinary and application-oriented techniques
- To promote ethical practices, biosafety awareness, and data interpretation skills

Unit I: Fundamental Techniques in Biology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Laboratory Practices and Biosafety** Laboratory organization and good laboratory practices (GLP) Biosafety guidelines and laboratory safety levels Handling of biological samples Sterilization and disinfection techniques	05
2	**Unit 2: Basic Microscopy Techniques** Principles of microscopy, Light Microscope (LM), Phase Contrast Microscope, Fluorescence Microscope, Confocal Microscope, Scanning Electron Microscope (SEM), Field Emission Scanning Electron Microscope (FESEM), Transmission Electron Microscope (TEM), Atomic Force Microscopy	07
3	**Unit 3: Preparation of Biological Samples** Preparation of buffers and solutions Measurement of pH and use of pH meter Centrifugation: Principles and types Cell fractionation techniques	04
4	**Unit 4: Cell Culture Techniques and Flow Cytometry** Cell culture fundamentals (cell culture requirements, media preparation, cell viability), Primary and secondary cell culture, Aseptic techniques, Cryopreservation Flow Cytometry: Principle, instrumentation, applications; Fluorescence-activated cell sorting (FACS)	07
5	**Unit 5: Separation and Analytical Techniques** Spectroscopy: Spectrophotometry and colorimetry, UV-VIS, IR, Spectroflurimetry, Mass spectroscopy, NMR Quantification of biomolecules (DNA, RNA and Protein) Chromatography: Paper, TLC and Column chromatography, HPLC, FPLC, Gas chromatography	07

Unit II: Applied Techniques in Biology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Histological Techniques** Fixation and tissue preparation for histology*:* purpose and mechanism of tissue fixation, dehydration, embedding, and sectioning Decalcification, biological sample preparation for SEM and TEM Microtomy: methods of microtomy, cryostat freezing microtome, ultramicrotomy, problems and remedies in microtomy Biological dyes and stains: characteristic features of biological dyes and stain; Properties, source and use of haematoxylin, eosin, basic fuchsin, acid fuchsin, and carmine; concept of vital dyes	08
2	**Unit 2: Histochemical Techniques I** Carbohydrate moieties: Glycogen and glycoproteins with oxidizable vicinal diols by Periodic acid Schiff method; Glycoproteins with carboxyl groups and/or O-sulphate esters by Alcian blue methods Protein end groups: General proteins by Bromophenol blue method $-NH_2$ groups by Ninhydrin-Schiff method; –SS groups by Performic acid – Schiff and performic acid – alcian blue methods	06
3	**Unit 3: Histochemical Techniques II** Lipid moieties: General lipids by Sudan black B method; Neutral lipids by total Sudan III and Sudan IV methods Nucleic acids: Methyl green pyronin for DNA and RNA; Feulgen reaction for DNA Enzymes: Acid and alkaline phosphatases by Metal precipitation and Azo dye Immunohistochemistry: Basic principle, essential requirements, types, and applications	06
4	**Unit 4: Core Techniques in Molecular Biology** Principles of DNA and RNA isolation, reagents, buffers and contamination control, quality assessment of nucleic acids (spectrophotometry and gel analysis) Polymerase Chain Reaction (PCR): Thermal cycler operation and amplification steps, primer design basics; Variants: RT-PCR and Real-time PCR (concept), troubleshooting PCR reactions	05
5	**Unit 5: Advanced and Emerging Techniques in Molecular Biology** Introduction to Next Generation Sequencing (NGS) Chromosome preparation and karyotyping Fluorescence in situ hybridization (FISH) principle Genome Editing: Overview of CRISPR–Cas genome editing, target recognition and gene modification concept	05

Suggested readings

Bancroft, J. D. and Gamble, M. (2002). *Theory & Practice of Histological Technique.* Churchill Livingstone.

Barrangou, R. and van der Oost, J. (Eds.). (2013). *CRISPR-Cas systems: RNA-mediated adaptive immunity in Bacteria and Archaea*. Springer-Verlag Berlin Heidelberg.

Brown, T. A. (2018). *Genomes 4*. 4th Ed. Garland Science.

Freshney, R. I. (2010). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications.* 6th Ed. John Wiley & Sons.

Friefelder, D. (1982). *Physical Biochemistry.* W. H. Freeman & Co. (Reprint 1999).

Hayat, M. A. (Ed.) (1970-1978). *Principles and Techniques of Electron Microscopy: Biological Applications*. 2nd Ed. van Nostrand Reinhold, New York.

Kiernan, J. A. (1999). *Histology and Histochemical Methods: Theory & Practice.* 3rd Ed. Butterwork Heinemann.

Lesk, A. M. (2025). *Introduction to Genomics*. 3rd Ed. Oxford: Oxford University Press.

Livingstone, C. and Weesner, F. M. (1965). *General Zoological Techniques*. The William & Wilkins Company.

Sharma, V. K. (1991). *Techniques in Microscopy and Cell Biology.* Tata-McGraw Hill.

Spencer, M. (1982). *Fundamentals of Light Microscopy.* Cambridge University Press, Cambridge.

Stoward, P. J. and Everson Pearse, A. G. (1991). *Histochemistry: Theory and Practice*. 4th Ed. Edinburgh, Churchill Livingstone.

Wilson, K. and Walker, J. (eds.) (2001). *Principles & Techniques of Practical Biochemistry.* 5th Ed. Cambridge University Press.

Primrose, S. B. and Twyman, R. M. (2007). *Principles of Gene Manipulation and Genomics*. 8th Ed. Blackwell Publishing.

Plummer, D. T. (1987). *An Introduction to Practical Biochemistry*. 3rd Ed. McGraw-Hill.

Van Pelt-Verkuil, E., Van Belkum, A. and Hays, J. P. (2008). *Principles and Technical Aspects of PCR Amplification*. 7th Ed. Springer Science + Business Media B.V.

Practical components

Full marks: 20

1. Use and handlings of microscopes
2. Histological staining of mammalian tissues (H&E)
3. Histochemical staining of carbohydrate, protein and lipid molecules
4. Estimation of blood Lipid profile
5. Centrifugation techniques and applications
6. Spectrophotometric estimation of proteins / nucleic acids
7. PCR amplification of genomic/plasmid DNA: Demonstration / virtual lab
8. Laboratory records
9. Viva-voce

Examination pattern

Full Marks: 20

1. Major Experiment (Performance, result and interpretation) based on 3/4/6/7	6
2. Minor Experiment based on 4/6	4
3. Identification based on 2	5
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

After successful completion of the course, the students will be able to:

- Explain the principles and applications of fundamental and advanced biological techniques
- Apply appropriate techniques for biological sample preparation and analysis
- Interpret experimental data generated from biochemical, cellular, and molecular techniques
- Integrate biological techniques in research, diagnostics, and interdisciplinary studies
- Demonstrate awareness of biosafety, ethics, and good laboratory practices

MAJOR COURSE
PG2ZOOL1013: Parasitology and Microbiology
Credits – 6 (Theory: 4, Practical: 2)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- Understand fundamentals of parasitology and microbiology, including morphology, life cycles, and classification of important parasites and microorganisms
- Explain host–parasite relationships, modes of transmission, pathogenic mechanisms, and host immune responses
- Develop laboratory skills for safe handling, culture, staining, and identification of microorganisms and parasites
- Understand disease epidemiology, diagnosis, prevention, and control strategies
- Correlate theoretical knowledge with applied aspects such as public health, biotechnology, agriculture, and environmental microbiology
- Promote scientific temper and analytical thinking through experiments, case studies, and problem-solving tasks
- Encourage ethical understanding regarding biosafety, bioethics, and responsible use of microorganisms and animals
- Prepare students for higher education, research, or careers in healthcare, diagnostics, and applied microbiology

Unit – I: Parasitology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: General idea** Symbionts, parasites, vectors and hosts	03
2	**Unit 2: Host-Parasite interaction** Host–parasite interactions, Epidemiology of parasitic diseases	04
3	**Unit 3: Protozoology** Classification of parasitic Protozoa General account, morphology, life cycle, pathogenicity, and control of *Plasmodium vivax, Leishmania donovani, Trypanosoma cruzi, Entamoeba histolytica and Giardia lamblia*	07
4	**Unit 4: Helminthology** Introduction to helminthes, General account, morphology, life cycle, pathogenicity, and control of *Schistosoma haematobium, Paragonimus westermani, Taenia saginata, Trichinella spiralis,* and *Dracunculus medinensis*	07
5	**Unit 5: Vector Biology** Vertical and horizontal transmission of pathogens and parasites Cyclo-developmental, propagative, and cyclo-propagative transmission Biology, medical importance, and control of *Aedes, Anopheles, Culex, Phlebotomus, Simulium, Tabanu*s, ticks, and mites	09

Unit – II: Microbiology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Pioneers of Microbiology** Contributions of Leeuwenhoek, Koch, Pasteur, Jenner and Flemming	03
2	**Unit 2**: **Microbial Ecology** Microbial habitat (air, water and soil), Interactions among microbial populations, Microbial community dynamics (Population selection, Succession within microbial communities, Microbial Diversity and stability), Abiotic limitations of microbial growth (Liebig`s Law of the Minimum, Shelford`s Law of Tolerance)	05
3	**Unit 3: Bacteriology** Major characteristics used in bacterial taxonomy, Structure and function of capsule, pili, flagella, cell wall, cell membrane, outer-membrane, plasmid and bacterial chromosome, Bacterial endospore Control of microbes: Physical and chemical agents, chemotherapeutic agents (sulfa drugs and antibiotics)	05
4	**Unit 4: Virology** Structural organization of viruses, Prions and viroids, Lytic cycle of bacteriophages with reference to *E. coli* and T4, Lysogeny, lysogenic conversion, induction and significance	05
5	**Unit 5: Animal and Veterinary Microbiology** Microbial interactions with animals (Marine and freshwater invertebrates, Ruminants), Symbiotic light production, Sulfide based mutualism, Infections of *Escherichia coli, Shigella dysenteriae, Streptococcus pyogenes and Staphylococcus aureus*, Microbial diseases of Cattle and Poultry birds	06
6	**Unit 6: Medical Microbiology** H**ost-**microbe interactions, Factors affecting host-susceptibility, Virulence factors and Pathogenicity islands Mode of transmission, pathogenicity and prevention of microbial diseases: Air-borne (Tuberculosis), food and waterborne (Cholera) and arthropod borne (Dengue and JE)	06

Suggested readings

Alexander, M. (1977). *Introduction to Soil Microbiology*. John Wiley and Sons, New York.

Atlas, R. M. (1984). *Microbiology, Fundamentals and Applications*. Macmillan.

Atlas, R. M. and Bartha, R. (2000). *Microbial Ecology: Fundamentals and Applications.* 4th Ed. Benjamin/ Cummings.

Black, J. G. (2011). *Microbiology: Principles and Explorations.* 8th Ed. John Wiley and Sons, New York.

Bogitsh, B. J. and Cheng, T. C. (2000). *Human Parasitology*. 2nd Ed. Academic Press, New York.

Campbell, R. (1983). *Microbial Ecology*. 2nd Ed. Oxford, Blackwell.

Chatterjee, K. D. (1981). *Parasitology (Protozoology and Helminthology*). 13th Ed. CBS.

Cox, F. E. G. (1993). *Modern Parasitology*. 2nd Ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.

Davis, B. D., Dulbecco, R., Eisen, H. N. and Ginsberg, H. S. (1990). *Microbiology.* 4th Ed. Harper and Row.

Dimmock, N. J. and Primrose, S. B. (1994). *Introduction to Modern Virology*. 4th Ed. Blackwell Scientific Publications. London.

Hati, A. K. (2001). *Medical Entomology*. Allied Book Agency, Kolkata.

Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.
Holt, J. G., Krieg, N. R., Sneath, P. H. A. Staley, J. T. and Williams, S. T. (1994). *Bergey's Manual of Determinative Bacteriology*. 9th Ed. Baltimore (MD): Williams and Wilkins.
Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International.
Maloy, S. R., Cronan, E. J. and Freifelder, D. (1994). *Microbial Genetics*. 2nd Ed. Jones and Bartlett.
Madigan, M., Bender, K, Buckley, D., Sattley, W. and Stahl, D. (2018). *Brock Biology of Microorganisms* 15th Ed. Pearson Education.
Mullen, G. R. and Durden, L. A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.
Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of Animal Parasites.* 6th Ed. Lea and Febiger, Philadelphia.
Pelczar, M. J., Reid, R. D. and Chan, E. C. (1993). *Microbiology.* 5th Ed. Macmillan. London.
Presscott, L. M., Harley, J. P. and Klein, D. A. (2011). *Microbiology*, 8th Ed. McGraw Hill, New York.
Roberts, L. S., Janovy, J. and Nadler, S. (2013). *Gerald D. Schmidt & Lary S. Roberts' Foundation of Parasitology*. 9th Ed. McGraw-Hill International.
Schlegel, H. G. (1993). *General Microbiology*. 7th Ed. Cambridge University Press.
Schmidt, G. D. (1989). *Essentials of Parasitology*. Wm. C. Brown Publishers (Indian print; 1990, Universal Book Stall).
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Slonczeweski, J. L. and Foster, J. W. (2009). *Microbiology – An Evolving Science.* Norton.
Smyth, J. D. (1994). *Animal Parasitology*. 3rd Ed. Cambridge University Press.
Soulsby, E. J. L. (1982). *Helminths, Arthropods and Protozoa of Domesticated Animals.* ELBS and Bailliere Tindall. London.
Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L. (1986). *General Microbiology.* 5th Ed. Macmillan.
Talaro, K. and Talaro, A. (1999). *Foundations in Microbiology*. 3rd Ed. Dubuque, McGraw Hill.
Tortora, G. J., Funke, B. R., and Case. C. L. (2008). *Microbiology. An Introduction*. 9th Ed. Benjamin/Cummings Publishing. Menlo Park Calif.
Voyleys, B. A. (2002). *The Biology of Viruses*. 2nd Ed. McGraw-Hill.
Willey, J., Sherwood, L. and Woolverton, C. J. (2017). *Prescott's Microbiology*. 10th Ed. McGraw Hill Education.

Practical components

Full marks: 20

1. Smear preparation and staining of parasitic Protozoa
2. Whole mount preparation of trematodes
3. Whole mount preparation of mosquito vectors (*Anopheles, Culex* and *Aedes*) and other arthropod parasites (*Pediculus* and *Columbicola*)
4. Identification of parasites and vectors (Slides): based on theoretical part
5. Preparation of liquid media (broth) and solid media for routine cultivation of bacteria
6. Preparation of slant and stab
7. Pure culture techniques: Spread plate, pour plate and streak plate
8. Study on colony morphology
9. Simple staining of bacteria and study of cell types; differential staining: Gram staining
10. Biochemical tests for characterization: Catalase, Nitrate reduction, Indole production, Methyl red and Voges-Proskauer test
11. Preparation of sanitizer
12. Laboratory records
13. Viva-voce

Examination pattern

	Full Marks: 20
1. Any one from 1 and 2	6
2. Any one from 5–11	6
3. Any one from 3 and 4	3
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

After completing this course, students will be able to:

- Identify and describe major groups of parasites (protozoans, helminths, arthropods) and microorganisms (bacteria, fungi, viruses)
- Explain the life cycles and pathogenic mechanisms of important human and animal parasites and microbes
- Perform basic laboratory techniques such as microscopy, culture, staining, and slide preparation safely and accurately
- Interpret experimental and diagnostic results for identifying pathogens and understanding infection processes
- Apply knowledge of epidemiology to propose control and prevention measures for infectious diseases
- Demonstrate understanding of host–pathogen interactions, immunity, and antimicrobial resistance
- Analyse case studies linking microbial or parasitic infections with health and environmental issues
- Communicate scientific information effectively through written reports, presentations, and lab records
- Follow biosafety and ethical guidelines in all laboratory and fieldwork contexts
- Integrate interdisciplinary knowledge to address real-world challenges in health, environment, and agriculture

MAJOR COURSE
PG2ZOOL1014: Immunology
Credits – 6 (Theory: 4, Practical: 2)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

After completion of the course, learners will be able to:

- Understand the fundamental principles of the immune system, including the structure and function of immune organs, cells, and molecules
- Comprehend the mechanisms of innate and adaptive immunity, including antigen recognition, lymphocyte activation, and immune regulation
- Interpret immunological processes underlying health and disease — such as hypersensitivity, autoimmunity, transplantation, and immunodeficiency
- Develop an understanding of applied immunology, including vaccination, immunodiagnostics, monoclonal antibody technology, and immune therapy
- Integrate molecular and cellular concepts to explain immune responses to infectious agents, tumours, and allergens
- Acquire skills in experimental immunology, including immunoassays, antigen–antibody interactions, and modern diagnostic techniques
- Relate immunological knowledge to real-world contexts in medicine, biotechnology, and public health, in alignment with NEP's interdisciplinary and application-oriented focus

Unit – I: Fundamental of Immunology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Immune System Organisation** History and scope of immunology, Features of immune responses, Innate vs adaptive immunity, cells of the immune system; Haematopoiesis; Primary and secondary lymphoid organs; cytokines, chemokines and immune signalling	06
2	**Unit 2: Innate Immunity** Components of the Innate Immune System; Physical and chemical barriers, Innate immune recognition receptors (PAMP, DAMP); Toll-like receptor signalling. The NLR family, Phagocytosis and inflammation (inflammasome). Complement pathways, Natural killer cells, acute phase response. Induction of the anti-viral state	06
3	**Unit 3: Antigens and Antibodies** Antigenicity and immunogenicity, Epitopes and haptens, Superantigens, Structure of immunoglobulins, Antibody classes and functions, Generation of antibody diversity, Antigen-antibody interactions (Precipitations, Agglutination, and Neutralization)	06
4	**Unit 4: Adaptive Immunity** Lymphocyte activation, capture and presentation of antigens; Major Histocompatibility Complex: Types, structure and function, Pathways of antigen processing T Cell and T-cell Receptor: development and selection; Concepts of MHC restriction and cross presentation. T-helper cell subsets (Th1, Th2, and Treg, Th17), Immunological synapse, T cell activation and signalling; co-stimulation (B7:CD28), Targeting co-stimulators for therapy. T cell anergy and exhaustion, cytotoxic T-cell responses	08

5	**Unit 5: Immune Regulation, Tolerance and Autoimmunity** Principles of immune regulation, self-tolerance; Mechanisms of central and peripheral tolerance Autoimmunity and major autoimmune disorders	04

Unit – II: Applied and Clinical Immunology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Immunity in Health and Disease** Immunological basis of health and disease; hypersensitivity reactions (Types I–IV) and their mechanisms; primary and secondary immunodeficiency diseases with special reference to acquired immunodeficiency syndrome (AIDS)	05
2	**Unit 2: Transplantation Immunology** Principles of transplantation; types of grafts; mechanisms of graft rejection and graft-versus-host disease (GVHD); Human Leukocyte Antigen (HLA) system, tissue typing and cross-matching; immunosuppressive therapy and clinical management of transplantation	05
3	**Unit 3: Tumour Immunology** Tumour antigens and immune surveillance mechanisms; interaction between immune system and cancer cells; immune evasion by tumours; principles of cancer immunotherapy including therapeutic antibodies, cancer vaccines and CAR-T cell therapy	06
4	**Unit 4: Immunotechnology and Applications** Monoclonal antibody production using hybridoma technology; principles and applications of immunological techniques including ELISA, Western blotting, flow cytometry and immunofluorescence; applications of immunotechnology in diagnosis and research; principles of conventional and recombinant vaccine design and development	10
5	**Unit 5: Immunisation** Concept and importance of immunisation; active and passive immunisation; types of vaccines and mechanisms of action; adjuvants and vaccine delivery systems; vaccination schedules and strategies; modern and experimental vaccinology; immunisation in special populations; vaccine safety, ethics and regulatory aspects with global and national perspectives	04

Suggested readings

Abbas, A. K., Lichtman, A. H. and Pillai, S. (2018). *Cellular and Molecular Immunology*. 9th Ed. Elsevier.

Abbas, A. K. and Lichtman, A. H. (2019). *Basic Immunology*. 6th Ed. Elsevier.

Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2019). *Immunology*. 8th Ed. W. H. Freeman and Co.

Kuby, J., Kindt, T. J., Goldsby, R. A. and Osborne, B. A. (2019*). Immunology*. W.H. Freeman.

Murphy, K. and Casey W. (2016). *Janeway's Immunobiology*. 8th Ed. Garland Science.

Roitt, I., Brostoff, J. and Male, D. (2022). *Immunology*. 10th Ed. Mosby.

Roitt, I. M. and Delves, P. J. (2017). *Roitt's Essential Immunology*. 13th Ed. Blackwell Science Ltd.

Hofmann, A. and Clokie, S. (Eds.) (2018). *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology*. 8th Ed. Cambridge University Press.

Practical components

Full marks: 20

1. Laboratory biosafety practices and handling of clinical samples
2. Identification of immune cells using blood smear preparation
3. Identification and demonstration of primary and secondary lymphoid organs of mouse
4. Identification and histological examination of mouse spleen, thymus, lymph nodes, bone marrow from histological sections or micrographs
5. Preparation of cell suspension from the lymphoid tissue (primary/secondary) of mouse for the estimation of live and dead cells by trypan blue method
6. Antigen–antibody reactions: Precipitation reaction (Ouchterlony double diffusion/ Radial immunodiffusion)
7. Agglutination test (Widal principle)
8. Demonstration of ELISA ((Direct/ Sandwich) and analysis of ELISA Data
9. Principle and applications of flow cytometry (data interpretation/virtual analysis)
10. Analysis of vaccination schedules and immunisation strategies (national immunisation programme case study)
11. Mini project / group presentation on emerging immunotherapy
12. Laboratory records
13. Viva-voce

Examination pattern

	Full Marks: 20
1. Major Experiment (Performance, result and interpretation) based on 5/6/7	6
2. Minor Experiment based on 2/3/8/9	4
3. Identification based on 4 (any two)	4
4. Laboratory notebook/ Case Study / Assignment	3
5. Viva-voce	3

Course outcomes

Upon successful completion of the course, students will be able to:

- Explain the organization and functioning of the immune system and its components (cells, tissues, organs)
- Differentiate between innate and adaptive immune mechanisms and describe their coordination in immune defense
- Illustrate the processes of antigen presentation, antibody generation, and T- and B-cell activation
- Analyse the immunological basis of vaccination, hypersensitivity, and autoimmune disorders
- Apply immunological techniques such as ELISA, immunofluorescence, Western blotting, and flow cytometry in diagnostics and research
- Evaluate the role of cytokines, MHC molecules, and immune checkpoints in health and disease
- Design and interpret basic immunological experiments and diagnostic assays
- Critically assess recent advances in immunotherapy, immunogenetics, and vaccine development
- Demonstrate awareness of ethical and biosafety issues in immunological research and clinical practice
- Integrate immunology with allied disciplines (microbiology, biotechnology, molecular biology, and public health) to address emerging biomedical challenges
- Integrate traditional and modern immunological knowledge in health contexts

MINOR COURSE
PG2ZOOL1021: Fundamentals of Zoology I
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- To provide advanced and integrated knowledge of Entomology, Parasitology, Ecology, and Fish Biology at the postgraduate level
- To develop conceptual clarity on structure, function, life processes, and adaptations of insects, parasites, and fishes
- To understand ecological principles governing populations, communities, and ecosystems
- To link zoological concepts with applied fields such as public health, agriculture, fisheries, and conservation biology
- To enhance analytical, critical thinking, and problem-solving skills relevant to research and professional practice
- To promote awareness of sustainability, biodiversity conservation, and ecosystem-based management

Unit – I: Entomology and Parasitology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (23)
1	**Unit 1: Entomology** Scope, history, and recent trends in Entomology Classification of insects up to orders with diagnostic characters (Gullan & Cranston, 2004) Detailed study of insect integument, digestive, respiratory, nervous, excretory and endocrine systems Insect development and metamorphosis: hormonal regulation (PTTH, ecdysone, and juvenile hormone) Behaviour in insects: Acoustic communication, social organization, and orientation Economic importance of insects: pollinators, predators, parasitoids, pests, and vectors Integrated Pest Management (IPM): Concept, components, and ecological basis	12
2	**Unit 2: Parasitology** Scope and modern approaches in Parasitology Types of parasites and hosts; host specificity and zoonosis Morphological, physiological, and biochemical adaptations of parasites Life cycles, pathogenicity, and control of selected protozoan and helminth parasites (*Plasmodium*, *Leishmania*, *Entamoeba*, *Ascaris* and *Taenia* – detailed account) Parasitic castration Host–parasite relationship: immunity, antigen–antibody interactions, and co-evolution Epidemiology of parasitic diseases and principles of prevention and control	11

Unit – II: **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (22)
1	**Unit 1: Ecology** Principles and scope of ecology; ecological hierarchy, ecotones, energy flow Population ecology: Characteristics, growth patterns, regulation, and life history strategies Community ecology: Concept of habitat and niche, Fundamental and realized niche, niche width and overlap, multidimensional niche concept, species interactions Ecosystem ecology: Succession, and stability productivity, biogeochemical cycles Conservation biology: Concept of megadiverse countries and biodiversity hotspots, flagship species, keystone species, indicator species, umbrella species, strategies for sustainable exploitation of biodiversity, Concept of Biosphere Reserve, National Park and Wildlife Sanctuary; Biosphere Reserves of India	11
2	**Unit 2: Fish Biology** Introduction to fish biology: Definition and scope of fish biology; Importance of fish in ecology, fisheries, and aquaculture; Diversity of fishes in freshwater and marine environments Classification of fishes up to subclasses (Romer, 1959): Major groups of fishes Chondrichthyes (cartilaginous fishes), Osteichthyes (bony fishes)], Basic characteristics of each group Internal anatomy and physiology: Digestive system and feeding habits, Respiratory system (gills), Excretory and osmoregulatory mechanisms Reproduction and Development: Types of reproduction in fishes, Sexual maturity, breeding behaviour and parental care; Induced breeding, Multiple breeding, Synthetic hormones; Egg development and larval stages Fish ecology and adaptations: Habitat types (freshwater, brackish, marine); Adaptations for swimming, feeding, and survival; Migration in fishes Economic importance of fishes: Role in fisheries and aquaculture, Nutritional value, Importance in livelihood and economy	11

Suggested readings

Atwal, A. S. and Dhaliwal, G. S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th Ed. Cambridge University Press.

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – An Outline of Entomology*. 4th Ed. Blackwell Publishing.

Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International.

Klowden, M. (2013). *Physiological Systems in Insects,* 3rd Ed. Academic Press.

Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management.* Pearson/Prentice Hall.

Cheng, T. C. (1986). *General Parasitology*. 2nd Ed. Academic Press, Inc. Orlando.U.S.A.

Cox, F. E. G. (1993). *Modern Parasitology*. 2nd Ed. Blackwell Scientific Publications. Lea and Febiger, Philadelphia.

Hati, A. K. (2001). *Medical Parasitology*. Allied Book Agency, Kolkata.

Noble, E. R. and Noble G. A. (1989). *Parasitology. The Biology of Animal Parasites.* 6th Ed. Lea and Febiger, Philadelphia.

Schmidt, G. D. and Roberts, L. S. (2001). *Foundation of Parasitology*. 3rd Ed. McGraw Hill Publishers.

Smyth, J. D. (1994). *Animal Parasitology*. 3rd Ed. Cambridge University Press.

Bond, C. E. (1996). *Biology of Fishes*. 2nd Ed. Saunders Publication.

Evans, D. H. (1998). *The Physiology of Fishes*. CRC Press.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd Ed. Hindusthan Publishing Corporation. John Wiley and Sons.
Khanna, S. S., Singh, H. R. (2015). *A Textbook of Fish Biology and Fisheries.* 3rd Ed. Narendra Publishing House, Delhi.
Srivastava, C. B. L. (1999). *Fish Biology*. Narendra Publishing House, Delhi.
Begon, M., Harper, J. L. and Townsend, C. R. (2006). *Ecology: Individuals, Populations and Communities*. 4th Ed. Blackwell Science.
Chapman, R. L. and Reiss, M. J. (1998). *Ecology – Principles and Applications*. 2nd Ed. Cambridge University Press.
Dash, M. C. (2001). *Fundamentals of Ecology*. 2nd Ed. Tata McGraw-Hill Company.
Krebs, C. J. (2009). *Ecology: The experimental analysis of distribution and abundance*. 6th Ed. Benjamin Cummings.
Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th Ed. Thompson Brooks/Cole.
Smith, T. M. and Smith, R. L. (2015). *Elements of Ecology*. 9th Ed. Pearson Education.
Sodhi, N. S. and Ehlich, P. R. (2010). *Conservation Biology for All*. Oxford University Press.
Stiling, P. D. (2014). *Ecology: Global insights and investigations*. 2nd Ed. McGraw-Hill Higher Education.

Practical components

Full marks: 20

1. Quantitative estimation of major physico-chemical components in an ideal aquatic ecosystem: temperature, pH, dissolved oxygen and carbon di-oxide, chloride, hardness and salinity
2. Quantitative estimation of soil edaphic factors and sediment: moisture, pH, phosphates and nitrates
3. Phototaxic movement of earthworm
4. Effects of different stimulants on coughing rate and operculum movement in fish
5. Identification of ecto- and endoparasites (*Plasmodium, Entamoeba, Ancylostoma, Fasciola, Pediculus, Pthirus, Columbicola,* and *Menopon*)
6. Identification of vectors (mosquito, sand fly, biting midge, bedbug, and flea)
7. Identification of common freshwater and marine fishes (*Cyprinus, Puntius, Anabas testudineus, Clarias batrachus, Channa punctata, Harpadon, Hippocampus, Scoliodon*, and *Pristis*)
8. Study of external morphology of a typical bony fish/cockroach
9. Wildlife census techniques: Line transact method, Pug mark analysis
10. Laboratory records
11. Viva-voce

Examination pattern

Full Marks: 20

1. Major Experiment (Performance, result and interpretation) based on 1/2	5
2. Minor Experiment based on 3/4	4
3. Identification of any three based on 5/6/7 (one from each item)	6
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

On successful completion of this course, the students will be able to:

- Demonstrate advanced understanding of insect diversity, structure, physiology, development, and behaviour
- Analyse parasitic adaptations, life cycles, host–parasite relationships, and epidemiology of major parasitic diseases
- Apply ecological principles to explain population dynamics, community interactions, ecosystem functioning, and environmental issues
- Explain fish biology with reference to anatomy, physiology, reproduction, ecology, and evolutionary adaptations
- Evaluate applied aspects of zoology including pest management, disease control, fisheries management, and biodiversity conservation
- Integrate interdisciplinary knowledge to address real-world problems related to health, agriculture, environment, and sustainability

SEMESTER – II

MAJOR COURSE
PG2ZOOL2011: Environmental Biology and Toxicology
Credits – 6 (Theory: 4, Practical: 2)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 15; Practical: 20)

Course objectives

- To develop an advanced understanding of environmental biology with special emphasis on animal–environment interactions
- To analyse ecosystem processes, biodiversity patterns, and environmental stressors affecting fauna
- To understand biological responses of animals to pollution, climate change, and habitat alteration
- To train students in zoological approaches to environmental assessment, monitoring, and conservation

UNIT I: Environmental Biology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Ecosystem Ecology** Ecosystem productivity, Community metabolism, Gaia hypothesis, Global production and decomposition, Microcosms, Macrocosms, Mesoscosms, Ecosystem cybernetics, Ecological footprint, Carbon sequestration	04
2	**Unit 2: Community Structure and Species Interactions** Nature of communities, Community attributes, Interspecific interactions (competition, herbivory, carnivory, pollination and symbiosis), Bioinvasion, Resource partitioning, Character displacement	04
3	**Unit 3: Biogeography and Diversity Pattern** Climate and community structures, Classification of communities, Major terrestrial biomes, Physiographic and biogeographic zones of India, Geological history and historical biogeography of India, Geographic origin of species, Explanation of species richness gradients	05
4	**Unit 4**: **Population Ecology** Population growth with discrete and overlapping generations, Concept of metapopulation – demes and dispersal, Theory of island biogeography	03
5	**Unit 5: Biodiversity and Conservation** Biodiversity: Organic evolution through the geological time scale, Levels of organization in the biological world - molecules to ecosystem, Gradients of biodiversity (latitudinal and insular), Mangroves, Coral reefs, Wetlands and terrestrial diversity, Direct and indirect benefits from biodiversity including ecosystem services, Bioprospecting (molecular techniques like RAPD, RFLP and DNA sequencing), Genetic diversity (sub species, breed, race, varieties and forms, variation of genes and alleles at DNA sequence levels), Threats to biodiversity (species extinction and their drivers - deforestation, land use change, overexploitation, habitat loss, genetic drift and global environmental change) Conservation Biology: Conservation of habitat, Design and management of nature reserve, Concept of corridor, Joint Forest management, Community reserve and conservation reserve, Threats to conservation management of the Himalayan salamander and Fishing Cat, Sundarban Biosphere Reserve, Wildlife conservation in India through post-independence initiative	09

6	**Unit 6: Environmental Management and Impact Assessment** Sustainable development, Environmental Impact Assessment (EIA), Requirement for Impact Assessment, Main steps of Impact Assessment (pre-study, study period and post-study period activities), Concept of Environmental Auditing (EA), Environmental Impact Statement (EIS) and Environmental management plan, Cost-benefit analysis (case studies with particular reference to mining project, cement industry and thermal power plant)	05

UNIT II: Toxicology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Fundamentals of Toxicology** Types of toxic substances (including natural toxins, concept of xenobiotics, mutagens, clastogens, teratogens, and carcinogens) Disposition and biotransformation (phase I and phase II reactions) Drugs as toxic substance (Paracetamol, Aspirin, Thalidomide)	05
2	**Unit 2: Effects of Toxic Substances** Biochemical and physiological effects Interactive effects: additive effects, potentiation and synergism	04
3	**Unit 3: Toxicity Tests** Dose, dosage, dose response Acute toxicity tests: Bioassay, LC_{50} and LD_{50}, Probit analysis and significance Chronic toxicity tests: Methods and significance; Mutagenicity testing (Ames test)	05
4	**Unit 4: Metal Toxicity** Source, exposure, disposition and effects of heavy metals (Cd, Hg, and Pb) and lighter elements (As, Se), Metal chelation	04
5	**Unit 5: Applied Toxicology** Environmental toxicology: Environmental pollutants, fate and transport of toxicants, ecotoxicological effects, environmental risk assessment, pollution prevention and management Occupational and industrial toxicology Clinical toxicology: Sources and routes of poisoning, clinical manifestations, diagnosis Forensic toxicology: Types of poisoning, specimen collection, interpretation of toxicological findings, medico-legal importance	06
6	**Unit 6: Pesticidal Toxicity** Concept and classification Insecticides and herbicides: Types (including bioinsecticides), sources, effects and degradation kinetics Mechanism of action: Organochlorines, Organophosphates, Carbamates, Pyrethroids, Neonicotinoids, Paraquat, and Phenoxy herbicides	06

Suggested readings

Begon, M., Harper, J. L. and Townsend, C. R. (2006). *Ecology: Individuals, Populations and communities*. 4th Ed. Blackwell science.

Calver, M., Lymbery, A., McComb, J. and Mamford, M. (2009). *Environmental Biology*. Cambridge University Press.

Cunningham, W. P. and Cunningham, M. A. (2007). *Principles of Environmental Science: Inquiry and Applications*. 4th Ed. Tata McGraw-Hill Company.

Duffus, J. H. and Worth H. G. J. (Ed.) (2006). *Fundamental Toxicology*. RSC publishing.
Enger, E. D. and Smith, B. F. (2008). *Environmental Science: A study of Interrelationships*. 11th Ed. McGraw-Hill Higher Education.
Fisher, M. R. (2018). *Environmental Biology*. Open Oregon Educational Resources.
Karr, S., Houtman, A. and Interlandi, J. (2018). *Environmental Science for a Changing World*. 3rd Ed. WH Freeman and Company, New York, NY.
Klaassen, C. D. (Ed.) (1996). *Casarett and Daul's Toxicology: The Basic Science of Poisons*. 5th Ed. McGraw-Hill, New York.
Krebs, C. J. (2009). *The Experimental Analysis of Distribution and Analysis Ecology*. 6th Ed. Pearson New International Ed.
Lomolino, M. V., Riddle, B. R., Whittaker, R. J. and Brown, J. H. (2010). *Biogeography*. 4th Ed. Sinauer Associates.
Lu, F. C. (1996). *Basic Toxicology: Fundamentals, Target organs and Risk Assessment*. 3rd Ed. Taylor and Francis.
Odum, E. P. and Barret, G. W. (2005). *Fundamentals of Ecology*. 5th Ed. Thompson Brooks/Cole.
Pandey, K., Shukla, J. P. and Trivedi, S. P. (2005). *Fundamentals of Toxicology*. New Central Book Agency (P) Ltd. Kolkata.
Plant, N. (2003). *Molecular Toxicology*. 1st Ed. Bios Scientific Publishers.
Ricklefs, R. E. and Miller, G. L. (2000). *Ecology*. 4th Ed. W. H. Freeman and Company.
Santra, S. (2005). *Environmental Science*. New Central Book Agency (P) Ltd.
Sher, A. and Gonzlez-sargas, E. (2026). *An Introduction to Conservation Biology*. Oxford University Press.
Smith, R. L. and Smith, T. M. (2001). *Ecology and Field Biology*. Benjamin Cummings Pearson Education.
Smith, T. M and Smith, R. L. (2015). *Elements of Ecology*. Global Ed. Pearson Education.
Sodhi, N. S. and Ehrlich, P. R. (2011). *Conservation Biology for All*. Oxford University Press.
Stiling, P. (2002). *Ecology – Science and Applications*. 2nd Ed. Prentice Hall of India.
Stine, K. E. and Brown, T. M. (2006). *Principles of Toxicology*. 2nd Ed. CRC, Taylor and Francis Group, New York.
Timbrell, J. (2002). *Introduction to Toxicology*. 3rd Ed. Taylor and Francis, London.

Practical components

Full marks: 20

1. Quantitative estimation of major physico-chemical components in an ideal aquatic ecosystem: Dissolved oxygen, Combined carbon di-oxide, Chloride, Hardness and salinity
2. Quantitative estimation of soil edaphic factors and sediment: Phosphates and Nitrates
3. Wildlife census techniques: Line transact method, Pug mark analysis
4. Phototaxic movement of earthworm
5. Effects of different stimulants on coughing rate and operculum movement in fish
6. Determination of LC_{50} and LD_{50}, Probit analysis
7. Evaluation of toxicity through assay of
    (a) Cytochrome P-450 and
    (b) Acetylcholinesterase
    (c) Catalase
8. Assessment of toxicity through behavioural studies of *Drosophila* larvae
    (a) Crawling activity
    (b) Climbing activity
9. Morphological deformities (study of symmetry) in biological organisms due to toxicant exposure
10. Laboratory records
11. Viva-voce

Examination pattern

Full Marks: 20

1. Experiment one (Performance, result and interpretation) based on 1/2/6	7
2. Experiment two (Performance, result and interpretation) based on 4/5/7/8	5
3. Census techniques/deformity analysis based on 3/9	3
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

After successful completion, the learner will be able to:

- Analyse community structure, species interactions, and ecological succession
- Analyse patterns of animal biodiversity and their conservation significance
- Interpret biogeographical patterns and factors influencing species distribution and diversity gradients
- Explain principles of environmental management and conduct basic Environmental Impact Assessment (EIA)
- Explain the toxicokinetic and toxicodynamic processes — absorption, distribution, metabolism, and excretion (ADME)
- Interpret toxicological data and relate dose-response relationships in organisms
- Assess ecological and human health risks using toxicological indices

MAJOR COURSE
PG2ZOOL2012: Entomology
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

After completion of this course, learners will be able to:

- Understand the fundamental principles of insect morphology, anatomy, physiology, and taxonomy
- Comprehend insect diversity and classification, and the evolutionary adaptations responsible for their ecological success
- Analyse insect behaviour and communication, including chemical, acoustic, and visual signalling mechanisms
- Study the ecological roles of insects, including their interactions with plants, animals, and humans
- Identify and describe economically important insects, including pests, vectors, and beneficial species
- Understand and apply concepts of pest management, biological control, and integrated pest management (IPM)
- Explore applied aspects such as forensic entomology, pollination biology, sericulture, apiculture, and insect biotechnology
- Develop laboratory and field-based skills for insect identification, collection, preservation, and experimental analysis
- Relate entomological knowledge to real-world problems in agriculture, medicine, environment, and industry, in alignment with NEP's emphasis on application and skill development

Unit – I: Entomology I **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Insect Diversity and Classification** Insect diversity and adaptive features Outline of classification of Insects up to the orders with examples (After Richards and Davies, 1977 with minor revision)	04
2	**Unit 2: Structure and Function-I** *External organs* Cuticle: Structure, formation Mouthparts: Mechanics and regulation of feeding Antenna: Sensory structures Eyes: Simple and compound, insect vision, receptor physiology Legs: Mechanics of locomotion Wing: Wing coupling, mechanism of flight, kinematics	06
3	**Unit 3: Structure and Function-II** *Internal organs* Alimentary canal: Gut structure, metabolic processes Circulatory system: Structure, haemolymph Tracheal system: Components, mechanisms of gaseous exchange Endocrine systems: Organs, types of hormones Excretory system: Mechanisms of urine formation Reproductive system: Male and female internal reproductive organs, sperm transfer, oviposition	06
4	**Unit 4: Metamorphosis** Types, Hormonal interplay	03

5	**Unit 5: Social organisation** Termites and honey bees Features of eusociality, caste system (Division of labour), communication system, cooperation and mutual care, communication and chemical Control	04

UNIT II: ENTOMOLOGY II **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (22)
1	**Unit 1: Acoustic Communication** Introduction and Concept, Types and Functions of Acoustic Signals, Sound-Producing organs, Mechanisms of sound production, Evolution of Acoustic Systems	02
2	**Unit 2: Chemical Communication** Introduction and concept, types of chemical communication, pheromones and their functions, allelochemicals (allomones, kairomones and synomones) and their functions	04
3	**Unit 3: Bioluminescence** Introduction and concept, bioluminescent organs and physiology, chemical basis of bioluminescence, functions and adaptive significance, applied aspects	02
4	**Unit 4: Insect-plants interactions** Plant structure and chemistry, Insects and host-plant interactions	02
5	**Unit 5: Insect control and management** Insecticides: Classification, mechanism of action (organochlorine, organophosphate, carbamate, pyrethroid and neonicotinoid), resistance Biopesticides, Insect Growth regulators Sterile Insect technique Integrated Pest Management: Concept, Economic Injury Level (EIL), Economic threshold (ET) Transgenic plants	07
6	**Unit 6: Forensic Entomology** Introduction and concept, insects of forensic importance, estimation of post-mortem interval (PMI), insects as indicators of crime scene characteristics, environmental and ecological considerations, collection and preservation of entomological evidence, legal and ethical aspects, applications and case studies	05

Suggested readings

Atwal, A. S. and Dhaliwal, G. S. (2002). *Agricultural pests of South Asia and their management.* Kalyani Publishers, New Delhi.

Chapman, R. F., Simpson, S. J. and Douglas, A. E. (2012). *The Insects: Structure and Function*. 5th Ed. Cambridge University Press.

David, B. V. and Ananthakrishnan, T. N. (2006). *General and Applied Entomology*. Tata McGraw-Hill Publishing.

Gillott, C. (2005). *Entomology*. 3rd Ed. Springer Online Book - ISBN-13 978-1-4020-3183-0 (e-book).

Gullan, P. J. and Cranston, P. S. (2014). *The Insects – An Outline of Entomology*. 4th Ed. Blackwell Publishing.

Gupta, A. P. (2009). *Insect Hemocytes*: *Development, Forms, Functions and Techniques*. Cambridge University Press.

Hoy, M. A. (2003). *Insect Molecular Genetics – An introduction to principles and Applications.* 2nd Ed. Academic Press.
Kettle, D. S. (1995). *Medical and Veterinary Entomology*. 2nd Ed. CAB International.
Klowden, M. (2013). *Physiological Systems in Insects*, 3rd Ed. Academic Press.
Mullen, G. R. and Durden, L. A. (2009). *Medical and Veterinary Entomology.* 2nd Ed. Academic Press.
Nation, J. L. Sr. (2016). *Insect Physiology and Biochemistry*. 3rd Ed. CRC Press. Taylor and Francis.
Pedigo, L. P. and Rice, E. M. (2009). *Entomology and Pest Management.* Pearson/Prentice Hall.
Rechcigl, J. E. and Rechcigl, N. A. (1998). *Biological and Biotechnological control of Insect pests.* Lewis Publishers.
Richards, O. W. and Davies, R. G. (1977). *Imms: A General Textbook of Entomology*. 10th Ed. Vol. 1 and 2. Chapman and Hall.
Romoser, S. W. and Stoffolano, J. G. (1998). *The Science of Entomology*. 4th Ed. McGraw Hill.
Schoonhoven, L. M., van Loon J. J. A. and Dicke, M. (2006). *Insect-Plant Biology*. 2nd Ed. Oxford University Press.
Speight, M. R., Hunter, M. D. and Watt, A. D. (2008). *Ecology of Insects: Concepts and Applications*. 2nd Ed. Wiley-Blackwell.
Srivastava, K. P. and Dhaliwal, G. S. (2013). *A Textbook of Applied Entomology.* 1st Ed. Kalyani Publishers, New Delhi.

Practical components

Full marks: 20

1. Digestive system of Honeybee, grasshopper
2. Nervous system of Honeybee, grasshopper
3. Mounting and study of:
   Mouthparts of grasshopper, plant bug, mosquito, house fly, and bee
   Wings of Ephemeroptera, Odonata, Dictyoptera, Thysanoptera, Hemiptera, Diptera, Hymenoptera, and Coleoptera
   Legs: Gressorial, cursorial, saltatorial, fossorial, natatorial, corbiculate, clasporial, and raptorial
   Antennae: Filiform, setaceous, plumose, pilose, pectinate, clavate, geniculate, aristate, stylate, serrate, and monilifom
   Abdominal appendages: Genitalia of grasshopper, plant bug, non-biting midge, and mosquito
4. Identification of common pests: Paddy (*Nilaparvata lugens*, *Nephotettix* spp., *Leptocorisa* spp. and *Scirpophaga incertulas*); Jute (*Apion corchori* and *Spilosoma obliqua*); vegetables (*Epilachna* sp.); stored grains (*Sitophilus oryzae*, *Callosobruchus chinensis* and *Tribolium castaneum*)
5. Identification of forensically/medicolegally important insects: Diptera: *Lucilia*, *Sarcophaga* and *Musca*; Beetles: staphylinid beetle, histerid beetle, skin beetle and carrion beetle
6. Social Insects: Morphological studies of different castes of social insects (Honeybee and termite)
7. Submission of prepared slides and pests
8. Laboratory records
9. Viva-voce

Examination pattern

Full Marks: 20

1. Any one from item no. 1/2	5
2. Identification from item no. 4	(2×2)=4
3. Identification from item no. 5	(2×1)=2
4. Identification from item no. 6	(2×1)=2
5. Submission based on item no. 3	2
6. Laboratory notebook	2
7. Viva-voce	3

Course outcomes

Upon successful completion of the course, students will be able to:

- Explain the structure, function, and classification of major insect groups
- Identify insects to family or genus level using morphological keys and diagnostic features
- Describe the physiological systems of insects — digestion, respiration, circulation, excretion, and reproduction
- Analyse patterns of insect development, metamorphosis, and reproductive strategies
- Interpret insect behaviour, communication, and social organization (e.g., termites, honeybees)
- Apply entomological knowledge in pest management, apiculture, sericulture, lac culture, and forensic science
- Demonstrate skills in insect collection, preservation, and experimental design for entomological research
- Critically assess environmental, ethical, and sustainability aspects of insect use and management
- Integrate basic and applied entomological concepts to address agricultural, environmental, and public health challenges

MAJOR COURSE
PG2ZOOL2013: Fish Biology and Fisheries
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- Understand the biology of fishes, including their morphology, anatomy, physiology, and adaptations to aquatic life
- Explore fish diversity and classification, emphasising economically important species in India
- Examine the principles of fish ecology, reproduction, growth, and behaviour
- Develop knowledge of fisheries science, including capture and culture fisheries, fish farming, and fishery management practices
- Introduce modern technologies in fish breeding, aquaculture, and resource conservation
- Foster entrepreneurial and skill-based learning, encouraging students to develop sustainable fishery and aquaculture ventures in line with NEP's vocational and multidisciplinary goals

Unit – I: Fish Biology **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (23)
1	**Unit 1: Classification of Fish** Principles of classification, extinct fish groups, distinctive characters of major fish orders: Cypriniformes, Siluriformes, Clupeiformes, Perciformes, Synbranchiformes, and Mugiliformes	02
2	**Unit 2: Structure, Development, Comparative Account, and Functions** Integument – mucogenic and keratinised, scale, bioluminescent organ, electric organs and electroreception, poison gland, swim bladder, Weberian ossicles, digestive system, excretion and osmoregulatory system	04
3	**Unit 3: Sense Organs** Eye and photoreception, olfactory organ, and chemoreception, acoustico-lateralis system (membranous labyrinth and lateral line), special sense organs (Ampullae of Lorenzini, Pit Organs)	04
4	**Unit 4: Endocrine System** Hypothalamo-hypophyseal system, Hypothalamic nucleus, Pituitary gland (Origin, location, anatomy and functional morphology, hormones), other endocrine glands (structure and functions): Thyroid, Corpuscles of Stannius, Ultimobranchials, Caudal neurosecretory system and Pineal (Endocrine function of the gonads)	05
5	**Unit 5: Reproduction and Development** Structure and functions of reproductive organs, gametogenesis, types and modes of reproduction, sexuality (intersex, bisexuality, hermaphroditism); breeding and parental care	04
6	**Unit 6: Fish Migration** Purpose and types of migration in fish, physiological factors controlling iono- and osmoregulation, energetics, environmental factors, anthropogenic impacts	04

Unit – II: Fisheries **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (30)
1	**Unit 1: Concepts of Fisheries and Aquaculture** Present status, scope, and possibilities of further development Fisheries resources, Nutritive value of fish Different culture systems (extensive, intensive, semi-intensive, fresh water, brackish water, coastal, hill stream, cage, pen, and race way)	04
2	**Unit 2: Inland Fisheries** Cultivable fishes, construction of pond, pond soil and water. Pond management for different stages of carp: Physico-chemical properties of pond water and soil and their maintenance, manuring (organic and inorganic) and liming, eradication of predatory and weed fish, and predatory insect, aquatic weeds: classifications and their control Induced breeding of carp, prawn and air breathing fish, Multiple breeding of carp, synthetic hormones Composite fish farming and polyculture, carrying capacity, stocking density, culture of air-breathing and carnivorous fish Inland fishing gears and fishing methods	06
3	**Unit 3: Ornamental Fish Culture and Aquarium Management** Design and construction of aquarium, common ornamental fishes, breeding and seed production (live bearers and egg layers), aquarium plants, maintenance, and water quality management	04
4	**Unit 4: Aquaculture Biotechnology** Aquaponics and hydroponics, hybridization and transgenic fish, pearl culture: composition of pearl, formation of natural pearl, nucleus insertion and pearl culture technology, oyster farming, fish oil: composition, extraction and purification	04
5	**Unit 5: Marine Fisheries** Resources, marine zonation, principal capture fisheries (Hilsa, Sardine, Mackerel, Bombay Duck, and Pomfrets), elasmobranch fishery (major groups, fishing methods, importance), molluscan fishery	04

Suggested readings

Bardach, J. E. and Ryther, J. H. (1972). *Aquaculture*. John Wiley and Sons.

Beaumont, A. R. and Hoare, K. (2003). *Biotechnology and Genetics in Fisheries and Aquaculture*. Blackwell Publishing.

Bond, C. E. (1996). *Biology of Fishes*. 2nd Ed. Saunders Publication.

Dunham, R. A. (2004). *Aquaculture and Fisheries Biotechnology: Genetic Approaches*. CABI Publishing, Cambridge, USA.

Evans, D. H. (1998). *The Physiology of Fishes*. CRC Press.

Hoar, W. S. and Randall, D. J. (Eds.). (1969–). *Fish Physiology*. Volumes I-XV, Academic Press, New York.

Jayaram, K. C. (1999). *The Freshwater Fishes of the Indian Region*. Narendra Publishing House, New Delhi.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd Ed. Hindusthan Pub. Corp. John Wiley and Sons.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd Ed. Hindusthan Publishing Corporation. John Wiley and Sons.

Khanna, S. S. and Singh, H. R. (2015). *A Textbook of Fish Biology and Fisheries.* 3rd Ed. Narendra Publishing House, Delhi.
Lagler, K. F., Bardach, J. E., Miller, R. R. and Passino, D. R. (1977). *Ichthyology*. 2nd Ed. John Wiley & Sons, New York.
Lowe, H. (2005). *Beginner's Guide to Aquarium Fish and Fish Care*. Abhishek Press, New Delhi.
Parker, R. (2012). *Aquaculture Science*/ 3rd Ed. Delmar, Cengage Learning, USA.
Pillay, T. V. R. and Kutty, M. N. (2005). *Aquaculture Principles and Practices*. 2nd Ed. Blackwell Publishing Ltd.
Reddy, P. V. G. K., Ayyappan, S., Thampy, D. M. and Krishna, G. (2005). *Textbook of Fish Genetics and Biotechnology*. ICAR, New Delhi.
Srivastava, C. B. L. (1999). *Fish Biology*. Narendra Publishing House, Delhi.

Practical components

Full marks: 20

1. Study of bucco-pharynx, gill rakers and gut content analysis in relation to food habits of teleosts
2. Urinogenital, olfactory and digestive systems in teleosts
3. Gas (swim or air) bladder and Weberian ossicles, Pituitary gland, Accessory respiratory organs
4. Histological preparation of testis, ovary, kidney, pituitary, hepato-pancreas and intestine of any major carp
5. Identification of different fish up to genus level under different major fish orders mentioned in theoretical part
6. Laboratory records
7. Submission of prepared slides
8. Viva-voce

Examination pattern

	Full Marks: 20
1. Study of food and feeding habit / organ systems	5
2. Weberian ossicles/ Pituitary gland/ Accessory respiratory organ	4
3. Identification of fish / histological slides (any two)	4
4. Submission based on item no. 4	2
5. Laboratory notebook	2
6. Viva-voce	3

Course outcomes

By the end of the course, students will be able to:

- Explain the taxonomy, morphology, and anatomical features of fishes
- Describe the physiological adaptations, feeding, and reproductive biology of fishes
- Identify and classify common freshwater and marine fish species based on diagnostic characteristics
- Understand the principles and methods of capture, culture, and ornamental fisheries
- Analyse fish growth, breeding, and population dynamics in relation to environmental factors
- Apply sustainable management and conservation practices in fisheries
- Demonstrate practical skills in fish handling, identification, and aquaculture techniques
- Evaluate the economic and ecological importance of fisheries resources
- Develop entrepreneurship and employability skills related to aquaculture, hatchery management, and fish marketing
- Exhibit awareness of environmental sustainability, biodiversity conservation, and ethical fishery practices

MAJOR COURSE
PG2ZOOL2014: Indian Knowledge System
Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- To introduce students to the principles of **I**ndian Knowledge Systems (IKS) related to animals, biodiversity, and aquatic resources
- To understand the indigenous knowledge of animals among Indian tribes, including folk taxonomy, cultural practices, and traditional medicinal uses
- To explore the role of religious beliefs, sacred traditions, and cultural ethics in biodiversity conservation
- To familiarise students with traditional veterinary practices, animal care, and behavioural observations practiced by indigenous communities
- To examine entomophagy in tribal societies, including its cultural, ecological, and nutritional significance
- To understand the nutritional value, medicinal uses, and traditional processing methods of edible insects
- To study indigenous fishing techniques, fish culture, and fish processing methods practiced in different parts of India
- To highlight the importance of community-based fisheries management and sustainable resource use based on traditional ecological knowledge
- To develop awareness about bioethics, animal welfare, biodiversity conservation policies, and issues of biopiracy related to traditional knowledge

Unit – I: **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (23)
1	**Unit 1: Ethnozoology and Indigenous Taxonomy** Indigenous knowledge of animals among Indian tribes Use of animals in folklore, rituals, and cultural practices Animal-based traditional medicine (Ayurveda, Siddha and Unani) Folk classification, traditional nomenclature, and biodiversity documentation by local communities	05
2	**Unit 2: Cultural Ethics and Biodiversity Conservation** Biodiversity and human welfare, Traditional knowledge of nutritive and medicinal value of indigenous foods Sacred groves, sacred tanks, temple tanks, totemic species, religious conservation practices, Role of folk music and drama and oral legends, Ancient Indian paintings (Rajasthani, Pahari, Deccan and Bengal School) Biodiversity and human welfare Role of religious ethos in conservation Ancient Indian views on coexistence with animals (Ahimsa, compassion and ecological ethics)	07
3	**Unit 3: Traditional Veterinary and Behavioral Knowledge** Animal care, breeding, and ecological observations	02

4	**Unit 4: Entomophagy in Indian Tribes** Traditional ecological knowledge related to edible insects Practices among tribes of North-East, Central, and South India Identification, harvesting, and seasonal availability of edible insects Cultural beliefs, rituals, and food traditions associated with insect consumption Entomophagy as a sustainable protein source	06
5	**Unit 5: Nutritional Significance, Traditional Processing and Preservation Methods of Insects** Nutritional composition of edible insects; health benefits and dietary importance Collection, preservation, cooking, and storage methods Medicinal and therapeutic uses of insects	03

Unit – II: **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (22)
1	**Unit 1: Traditional Fishing Techniques:** Indigenous fishing gears such as nets, traps, bamboo devices, hooks and lines; Community-based fishing methods used in rivers, lakes, ponds, and wetlands; Seasonal and eco-friendly fishing practices	03
2	**Unit 2: Indigenous Fish Culture Practices:** Traditional pond preparation and water management, Use of natural feed, organic manure, and plant-based inputs in fish culture, Indigenous methods of fish seed collection and stocking	04
3	**Unit 3: Traditional Fish Processing and Preservation:** Indigenous preservation methods such as drying, salting, smoking, and fermentation; Traditional storage and local marketing practices	05
4	**Unit 4: Community-Based Fisheries Management:** Role of fishermen communities in managing aquatic resources; Traditional rules, customs, and beliefs for conservation of fish stocks; Role of IKS in sustainable fisheries and rural livelihood development	05
5	**Unit 5: Bioethics and Biodiversity Policy** Bioethics, Biopiracy, animal welfare, and biodiversity policy (NBA 2002, Nagoya Protocol)	05

Suggested readings

AICTE (2021). *Indian Knowledge System (IKS): A Course Introduction*.

Berkes, F. (2018). *Sacred Ecology*. 4th Ed. Routledge.

Capra, F. (1996). *The Web of Life: A New Scientific Understanding of Living Systems*.

Chakravorty, J., Ghosh, S., Jung, C., and Meyer-Rochow, V. B. (2014). *Entomophagy: A Custom of Consuming Insects among Tribes of Arunachal Pradesh, India.* In: R. K. Mishra (Ed.), Recent Advances in Entomological Research: From Molecular Biology to Pest Management. Springer India, New Delhi, pp. 65–81.

FAO (2014). *Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries (SSF Guidelines).*

FAO. (1990). *Fishing Gear and Methods*. FAO Fisheries Technical Papers.

Gadgil, M. and Guha, R. (1993). *This Fissured Land: An Ecological History of India*. 1st Ed. University of California Press.

Govindan, T. K. (1985). *Fish Processing Technology.* Oxford & IBH.

Govt. of India (IKS Division, MoE). *Indian Knowledge System Framework and Guidelines.*

Jain, S. K. (1996). *Ethnobiology in Human Welfare*. Deep Publications, New Delhi.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd Ed. Hindustan Publishing Corporation, New Delhi.

Kurien, J. (2003). *Community Institutions for Fisheries Management.*

National Biodiversity Authority (NBA). *The Biological Diversity Act, 2002 and Rules.*

Pillay, T. V. R. and Kutty, M. N. (2005). *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell Publishing.

Sastri, P. V. S. and Bhat, M. R. (1947). *Varahamihira's Brihat Samhita*. M.B.D. Electric Printing Works, Bangalore.
Sateesh, M. K. (2017). *Bioethics and Biosafety*. I.K. International Publishing House.
Sen, S. (2022). *Indian Knowledge Systems: Concepts and Applications*. NCERT/UGC.
Sharma, P. V. (2004). *History of Medicine in India: Ayurveda through the Ages*.
Singh, K. and Sharma, A. (2020). *Insects as Food and Feed: An Indian Perspective.*
Singh, K. P. (2018). *Ethnozoology of India*. Springer.
Srivastava, S. (2013). *Ethnozoology and Indian traditional food systems.*
UGC IKS Resource Modules / MOOC materials.
UNESCO. (2005). *Universal Declaration on Bioethics and Human Rights.*
Van Huis, A. et al. (2013). *Edible Insects: Future Prospects for Food and Feed Security*. FAO.

Practical components

Full marks: 20

1. Preparation of a report (2,000–2,500 words) based on: Field visit on indigenous knowledge of animals among local communities, documenting folk taxonomy, traditional uses, and cultural significance// OR Case study on a sacred grove, sacred pond/tank, or culturally protected animal species//OR Documentation of indigenous practices like indigenous fishing techniques, traditional fishing gears, and sustainable fishing practices// OR Study of traditional methods of fish processing and preservation such as drying, salting, smoking, or fermentation practiced in the locality// OR Survey traditional ecological knowledge related to edible insects, including identification, harvesting methods, seasonality, processing, and cultural practices// OR Prepare a People's Biodiversity Register documenting locally important animals, fishes, or edible insects along with their traditional uses and local names.
2. Oral presentation (8–10 minutes) using PowerPoint or other suitable visual aids, highlighting the objectives, methodology, findings, and significance of the chosen topic.
3. Assessment of conceptual understanding, analytical ability, and response to questions related to the report and presentation.

Examination pattern

Full Marks: 20

1. Report submission	10
2. Presentation	05
3. Interaction/Viva-voce	05

Course outcomes

By the end of this course, students will be able to:

- Explain the role of indigenous knowledge in understanding animal diversity, folk taxonomy, and traditional uses of fauna
- Analyse the relationship between culture, religion, and biodiversity conservation, including sacred groves, totemic species, and ethical principles such as Ahimsa
- Describe traditional practices of animal care, breeding, and ecological observation used by indigenous communities
- Identify edible insect species and evaluate the cultural and nutritional significance of entomophagy in different tribal regions of India
- Assess the nutritional, medicinal, and therapeutic importance of insect**s** and their traditional methods of processing and preservation
- Recognise indigenous fishing techniques and fish culture practices and evaluate their ecological sustainability
- Explain traditional fish processing, preservation, and marketing systems used in rural and tribal communities
- Evaluate community-based fisheries management practices and their role in sustainable livelihood and conservation
- Discuss ethical and legal issues related to biodiversity conservation, including bioethics, animal welfare, biopiracy and national/international policies

MINOR COURSE

PG2ZOOL2021: Fundamentals of Zoology II

Credits – 4 (Theory: 3, Practical: 1)

Full Marks. 75 (Theory: 40; Internal Assessment (Evaluation+Attendance): 10+05=15; Practical: 20)

Course objectives

- To impart comprehensive knowledge of molecular biology, cell biology, genetics, immunology, biochemistry, and physiology
- To develop an integrated understanding of structure–function relationships at molecular, cellular, and organismal levels
- To strengthen analytical and problem-solving skills relevant to modern biological research
- To familiarise students with regulatory mechanisms underlying metabolism, immunity, and physiological processes
- To promote interdisciplinary thinking and application of biological concepts in health, biotechnology, and life sciences

Unit – I: **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (23)
1	**Unit 1: Molecular Biology** Organization of genetic material: DNA structure, properties, and types DNA replication, transcription, and translation: enzymes and regulation Gene regulation in prokaryotes and eukaryotes (operon concept, epigenetic regulation – overview) Recombinant DNA technology: Basic tools and applications	08
2	**Unit 2: Cell Biology** Prokaryotic and eukaryotic cell organisation Structure and functions of cell membrane, nucleus, mitochondria, ER, Golgi complex, lysosomes, and cytoskeleton Cell cycle and its regulation; checkpoints and apoptosis Cell signaling and communication (receptors and second messengers) Cellular malfunction and disease (cancer)	07
3	**Unit 3: Cytogenetics and Genetics** Mendelian and non-Mendelian inheritance Chromosomal aberrations (numerical and structural) Chromosomal disorders: Down syndrome, Turner syndrome, Klinefelter syndrome, Cri du chat syndrome, Chronic Myelogenous Leukemia, Burkitt lymphoma Single-Gene Disorders: Sickle cell anaemia, haemophilia, Huntington's disease	08

Unit – II: **Full Marks: 20**

Four questions (out of six) of 1 mark each, two questions (out of four) of 4 marks each and one question (out of two) of 8 marks are to be answered

Sl No.	Topics	Lectures (22)
1	**Unit 1: Clinical Immunology** Components of the immune system: innate and adaptive immunity Antigens, antibodies, and antigen–antibody interactions Tissue transplantation and graft rejection: Types of grafts; Immunological basis of graft rejection; Role of histocompatibility antigens (MHC) Types of hypersensitivity reactions; Mechanism of allergic diseases such as allergy Concept of immune tolerance; Autoimmune disorders with examples Immunodeficiency Disorders Principles of vaccination; Types of vaccines and immunisation programmes Basic diagnostic techniques such as ELISA and antigen detection	08
2	**Unit 2: Clinical Biochemistry** Composition and functions of blood plasma; Major biochemical constituents of blood (glucose, proteins, lipids, and electrolytes) Regulation of blood glucose; Hyperglycemia and hypoglycaemia; Biochemical basis of diabetes mellitus Plasma proteins and their functions; Albumin and globulin ratio; Protein abnormalities in disease Cholesterol and lipoproteins; HDL, LDL and triglycerides; Clinical significance in atherosclerosis Urea, creatinine, and uric acid; Biochemical indicators of kidney disease Role of hormones in metabolism; Thyroid function tests and metabolic regulation	07
3	**Unit 3: Physiology** Concept of homeostasis and internal environment Hemostasis and blood clotting, cardiac cycle and regulation of blood pressure Structure of respiratory organs; Mechanism of breathing (inspiration and expiration); Exchange and transport of respiratory gases; Regulation of respiration Structure and function of kidneys; Formation of urine; Regulation of water and electrolyte balance Structure and functions of neurons; Nerve impulse transmission and synapse Endocrine glands and hormones; Hormonal regulation of physiological processes Concept of thermoregulation; Role of the hypothalamus in temperature regulation; Thermoregulation in ectotherms and endotherms; Physiological responses to high and low temperatures and altitudes	07

Suggested readings

Abbas, A. K. and Lichtman, A. H. (2019). *Basic Immunology*. 6th Ed. Elsevier.

Berg, J. M., Tymoczko, J. L., Gatto, G. J. Jr. and Stryer, L. (2015). *Biochemistry*. 8th Ed. W.H. Freeman and Co., New York.

Brooker, R. J. and Robert, J. (2024). *Genetics: Analysis and Principles*. 8th Ed. Mc Graw Hill.
Bruce, A., Dennis, B., Levis, J., Martin, R., Keith, R. and Watson, J. (2008). *Molecular Biology of the Cell*. 5th Ed. Garland Publishing Inc., New York and London.
Campbell, M. K., Farrell, S. O. and McDougal, O. M. (2018). *Biochemistry*. 9th Ed. Cengage.
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Cooper, G. M. and Hausman, R. E. (2009). *The Cell: A Molecular Approach*. 5th Ed. ASM Press and Sunderland, Washington, D.C.; Sinauer Associates, MA.
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Goldsby, R. A., Kindt, T. J., Kuby, J. and Osborne, B. A. (2019). *Immunology*. 8th Ed. W. H. Freeman and Co.
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Practical components

Full marks: 20

1. Isolation of DNA from plant/animal tissues
2. Qualitative tests for DNA and RNA
3. Demonstration of agarose gel electrophoresis
4. Demonstration of PCR and blotting techniques
5. Study of mitosis from onion root tip
6. Study of meiosis from grasshopper testis lobes
7. Problems of Linkage maps in *Drosophila*
8. Pedigree analysis for inherited traits
9. Identification of chromosomal aberrations using karyotypes/photographs
10. Study of blood cells and differential leukocyte count (DLC)
11. Demonstration of antigen–antibody reactions (agglutination/precipitation)
12. Demonstration of immunological techniques (ELISA)

Examination pattern

Full Marks: 20

1. One question from item 5/6/10	6
2. One question from item nos. 7/8	5
3. Identification from item no. 9	4
4. Laboratory notebook	2
5. Viva-voce	3

Course outcomes

Students will be able to:

- Explain molecular mechanisms governing gene expression
- Describe cellular organization and regulatory pathways
- Analyse genetic principles and their applications in biology
- Explain immune mechanisms and their biological significance
- Understand biochemical pathways and metabolic regulation
- Interpret physiological processes maintaining homeostasis
- Perform basic laboratory techniques in molecular, cellular, and functional biology
- Analyse experimental observations related to genetics, immunology, biochemistry, and physiology
- Interpret biological data and present results in a scientific manner
- Demonstrate laboratory safety, precision, and ethical practices