MAHARAJA SURAJMAL BRIJ UNIVERSITY
BHARATPUR, RAJASTHAN

MASTERS IN ZOOLOGY

(TWO YEARS)

PROGRAM BROCHURE

SYLLABUS

M.Sc. (ZOOLOGY)

(Semester Scheme)

(For University and Affiliated Colleges)

Proposed to be implemented from

Academic Session: 2025–2026

Syllabus based on CBCS, NEP 2020 Frame Work For the

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I & II Semester Examination 2025-26
III & IV Semester Examination 2026-27
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I. Introduction to NEP 2020

National Education Policy (NEP) 2020

The courses have been structured to foster interdisciplinary learning, research-oriented education and curricular flexibility. The revised design emphasizes skill development, critical thinking and experiential learning, ensuring alignment with global academic standards and emerging industry demands. It promotes academic mobility and lifelong learning, while integrating innovative pedagogical practices and digital learning tools. In consonance with the National Education Policy (NEP) 2020, this reform seeks to enhance student employability, innovation capacity and holistic understanding of the discipline.

Choice Based Credit System (CBCS)

The curriculum based on CBCS pattern provides an opportunity to the students to choose from a range of prescribed courses based on their interests. The CBCS course structure comprises of the core and elective/minor or skill-based content and the evaluation is based on the grading system, which is considered better than the conventional marks system. The grading system provides uniformity in evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations, which may help students to move across institutions of higher learning. The uniformity in evaluation system can be helpful to employers in assessing the performance of the candidates.

Definitions:

(i) '**Academic Programme**' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department or jointly under more than one such Department.

(ii) '**Course**' means a segment of a subject that is part of an Academic Programme.

(iii) '**Programme Structure**' means a list of courses (Core, Elective, Skill-based Course etc.) that makes up an academic programme, specifying the syllabus, credits, hours of teaching, evaluation and examination scheme, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University rules, eligibility criteria for admission.

(iv) '**Core Course**" means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course.

(v) **'Elective Course'** means an optional course to be selected by a student out of such courses offered in the same or any other Department.

(vi) PG **'General Elective'** means an elective course which is available for students of all programs other than students of same department. Students of other Department will opt these courses subject to fulfilling of eligibility of criteria as laid down by the Department offering the course.

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(vii) **'Credit'** means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course.

(viii) **'SGPA'** means Semester Grade Point Average calculated for individual semester.

(ix) **'CGPA'** is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.

(x) **'Grand CGPA'** is calculated in the last year of the two-year course by clubbing together the CGPA of two years, i.e., four semesters. This cumulative grade point average, presented in the form of a Transcript, is a comprehensive reflection of the student's academic performance throughout the program. To benefit the student, a formula for converting the Grand CGPA into percentage marks is provided in the Transcript, aiding in their future academic and career pursuits.

Programme Objectives (POs)

The **M.Sc. Zoology** programme aims to provide an in-depth and interdisciplinary understanding of animal life, integrating classical zoological principles with modern scientific approaches. The programme is designed to:

- **Build Strong Foundations:** Provide comprehensive knowledge of animal structure, function, diversity, evolution and classification through core papers such as *Taxonomy and Biosystematics, Comparative Animal Physiology, Cell and Molecular Biology* and*Developmental Biology*.
- **Foster Research and Analytical Skills:** Develop scientific temper, critical thinking and problem-solving abilities through experimental design, data analysis and interpretation of biological systems at cellular, molecular, organismal and ecosystem levels.
- **Encourage Interdisciplinary Learning:** Integrate traditional zoological knowledge with modern disciplines such as *Molecular Genetics, Genomics, Biotechnology, Bioinformatics, Chronobiology* and*One Health*, fostering an understanding of current trends in life sciences.
- **Promote Hands-on Training and Technical Proficiency:** Ensure practical competency through intensive laboratory sessions, fieldwork and internships, providing exposure to contemporary tools and techniques in biological and ecological research.
- **Cultivate Ethical and Environmental Responsibility:** Instil ethical values, sustainability awareness and social responsibility in addressing issues related to animal welfare, biodiversity conservation and environmental management.
- **Prepare for Professional and Academic Careers:** Equip students with knowledge and skills for diverse career paths in academia, research, biotechnology, healthcare, environmental consultancy, wildlife conservation and public policy.
- **Encourage Lifelong Learning and Innovation:** Promote curiosity, creativity and an aptitude for continuous learning, encouraging students to contribute to scientific discovery, innovation and societal well-being.

Programme Specific Outcomes (PSOs)

Upon successful completion of the **M.Sc. Zoology** programme, students will be able to:

- **Demonstrate Advanced Knowledge:** Exhibit in-depth understanding of animal physiology, molecular and cellular processes, genetics, developmental biology and ecological systems.

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- **Apply Molecular and Analytical Techniques:** Skilfully perform and interpret laboratory experiments involving microscopy, molecular markers, genetic engineering and bioinformatics tools.
- **Integrate Interdisciplinary Concepts:** Apply integrated knowledge from *biochemistry, genetics, molecular biology, biotechnology andecology* to address real-world biological and environmental challenges.
- **Analyse and Interpret Biological Data:** Critically evaluate biological phenomena using quantitative and qualitative analytical methods and effectively communicate scientific results through written and oral presentations.
- **Conduct Independent and Ethical Research:** Design, execute and report scientific investigations adhering to ethical standards and biosafety regulations, demonstrating proficiency in project management and research documentation.
- **Address Emerging Global Challenges:** Utilize understanding from elective specializations (e.g., *Animal Behaviour, Chronobiology, Environmental Biology, Biotechnology, Neuroscience, Wildlife Conservation andCancer Biology*) to contribute to One Health initiatives and sustainable development.
- **Develop Professional Competence:** Apply zoological knowledge in professional contexts such as teaching, laboratory research, biodiversity management, biotechnology industries and policy frameworks.
- **Engage in Lifelong Learning and Innovation:** Continue advancing skills through research, training and interdisciplinary collaboration, contributing to scientific innovation and societal progress.

Eligibility for Admissions in M.Sc. Zoology programme:

This course is open to students who have studied Zoology, Biological Sciences or Life Science in B.Sc. and admission to the M.Sc. Zoology programme shall be governed by the rules and regulations framed by the Commissionerate of College Education (CCE), Rajasthan, Jaipur and Maharaja SurajmalBrij University, Bharatpur. Only those candidates who satisfy the minimum eligibility criteria prescribed by the University shall be considered for admission.

Assessment of Students' Performance and Scheme of Examination:

1. Examination Schedule

Examinations shall be conducted at the end of each semester as per the **Academic Calendar** notified by **Maharaja SurajmalBrij University (MSBU), Bharatpur**.

2. General Scheme of Examination (NEP-2020 Aligned)

A. Continuous Assessment (CA)

- Each semester shall include **continuous assessment** for both **theory** and **practical** components.
- The assessment shall comprise **internal tests, seminars, assignments, oral/viva-voce examinations** and evaluation of **class performance and regularity**.
- A candidate must secure the **minimum prescribed grade** separately in **CA** and **End of Semester Examination (EoSE)** to qualify in each paper.

B. End of Semester Examination (EoSE)

- Each **theory paper** shall carry **100 marks**, with **20% weightage** from CA and **80% weightage** from the EoSE.

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- The **EoSE** shall be of **3 hours duration**.
- The question paper shall consist of **five questions** in total:
  - **Part A:** Eight short-answer questions (2 marks each) covering the entire syllabus to assess conceptual understanding and application.
  - **Part B:** Four descriptive questions (16 marks each), one from each unit, with **internal choice**.

C. Laboratory Examination

- Each practical examination shall be of **4 hours duration**, comprising **laboratory experiments/exercises, record evaluation and viva-voce**.
- Evaluation shall be conducted in a **1:1 ratio** between **experimental work** and **viva-voce/record assessment**.
- Practical examinations shall be conducted by a **Board of Examiners** consisting of **one Internal Examiner** (appointed by the Head of Department) and **one External Examiner** (appointed by the University).

D. Medium of Instruction

- The **medium of instruction and examination** shall be **English only**.

E. Selection of Elective Courses:

- The number of seats in each elective course would be limited and will be announced before the commencement of the course in each year. The selection of elective papers in 1st and 2nd Semesters shall be based on merit criteria decided by the Academic committee of the Department.

Examination Scheme: Choice Based Credit System (CBCS)

1. **Credit Structure:**
   - Each paper of 100 marks carries **4 credits**.
   - The *M.Sc. Zoology* programme comprises **100 credits** in total.
     - **Semester I – IV:** 24 credits each (Total = 96 credits)
     - **Internship/Project:** 4 credits (4–6 weeks; minimum 120 hours)
2. **Assessment Components:**
   - Continuous Assessment (CA): **20% weightage**
   - End of Semester Examination (EoSE): **80% weightage**
3. **Attendance Requirement:**
   - A minimum of **75% attendance** in each course is mandatory for appearing in the EoSE.
4. **Minimum Grade Requirement:**
   - To qualify in any course, a student must secure at least a **'C' grade** in both **CA** and **EoSE** separately.
   - Credit points will be awarded only after earning the minimum qualifying grade in each component.
5. **Non-Collegiate Students:**
   - Non-collegiate students shall not be eligible for continuous assessment.
   - They must secure a minimum of a **'C' grade** in the EoSE to earn credits.
6. **Credit Hours:**
   - **Theory Courses:** 1 credit = 15 hours of teaching.
   - **Practical Courses:** 1 credit = 30 hours of laboratory work.
   - A 4-credit practical course = 120 hours of laboratory work per semester.

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7. **Question Paper Pattern (Theory):**
   - **Maximum Marks:** 80 (EoSE)
   - **Duration:** 3 hours
     - **Part A:** 8 very short answer questions × 2 marks = 16 marks (covering entire syllabus)
     - **Part B:** 4 descriptive questions (one per unit) × 16 marks = 64 marks (each with internal choice)
8. **Practical Examination:**
   - Duration: 4 hours
   - Components: Experimental work, Record evaluation and Viva-voce
   - Total Marks: 100 (Internal + External)
9. **Internship / Project Work:**
   - A mandatory internship or project of **4–6 weeks** duration (minimum 120 hours) carrying **4 credits** will be completed during the final semester.
   - The internship aims to provide practical exposure, research experience, or field engagement as per NEP-2020 guidelines.
10. **Total Credit Summary (as per NEP-2020)**

Component	Credit Distribution
Semester I	24
Semester II	24
Semester III	24
Semester IV	24
Internship / Project	**4**
Grand Total	**100 Credits**

II. Programme Structure:

The M.Sc. in Zoology programme is a two-year course divided into four semesters, each semester is of six months duration. Students would have the option of exiting after successful completion of first year of the programme, with a **Masters' Diploma Degree in Zoology**. To earn a Diploma Degree, a student would need to successfully complete **52 credits** i.e. 48 credits in First Year (two semesters) of the Programme and 4 credits of internship/project. The 2-year full-time **Masters' degree in Zoology** with 100 credits shall be the preferred option as it provides the full range of subject education including Internship and Master Thesis.

Year	Semester	Semester	Credits
First Year	Semester I	Semester II	
Optional Exit point 1 with a Diploma Degree in Zoology			**24+24+4*=52**
Second Year	Semester III	Semester IV	
Preferred and Final Exit point 2 with a Masters' Degree in Zoology			**100**

Course Credit Scheme:

Year Wise	Particular Course Discipline	Course Type	Credit Details		Total (I + II)
			Semester (I) Odd	Semester (II) Even	
	Centric Core Paper-I	Major	4	4	8
	Centric Core Paper-II	Major	4	4	8

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I Year	Centric Core Elective Paper -III	Major	4	4	8
	Centric Core **Elective** Paper -IV	Major	4	----	4
	Practical Paper	Major	4	4	8
	Introduction to Research	Major	----	4	4
	Skill Enhancement Course	Major/Minor	4	----	4
	Interdisciplinary Elective	Major/Minor	----	4	4
Total Semester Wise Credit			**24**	**24**	**48**

Year Wise	Particular Course Discipline	Course Type	Credit Details		Total (III + IV)
			Semester (III) Odd	Semester (IV) Even	
II Year	Centric Core Paper -I	Major	4	4	8
	Centric Core Paper -II	Major	4	4	8
	Centric Core **Elective** Paper -III	Major	4	----	4
	Centric Core **Elective** Paper -IV	Major	4	----	4
	Practical Paper	Major	4	4	8
	Skill Enhancement Course (SEC)	Major/Minor	4	----	4
	Interdisciplinary Elective	Major/Minor	----	4	4
	Dissertation/ Fieldwork / Project	Major	----	8	8
Total Semester Wise Credit			**24**	**24**	**48**

Total Credit= (48+48+4*=100);*Internship: It must be **4-6 Weeks (120 Hours)** During Summer Vacation 04 Credit

III. Semester wise Details of M.Sc. in Zoology Course:

The course structure of **TWO YEARS Master in Zoology programme** shall be as under:

Semester wise Details of M.Sc. Zoology Course

Course Code.	Course Title	Course type	Credit
Semester I			
ZOO-20101-T	**Taxonomy and Non-Chordata**	Core Course 01	04
ZOO-20102-T	**Cell and Molecular Biology**	Core Course 02	04
ZOO-20103-P	Lab based on ZOO	Core Course 03	02
ZOO-20104-T	Toxicology and Xenobiotics	Elective Course 04	04
ZOO-20105-T	Advanced Genetic Analysis		
ZOO-20106-T	Animal Biotechnology		
ZOO-20107-T	Microbiology and Microbial Technology		
ZOO-20108-T	Principles of Endocrinology		
ZOO-20109-T	Population and Evolutionary Genetics	Elective Course 05	04
ZOO-20110-T	Applied Zoology		
ZOO-20111-T	Genetics		
ZOO-20112-T	Environmental Pollution and Management		
ZOO-20113-T	Stem Cell Biology		
ZOO-20114-P	Lab based on ZOO-20105-T	Elective Course 06	01
ZOO-20115-P	Lab based on ZOO-20106-T		
ZOO-20116-P	Lab based on ZOO-20107-T		

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ZOO-20117-P	Lab based on ZOO-20108-T		
ZOO-20118-P	Lab based on ZOO-20109-T		
ZOO-20119-P	Lab based on ZOO-20110-T		
ZOO-20120-P	Lab based on ZOO-20111-T	Elective Course 07	01
ZOO-20121-P	Lab based on ZOO-20112-T		
ZOO-20122-P	Lab based on ZOO-20113-T		
ZOO-20123-P	Lab based on ZOO-		
SEC-20124-T	Skill Enhancement Course **(SEC)**	SEC Course	04
	Semester Total		**24**
	Semester II		
ZOO-20201-T	**Chordata**	Core Course 08	04
ZOO-20202-T	**Biochemistry**	Core Course 09	04
IRM-20203-T	**Introduction to Research Methodology**	Core Course 10	04
ZOO-20204-P	Lab based on ZOO-20201-203	Core Course 11	03
ZOO-20205-T	Animal Behaviour and Neurobiology	Elective Course 12	04
ZOO-20206-T	Biostatistics and Bioinformatics		
ZOO-20207-T	Immunology		
ZOO-20208-T	Biosafety and Bioethics		
ZOO-20209-T	Epigenetics and Gene Regulation		
ZOO-20210-P	Lab based on ZOO-20205-T	Elective Course 13	01
ZOO-20211-P	Lab based on ZOO-20206-T		
ZOO-20212-P	Lab based on ZOO-20207-T		
ZOO-20213-P	Lab based on ZOO-20208-T		
ZOO-20214-P	Lab based on ZOO-20209-T		
IEC 20215-T	Interdisciplinary Elective Course (IEC)	Inter departmental Course	4
	Semester Total		**24**
	Semester III		
ZOO-20301-T	**Animal Physiology**	Core Course 14	04
ZOO-20302-T	**Tools and Techniques**	Core Course 15	04
ZOO-20303-P	Lab based on ZOO-20301 & 302	Core Course 16	02
	Elective Papers for Specializations		
	Group A: Entomology and Vector Biology		
ZOO-20304-T	Insect Systematics, Morphology and Physiology	Elective Course 17	04
ZOO-20305-T	Applied Entomology, Vector Control and Pollination Biology	Elective Course 18	04
ZOO-20306-P	Lab based on ZOO-20304 and 305	Elective Course 19	02
	Group B: Fishery & Aquatic Biology		
ZOO-20307-T	Fish Biology, Aquaculture and Resource Management	Elective Course 17	04
ZOO-20308-T	Fish Nutrition, Health and Sustainable Fisheries	Elective Course 18	04
ZOO-20309-P	Lab based on ZOO-20307 and 308-T	Elective Course 19	02

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	Group C: Cell and Molecular Biology		
ZOO-20310-T	Molecular Cell Organization and Function	Elective Course 17	04
ZOO-20311-T	Gene Regulation, Cell Signalling and Molecular Interactions	Elective Course 18	04
ZOO-20312-T	Lab based on ZOO ... and ...	Elective Course 19	02
	Group D: Wildlife and Conservation		
ZOO-20313-T	Principles of Wildlife Ecology and Management	Elective Course 17	04
ZOO-20314-T	Conservation Genetics, Protected Area and Population Management	Elective Course 18	04
ZOO-20315-P	Lab based on ZOO-20313-T & 314-T	Elective Course 19	02
	Group E: Environmental Pollution		
ZOO-20316-T	Environmental Pollution, Toxicology and Impact Studies	Elective Course 17	04
ZOO-20317-T	Climate Change Biology, Sustainability and Mitigation Strategies	Elective Course 18	04
ZOO-20318-P	Lab based on ZOO-20317-318	Elective Course 19	02
	Group F: Biotechnology		
ZOO-20319-T	Recombinant DNA Technology and Genetic Engineering	Elective Course 17	04
ZOO-20320-T	Industrial, Environmental and Animal Biotechnology	Elective Course 18	04
ZOO-20321-P	Lab based on ZOO-20319 & 320	Elective Course 19	02
	Group G: Cancer Biology and Molecular Medicine		
ZOO-20322-T	Cellular Basis of Cancer and Oncogenes	Elective Course 17	04
ZOO-20323-T	Molecular Oncology, Diagnosis and Therapeutic Approaches	Elective Course 18	04
ZOO-20324-P	Lab based on ZOO-20322 & 323	Elective Course 19	02
	Group H: Neuroscience and Behavioural Biology		
ZOO-20325-T	Neuroanatomy, Neural Physiology and Sensory Systems	Elective Course 17	04
ZOO-20326-T	Neuroendocrinology, Learning, Memory and Behavioural Adaptations	Elective Course 18	04
ZOO-20327-P	Lab based on ZOO-20325 & 326	Elective Course 19	02
SEC-20328-T	Skill Enhancement Course (SEC)	SEC Course	04
	Semester IV		
ZOO-20401-T	**Ecology and Environmental Biology**	Core Course 20	04
ZOO-20402-T	**Developmental Biology**	Core Course 21	04
ZOO-20403-P	Lab based on ZOO-20401 and 402	Elective Course 22	04
IEC-20404-T	Interdisciplinary Elective Course **(IEC)**	IEC Course	04
	Dissertation/ Fieldwork / Project / Seminar	For opted option	08

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M.Sc. Zoology (Semester–I)
Core Course 01
ZOO-20101-T- Taxonomy and Non–Chordates

Credits: 04 **Total Hours:** 60 (Theory)

1. Course Objectives (COs):

- **Appreciation of Diversity:** Demonstrate a deep appreciation of non-chordate diversity by recognizing their taxonomic position, ecological roles and contributions to global biodiversity.
- **Structural & Functional Understanding:** Analyze the structural and functional organization of major non-chordate groups and relate these features to their adaptations, survival strategies and ecological significance.
- **Evolutionary Relationships:** Interpret evolutionary relationships among non-chordate phyla using morphological characters and modern systematics, including molecular and phylogenetic tools.
- **Integrative Systematics Skills:** Apply integrative taxonomy approaches—including morphological analysis, molecular markersanddigital databases—to classify, identifyanddocument invertebrate species accurately.

2.Learning Outcomes (LOs):

Aligned with NEP-2020 higher-order competencies:

- **Knowledge & Understanding:** Explain taxonomic principles, non-chordate classificationandtheir role in biodiversity and conservation.
- **Skills & Application:** Use integrative tools (morphological + molecular), taxonomic keysanddigital databases for species identification and classification.
- **Critical Thinking & Analysis:** Evaluate phylogenetic relationships, evolutionary trendsandlife-history adaptations among non-chordates.
- **Professional Competency:** Prepare museum-style specimen records, maintain biodiversity documentationandfollow modern biosystematic methods in research.

Detailed Course Content

Unit I: Principles of Taxonomy and Systematics (15 Hours)

- Introduction to taxonomy and systematics: history, definition and scope
- Species concepts (biological, morphological, phylogenetic, ecological)
- Theories and systems of classification (evolutionary, phenetic, cladistic)
- Taxonomic hierarchy: ranks, nomenclature principles (ICZN)
- Typification (holotype, lectotype, neotype), synonymy, valid names
- Use of keys (dichotomous, multi-access), taxonomic revisions
- Importance of museum collections, specimen preservation, curation and field sampling

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Unit II: Protozoa, Porifera&Cnidaria(15 Hours)

- **Protozoa:** Ultrastructure, Osmoregulation, Locomotion, Nutrition and Reproduction
- **Porifera:** Cell types, Skeleton and Reproduction
- **Cnidaria:** Origin of Metazoa, Polymorphism, Metagenesis, Corals and Pigments

UNIT III: Platyhelminthes, Aschelminths& Annelida(15 Hours)

- **Platyhelminthes:**Origin and evolution of Bilateria, Parasitic adaptations, General organization of Trematoda and Cestoda, Larval stages of Trematoda and Cestoda and Life cycle patterns
- **Aschelminthes(Nematoda):** General organization, Economic importance of nematodes in animals and plants
- **Annelida:**Coelom and Metamerism, Adaptive radiation in Polychaeta, Segmental organs and Filter feeding

UNIT IV:Arthropoda, Mollusca, Echinodermata & Minor Phyla (15 Hours)

- **Arthropoda:**Organization and affinities of Onychophora, Larval forms in Crustacea, Parasitism in Crustacea, Respiratory and excretory organs in Arthropods, General organization ofTardigrada, Pycnogonida and Trilobitomorpha
- **Mollusca:**Foot and Radula, Respiration, Nervous system, Torsion in gastropods and Shell types
- **Echinodermata:**Origin of Deuterostomia, Water vascular system, Larval forms & affinities
- **Minor Phyla:**General organization and affinities ofRotifera, Phoronida, Ectoprocta, Endoprocta and Ctenophora

Practical Syllabus:Credits: 01(30 Hours)

1. **Preparation of Taxonomic Keys:**Hands-on construction of dichotomous and multi-access keys and their application in identifying given specimens.
2. **Study of Diagnostic Characters:**Observation and interpretation of taxonomic characters from preserved specimens representing different invertebrate groups.
3. **Species Concepts & Nomenclature:**Exercises on biological, morphologicalandphylogenetic species concepts; practice on synonymy, valid namesandICZN rules.
4. **Identification Using Monographs and Field Guides:** Use of standard taxonomic literature, monographs, diagnostic keysandfield guides for specimen identification.
5. **Identification, classification and distinguishing characters of nonchordates(Protozoa to Echinodermata).**
6. **Identification and study of permanent slides(Protozoa to Echinodermata)**
7. **Field Collection Techniques:**Collection methods for insects, molluscs, annelids, etc., using nets, trapsandsimple field equipment.

8. **Preservation and Labelling Methods:** Techniques of preservation, fixation, labellingandpreparation of wet and dry zoological specimens.
9. **Museum Preparation and Permanent Mounting:** Preparation of museum jars, slides, museum sheetsandpermanent mounts of *Obelia, Cercaria, Daphnia, Cyclops*, Zoea, Megalopa, Mysis, *Lucifer*.
10. **Museum Curation and Cataloguing:** Accessioning, cataloguing, labellingandmaintenance of museum records and registers.
11. **Study of Live and Prepared Slides:** Live study of *Amoeba* and *Paramecium*; observation of *Hydra*; identification of Trematodes, CestodesandNematodes; mouthparts and salivary glands of cockroach.
12. **Anatomy (Dissection-Based Study):**
    - **Cockroach (*Periplanetaamericana*)** – Alimentary canal, tracheal system, nervous system, reproductive system
    - **Prawn (Palaemon)**- Alimentary canal, appendages, nervous system,

NOTE

- If slides are not available, **diagrams or photographs** may be used.
- Specimens must **not** belong to species protected under the Wildlife Protection Act, 1972.
- Dissection-based anatomy must follow ethical guidelines using allowed species only.

Suggested Readings:

1. Mayr, E. (1969). *Principles of Systematic Zoology*. McGraw–Hill.
2. Simpson, G.G. (1961). *Principles of Animal Taxonomy*. Oxford University Press.
3. Barnes, R.D. (1987). *Invertebrate Zoology*. Saunders College Publishing.
4. Ruppert, E.E., Fox, R.S., & Barnes, R.D. (2004). *Invertebrate Zoology*. Brooks/Cole Publishing.
5. Hickman, C.P., Roberts, L.S., Keen, S.L., Larson, A., &Eisenhour, D.J. (2014). *Integrated Principles of Zoology*. McGraw–Hill.
6. Barrington, E.J.W. Invertebrate Structure and function. Affiliated East-West Press Pvt. Ltd.
7. Winston, J.E. (1999). *Describing Species: Practical Taxonomic Procedure*. Columbia University Press.
8. Wheeler, Q.D. (Ed.) (2008). *The New Taxonomy*. CRC Press.
9. Pechenik, J.A. (2014). *Biology of the Invertebrates*. McGraw–Hill.
10. Padial, J.M., Miralles, A., De la Riva, I., &Vences, M. (2010). *Integrative Taxonomy: Current Trends in Taxonomy. Biological Journal of the Linnean Society*.
11. Barnes, R.S.K., Calow, P., Olive, P.J.W., Golding, D.W., & Spicer, J.I. (2009). *The Invertebrates: A Synthesis*. Wiley–Blackwell.
12. Hunter, P.R. (1979). *Life of Invertebrates*. Collier Macmillan.
13. Marshall, A.J. (Ed.) (1972). *Parker &Haswell's Textbook of Zoology*, Vol. I (7th ed.). Macmillan.
14. Moore, J. (2001). *An Introduction to the Invertebrates*. Cambridge University Press.
15. Brusca, R.C., &Brusca, G.J. (2016). *Invertebrates*. Sinauer Associates.
16. Nielsen, C. (2012). *Animal Evolution: Interrelationships Among the Living Phyla*. Oxford University Press.
17. Kapoor, V. C. (2019): "THEORY AND PRACTICE OF ANIMAL TAXONOMY AND BIODIVERSITY" (8th Edition) Oxford & IBH Publishing Co. Pvt. Ltd.
18.

M.Sc. Zoology (Semester–I)

Core Course 02

ZOO-20102-T- Cell and Molecular Biology

Credits: 04 **Hours:** 60 (Theory)

Course Objectives (COs):

The course aims to:

- Provide students with an integrated understanding of cellular architecture, membrane dynamics and the structural organization of prokaryotic and eukaryotic cells.
- Develop a strong conceptual foundation in genome organization, molecular mechanisms of DNA replication, transcription, translation and gene regulation.
- Enable students to understand cellular communication, signal transduction pathways and regulatory processes essential for maintaining cellular homeostasis.
- Equip learners with knowledge and applied skills in modern molecular biology techniques used in genomics, proteomics, gene expression analysis and experimental research.

Learning Objectives (LOs):

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

- Understand the structure, function and dynamics of prokaryotic and eukaryotic cells.
- Explain principles of genome organization, DNA–RNA biology and gene regulation.
- Analyze molecular mechanisms of replication, transcription, translation and epigenetic regulation.
- Describe cell communication, signal transduction pathways and cellular responses.
- Apply advanced molecular techniques used in genomics, proteomics and cell biology.

Detailed Course Content

UNIT I: Cell Structure, Membranes & Cytoskeleton(15 Hours)

- **Biomembranes and Membrane Architecture**
  - Fluid mosaic model: lipid bilayer and protein components
  - Physical properties, membrane asymmetry, membrane dynamics
- **Cytoskeletal Systems**
  - Microfilaments: Actin organization, actin-binding proteins, myosin-driven cellular movements
  - Intermediate filaments: Types, organization, mechanical functions
  - Microtubules: Structure, assembly/disassembly dynamics
  - Motor proteins: Kinesin and Dynein, cargo transport and cellular motility

UNIT II: Endomembrane System, Intracellular Transport & Cellular Communication

- **Endomembrane System & Trafficking(15 Hours)**

- Compartmentalization in eukaryotic cells
- Gated transport between nucleus and cytosol
- Nuclear pore complex: structure and transport mechanisms
- Signal sequences and sorting receptors
- Role of monomeric GTPases in protein sorting
- Protein targeting to ER and mitochondria
- Vesicular trafficking, secretory pathways, receptor-mediated endocytosis

- **Cellular Communication & Signal Transduction**
  - General principles of cell communication
  - Extracellular matrix and cell adhesion mechanisms
  - Signalling molecules and cell-surface receptors: GPCRs, Ion-channel linked receptors, Enzyme-linked receptors
  - Second messengers
  - Regulation of signalling pathways:JAK–STAT pathwayand MAP Kinase pathway
- **Cell Cycle and Cell Division**
  - Overview and regulation of the cell cycle
  - Cell-cycle checkpoints
  - Regulation of mitosis and meiosis
  - Cancer biology and apoptosis mechanisms

UNIT III: DNA Structure, Replication & Gene Expression(15 Hours)

- **DNA Replication**
  - Enzymes of replication: DNA polymerases and accessory factors
  - Origin of replication, formation of primosome
  - Unit of replication, replication fork, replisome
  - Fidelity and proofreading mechanisms
  - Termination of replication
- **Transcription (Prokaryotes & Eukaryotes)**
  - Fine structure of gene, transcription unit
  - RNA polymerases
  - General transcription factors & transcription machinery
  - Steps: initiation, elongation, termination
  - Differences between prokaryotic & eukaryotic transcription

UNIT IV–RNA Processing &Post-Transcriptional modification, Gene Regulation, Translation and Translational Control

RNA Processing & Post-Transcriptional Control

- Capping, splicing, polyadenylation
- RNA editing
- Gene silencing and RNA interference (RNAi)

Regulation of Gene Expression

- Transcriptional regulation:lac operon and trp operon
- Role of chromatin remodelling in gene expression

Translation (Prokaryotes & Eukaryotes)(15 Hours)

- tRNAaminoacylation
- tRNA identity and aminoacyl-tRNAsynthetases
- Initiation, elongation & termination of translation

Post-Translational Events

- Protein folding and molecular chaperones
- Intracellular protein degradation (ubiquitin–proteasome pathway)

Practical Syllabus: Credits: 01 (30 Hours)

1. Preparation and observation of prokaryotic and eukaryotic cell ultrastructure using permanent slides/photomicrographs.
2. Isolation of genomic DNA from plant/animal tissues and assessment of purity (A260/A280).
3. Agarose gel electrophoresis for separation of DNA fragments and determination of band size.
4. Extraction of total RNA and verification of integrity through gel analysis.
5. PCR amplification of a target DNA sequence (qualitative demonstration).
6. Protein estimation using Bradford or Lowry method and standard curve preparation.
7. SDS–PAGE analysis for protein separation and interpretation of banding patterns.
8. Study of mitosis and meiosis using squash preparation and identification of cell-cycle stages.
9. Demonstration of enzyme activity assay (e.g., catalase/β-galactosidase) and effect of variables.
10. Bioinformatics-based analysis of gene or protein sequence (NCBI, BLAST, ORF finder).

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. **Molecular Biology of the Cell.** Garland Science.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M., Scott, M., Bretscher, A., Ploegh, H., &Matsudaira, P. **Molecular Cell Biology.** W.H. Freeman.
3. Karp, G. **Cell and Molecular Biology: Concepts and Experiments.** Wiley.
4. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., &Losick, R. **Molecular Biology of the Gene.** Benjamin Cummings.
5. Becker, W.M., Kleinsmith, L.J., Hardin, J., &Bertoni, G. **The World of the Cell.** Pearson.
6. Nelson, D.L., & Cox, M.M. **Lehninger Principles of Biochemistry.** W.H. Freeman.
7. Lewin, B. **Genes XII.** Jones & Bartlett Learning.
8. Berg, J.M., Tymoczko, J.L., &Stryer, L. **Biochemistry.** W.H. Freeman.
9. Gupta, P.K. **Cell and Molecular Biology.**Rastogi Publications.
10. Sambrook, J., & Russell, D.W. **Molecular Cloning: A Laboratory Manual.** Cold Spring Harbor Laboratory Press.

M.Sc. Zoology (Semester–I)

Core Course 03

ZOO-20103-P- Laboratory Course Based on ZOO-20101 & ZOO-20102 (Taxonomy and Non-Chordates+ Cell & Molecular Biology)

Credits: 02 **Total Hours:** 60 (Practical)

Scheme of Practical Examination

Laboratory Course Based on ZOOLCC101 & ZOOLCC102

S. No.	Particulars	Marks
1	Exercise based on **ZOO-20101: Taxonomy and Invertebrates**	08
2	Exercise based on **ZOO-20102: Cell and Molecular Biology**	08
4	**Spotting***(6 specimens × 2 marks each)*	12
5	**Seminar / Presentation**	04
6	**Viva Voce**	04
7	**Practical Record / Journal**	04
Total Marks		**40**

Guidelines for Practical Examination

- Each exercise should test applied and conceptual understanding aligned with NEP–2020 learning outcomes.
- Spotting should include museum specimens, permanent slides, diagrams, or photographs from all three core courses.
- Seminar presentation will assess analytical thinking, data interpretation and communication skills.
- Viva voce will evaluate practical knowledge, integration of theory with experiment and contemporary understanding.
- Practical records should be neat, properly labelled and duly certified by the course instructor.

M.Sc. Zoology (Semester–I)
Elective Course 04
ZOO -20104-T Toxicology and Xenobiotics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- To introduce students to the basic principles of toxicology and how xenobiotics interact with biological systems.
- To explain exposure routes, dose–response relationships and methods used to evaluate toxicity.
- To develop understanding of biochemical, physiological and molecular mechanisms of toxicity, including nanotoxicology and toxicogenomics.
- To examine xenobiotic biotransformation, bioaccumulation, biomagnification and safety evaluation approaches.

Learning Outcomes (LOs):

After completing the course, students will be able to:

- Describe types of toxicants, xenobiotics and their interactions with cells and tissues.
- Interpret exposure routes, dose–response curves, toxicity indices (LD_{50}/LC_{50}) and factors influencing toxicity.
- Analyse mechanisms of toxicity, nanotoxic effects and gene expression changes associated with toxicant exposure.
- Explain xenobiotic biotransformation, accumulation processes and principles of risk assessment and antidotal therapy.

Detailed Course Content

UNIT I: Introduction to Toxicology &Xenobiotics **(15 Hours)**

- **Basic Concepts of Toxicology**
  - Definitions: toxicants, toxins, xenobiotics.
  - Scope and significance of toxicology in environmental and biomedical sciences.
  - Classification of toxicants (natural, chemical, biological, physical).
  - Concepts of local vs. systemic toxicity.
  - Immediate vs. delayed toxicity; reversible vs. irreversible effects.
- **Principles of Xenobiotic Action**
  - Interaction of xenobiotics with biomolecules.
  - Absorption, distribution, storage and elimination of toxicants.
  - Concept of selective toxicity: mechanisms and significance.

UNIT II: Exposure & Dose–Response Relationships **(15 Hours)**

- **Exposure to Toxicants**
  - Routes/methods: oral, dermal, inhalation, injection, gills/integument (aquatic fauna).

- Frequency & duration of exposure: acute, sub-acute, sub-chronic, chronic.
- Environmental and ecological exposure dynamics.

- **Dose–Response Concepts**
  - Classical dose–response curves; LD_{50}, LC_{50}, ED_{50}.
  - Threshold and non-threshold responses.
  - Concept of Maximum Acceptable Toxicant Concentration (MATC) and safe concentration.
- **Factors Affecting Toxicity**
  - Chemical properties of toxicants.
  - Surrounding medium (pH, salinity, temperature).
  - Physiological condition & species differences.
  - Bioavailability and environmental modifiers.

UNIT III: Toxicity Testing & Emerging Toxicology **(15 Hours)**

- **Toxicity Tests (Bioassays)**
  - Concept and design of bioassays.
  - Acute toxicity tests: terrestrial and aquatic animals.
  - Chronic toxicity tests and sub-lethal endpoints.
- **Nanotoxicology**
  - Nano-scale toxicants and interaction with cells.
  - Environmental, occupational and health impacts of nanotoxicants.
- **Toxicogenomics**
  - Gene expression responses to toxicants.
  - Use of genomics, transcriptomics and proteomics to detect toxicity.

UNIT IV: Biotransformation & Fate of Xenobiotics **(15 Hours)**

- **Bioaccumulation &Biomagnification**
  - Concepts: bioconcentration, bioaccumulation, biomagnification.
  - Bioconcentration factor (BCF).
  - Processes and pathways of accumulation in organisms.
- **Biotransformation of Xenobiotics**
  - Concepts of biotransformation and detoxification.
  - Phases I and II reactions.
  - Biotransformation enzymes: CYP450s, transferases, oxidases, hydrolases.
  - Sites of biotransformation (liver, kidney, gills).
  - Factors affecting biotransformation (species, age, physiology, environmental factors).
- **Safety Evaluation &Antidotal Therapy**
  - Toxicity mitigation and antidotes.
  - Principles of risk assessment.
  - Safety margins and regulatory toxicology.

Practical Syllabus: Credits: 01 (30 Hours)

1. Identification and classification of toxicants (natural, chemical, biological, physical) using available samples or charts.
2. Demonstration of exposure routes using model organisms or simulated systems (oral, dermal, inhalation).

3. Determination of **LC_{50} or LD_{50}** using simple aquatic bioassays (fish/arthropods/algal assays – ethical & permissible species only).
4. Analysis of a **dose–response curve** and calculation of toxicity parameters (ED_{50}, MATC).
5. Study of factors affecting toxicity: effects of pH, temperature and salinity on toxicant activity (experimental demonstration).
6. Study of acute vs. chronic toxicity symptoms in model organisms (videos/data-based learning where required).
7. Demonstration of **bioaccumulation** using dye/chemical uptake in invertebrates or plant tissues.
8. Study of detoxification/biotransformation enzymes (e.g. peroxidase, catalase activity assays).
9. Observation of nanoparticle interaction with cells (microscopy/data sheets/case study).
10. Case-study-based exercise on toxicogenomics: interpreting gene expression or protein data after toxicant exposure.

Suggested Readings:

1. Klaassen, C. D., & Watkins, J. B. (Eds.).*Casarett&Doull's**Essentials of Toxicology***. 3rd Edition, McGraw-Hill Education, 2015.
2. Hodgson, E. (Ed.).***A Textbook of Modern Toxicology.*** 4th Edition, Wiley-Blackwell, 2010.
3. Conn, E. E., &Stumpf, P. K.***Outlines of Biochemistry.*** 5th Edition, Wiley India, 2012.
4. Rand, G. M., Wells, P. G., & McCarty, L. S. (Eds.).***Introduction to Aquatic Toxicology.*** CRC Press, 1995.
5. Sahu, S. C., &Casciano, D. A. (Eds.).***Handbook of Nanotoxicology, NanomedicineandNano-Safety.*** Wiley, 2019.
6. Rand, G. M., &Petrocelli, S. R. (Eds.).***Fundamentals of Aquatic Toxicology: Effects, Environmental FateandRisk Assessment.*** Hemisphere Publishing, 1985.
7. OECD.***OECD Guidelines for the Testing of Chemicals*** **(Test Nos. 202, 203, 210, 305).** OECD Publishing, 2020.
8. APHA, AWWA, & WEF.***Standard Methods for the Examination of Water and Wastewater.*** 23rd Edition, American Public Health Association, 2017.
9. Hayes, A. W. (Ed.).***Principles and Methods of Toxicology.*** **6th Edition, CRC Press, 2014.**
10. World Health Organization (WHO).*Environmental Health Criteria (EHC) Series*. WHO Press, 1982–present.

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO-20105-T Advanced Genetic Analysis

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

- To develop an advanced understanding of classical and modern genetic analysis.
- To apply genetic principles for mapping, mutation analysis and gene interactions.
- To interpret genomic, transcriptomic and molecular data for functional analysis.
- To understand population, evolutionary and quantitativegenetic analytical tools.
- To provide skills for problem solving, data interpretation and genetic experimentation.

LEARNING OUTCOMES (LOs):

Upon completion of this course, students will be able to:

- Apply advanced classical and molecular genetic principles for experimental analysis.
- Interpret genome, transcriptome and mutation datasets using modern tools.
- Perform quantitative genetic calculations and understand genetic architecture of traits.
- Analyse population structure, evolutionary processes and genetic variation statistically.
- Use genetic knowledge for applications in health, conservation, breeding and biotechnology.

Detailed Course Content

UNIT I: Classical & Molecular Genetic Analysis (15 hrs)

- Mendelian principles revisited; extensions of Mendelian inheritance.
- Gene interactions: epistasis, complementation tests, suppressors & enhancers.
- Chromosome mapping: two-point & three-point test crosses, interference, coincidence.
- Sex-linkage, sex-limited and sex-influenced traits.
- Cytogenetic techniques: karyotyping, banding, FISH, chromosome painting.
- Mutation analysis: forward & reverse genetics, mutagenesis screens.

UNIT II: Genomic Tools & Functional Analysis (15 hrs)

- Genome sequencing approaches: Sanger, NGS, long-read sequencing.
- Genome annotation and comparative genomics.
- Transcriptomics: RNA-Seq workflow, differential gene expression.
- Gene knock-out/knock-down strategies: CRISPR-Cas, RNAi, transposon mutagenesis.
- Functional assays: reporter genes, promoter analysis, enhancer mapping.
- Structural variants: CNVs, inversions, translocations – detection & impacts.

UNIT III: Quantitative & Statistical Genetic Analysis (15 hrs)

- Quantitative traits: variance components, polygenic basis, threshold traits.
- Heritability estimation: broad- & narrow-sense; parent-offspring regression.
- QTL mapping: linkage mapping & association studies (GWAS basics).
- Statistical tools: regression, ANOVA, Hardy–Weinberg testing, chi-square models.
- Genetic correlation, pleiotropy and genotype-by-environment interactions (G×E).
- Predictive models: BLUP, genomic selection (introductory).

UNIT IV: Population, Evolutionary & Applied Genetic Analysis (15 hrs)

- Population structure: gene flow, genetic drift, F-statistics.
- Linkage disequilibrium, haplotypes & demographic inference.
- Molecular evolution: substitution models, molecular clock concepts.
- Phylogenetic reconstruction: distance, parsimony, likelihood.
- Human genetic analysis: pedigrees, disease mapping, association tests.
- Applications: conservation genetics, forensic genetics, medical genomics.

PRACTICAL SYLLABUS (1 Credit)(30hrs)

1. Problems on gene interactions, epistasis & complementation.
2. Mapping exercises: two-point & three-point crosses (problem sets).
3. Analysis of karyotypes and structural chromosomal abnormalities.
4. Hands-on demonstrations (virtual/real): PCR, gel electrophoresis, sequencing data.
5. Basic bioinformatics tools: BLAST, genome browsers, SNP databases.
6. RNA-Seq dataset interpretation (counts, fold change, basic plots – demonstration).
7. Population genetics exercises: F-statistics, HWE, LD (calculation sets).
8. Report on any genetic technology (CRISPR, GWAS, NGS platform, etc.).

Suggested Readings:

1. **Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., &Doebley, J.** (2015). *Introduction to Genetic Analysis* (11th ed.). W. H. Freeman.
2. **Pierce, B. A.** (2020). *Genetics: A Conceptual Approach* (7th ed.). W. H. Freeman.
3. **Hartl, D. L., & Jones, E. W.** (2012). *Genetics: Analysis of Genes and Genomes* (8th ed.). Jones & Bartlett Learning.
4. **Klug, W. S., Cummings, M. R., Spencer, C. A., &Palladino, M. A.** (2019). *Concepts of Genetics* (12th ed.). Pearson.
5. **Lewin, B., Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T.** (2017). *Lewin's Genes XII*. Jones & Bartlett Publishers.
6. **Lodish, H., Berk, A., Kaiser, C. A., et al.** (2016). *Molecular Cell Biology* (8th ed.). W. H. Freeman. *(For genomics, transcriptomics, functional assays)*
7. **Slatkin, M., &Veuille, M. (Eds.)** (2002). *Modern Developments in Theoretical Population Genetics*. Oxford University Press. *(Population structure, drift, F-statistics)*
8. **Lynch, M., & Walsh, B.** (1998). *Genetics and Analysis of Quantitative Traits*. Sinauer Associates. *(Gold standard for variance components, heritability, QTLs)*
9. **Yang, H., & White, M. A.** (2019). *Bioinformatics and Functional Genomics* (4th ed.). Wiley-Blackwell. *(Genome annotation, RNA-seq, transcriptomics workflows)*
10. **Primrose, S. B., Twyman, R. M., & Old, R. W.** (2012). *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell. *(CRISPR, knockouts, transposon mutagenesis, sequencing)*

M.Sc. Zoology (Semester–I)
Elective Course 04
ZOO-20106-T- Animal Biotechnology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- To understand molecular tools and techniques used in animal biotechnology.
- To learn genetic engineering, genome editing and transgenesis.
- To develop knowledge of cell culture, stem cells and biotechnology applications in health and industry.

Learning Outcomes (LOs):

Students will be able to –

- Understand methods of gene manipulation.
- Apply animal cell culture and transgenic techniques.
- Explain applications in medicine, reproduction, agriculture and conservation.

Detailed Course Content

UNIT–I: Fundamentals of Animal Biotechnology **(15 Hours)**

1. Introduction & Scope

- Definition, history and scope of animal biotechnology.
- Interdisciplinary importance; relation with genetics, microbiology and biochemistry.
- Regulatory frameworks: DBT, CPCSEA, NIH, OECD.

2. Molecular Foundations

- DNA and RNA structure, gene organization, gene regulation in eukaryotes.
- Epigenetics: DNA methylation, histone modification, RNA interference.

3. Essential Molecular Techniques

- PCR and its variants (qPCR, RT-PCR).
- Gel electrophoresis: agarose, PAGE.
- DNA sequencing: Sanger sequencing and Next-Generation Sequencing (NGS).
- DNA barcoding and molecular identification of animals.

UNIT–II: Genetic Engineering & Genome Manipulation (15 Hours)

1. Tools of Gene Manipulation

- Restriction endonucleases, ligases, polymerases.
- Cloning vectors: plasmids, bacteriophage vectors, cosmids, BAC, YAC.
- Expression vectors and reporter gene systems (GFP, LacZ).

2. Recombinant DNA Technology

- Steps in gene cloning: cutting, ligation, transformation, selection and screening.
- Expression of recombinant proteins in bacteria, yeast and insect cells.
- Applications of recombinant proteins in medicine and veterinary sciences.

3. Genome Editing

- CRISPR–Cas9: mechanism, components and applications.
- ZFNs and TALENs: basic principles and uses.
- Knock-in and knock-out animal models.
- Ethical, biosafety and regulatory concerns.

UNIT–III: Animal Cell Culture, Stem Cells & Transgenic Animals(15 Hours)

1. Animal Cell Culture Technology

- Principles of culture: media composition, physical & chemical requirements.
- Types of cultures: primary culture, secondary culture, continuous cell lines.
- Cell proliferation, differentiation, contamination control and cryopreservation.
- Cell viability assays and toxicity evaluation.

2. Stem Cell Biotechnology

- Types of stem cells: embryonic, adult, hematopoietic and iPSCs.
- Stem cell markers and characterization.
- Applications: regenerative medicine, tissue engineering, organoids.

3. Transgenic and Cloned Animals

- Methods: microinjection, viral vector-mediated gene transfer, somatic cell nuclear transfer (SCNT).
- Transgenic mice, fish, goats, pigs—case studies.
- Applications in disease models, biopharmaceutical production and livestock improvement.

UNIT–IV: Applied Aspects of Animal Biotechnology(15 Hours)

1. Medical & Veterinary Biotechnology

- Recombinant vaccines: DNA vaccines, subunit vaccines, mRNA vaccines.
- Hybridoma technology and monoclonal antibodies.
- Diagnostic tools: ELISA, western blotting, lateral flow assays, biosensors.
- Gene therapy: vectors, delivery systems, current trends.

2. Reproductive Biotechnology

- Assisted Reproductive Technologies (ART): IVF, embryo transfer, ICSI.
- Gamete and embryo cryopreservation.
- Cloning in mammals: principles and limitations.
- Applications in livestock improvement and conservation.

3. Environmental & Industrial Biotechnology

- Bioremediation and biodegradation using animal-associated microbes.
- Aquaculture biotechnology: growth enhancement, disease resistance, improved feed conversion.
- Forensic biotechnology: wildlife DNA profiling and species identification.
- Industrial production using animal cell lines.

Practical Syllabus: Credits: 01 (30 Hours)

1. DNA Isolation from Animal Tissue (Demo/Hands-on)

- Extraction from fish muscle/animal blood using simple lysis& precipitation.
- Verify purity using spectrophotometer (A260/A280).

2. Agarose Gel Electrophoresis of DNA

- Run λ DNA / PCR products.
- Interpretation of band size using DNA ladder.

3. PCR Amplification of a Target Gene

- Setup PCR reaction (primers, template, polymerase).
- Observe amplified product on gel.

4. Restriction Digestion and Fragment Analysis

- Perform digestion using EcoRI/HindIII.
- Analyze fragments on agarose gel.

5. Bacterial Transformation Using Plasmid DNA

- Competent cell preparation ($CaCl_2$ method – demo).
- Transformation with pUC18/pBR322; blue–white screening (theory/demo).

6. Analysis of DNA Barcodes Using Software

- Use MEGA/NCBI BLAST to compare sequences.

- Species identification from provided FASTA files.

7. Cell Culture Techniques (Demonstration)

- Media preparation, aseptic techniques, passaging concept.
- Observe mammalian cell lines (HeLa/CHO) under microscope.

8. Trypan Blue Cell Viability Assay

- Counting live vs. dead cells using haemocytometer.
- Plot simple growth curve (provided data allowed).

9. Case Study on CRISPR Gene Editing

- Demonstration using CRISPR design tool (Benchling/online).
- sgRNA design and off-target analysis (theoretical).

10. Hybridoma and Monoclonal Antibody Technology (Simulation/Charts)

- Preparation steps, fusion strategy using PEG.
- ELISA interpretation for antibody detection (sample dataset).

Suggested Readings:

1. Rastogi, S. C.*(Latest Edition).***Cell and Molecular Biology**. New Age Int. Publishers, New Delhi.
2. Verma, P. S., & Agarwal, V. K.*(Latest Edition).***Cell Biology, Genetics, Molecular Biology, Evolution & Ecology**. S. Chand & Company, New Delhi.
3. Singh, B. D. (Latest Edition).**Biotechnology: Expanding Horizons.** Kalyani Publishers, New Delhi.
4. Dubey, R. C.*(Latest Edition).***A Textbook of Biotechnology**. S. Chand & Company.
5. Satyanarayana, U., &Chakrapani, U.**Biotechnology** (Indian Edition). Elsevier India.
6. Gupta, P. K.*(Latest Edition).***Elements of Biotechnology**.Rastogi Publications, Meerut.
7. Narang, U., & Kumar, A. **Genetic Engineering & Biotechnology**. S. Vikas Publishing House.
8. Freshney, R. I.*(Indian Edition).* **Culture of Animal Cells: A Manual of Basic Technique**. Wiley India.
9. Glick, B. R., & Pasternak, J. J.*(Indian Edition).* **Molecular Biotechnology: Principles and Applications**. ASM Press / Pan India edition.
10. Brown, T. A.*(Indian Edition).* **Gene Cloning and DNA Analysis**. Wiley India.

M.Sc. Zoology (Semester–I)

Elective Course 04

ZOO-20107-T Microbiology and Microbial Technology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- To introduce microbial diversity, structure, physiology and classification.
- To understand microbial growth, metabolism, genetics and host–microbe interactions.
- To expose students to applied microbiology including industrial, medical, agricultural and environmental uses.
- To provide knowledge of microbial technology, bioprocessing, fermentation and product development.

Course Outcomes (LOs):

Learners will be able to:

- Identify and classify microorganisms based on structure and characteristics.
- Understand microbial growth, metabolism, genetics and pathogenesis.
- Explain industrial fermentation processes and microbial products.
- Apply knowledge of microbes in healthcare, agriculture and biotechnology.

Detailed Course Content

UNIT I: Microbial Diversity, Structure & Physiology **(15 Hours)**

1. Introduction to Microbiology

- Scope, history and significance of microbiology
- Major groups of microorganisms: bacteria, archaea, cyanobacteria, fungi, protozoa, viruses

2. Microbial Systematics and Classification

- Principles of microbial taxonomy
- Bergey's Manual classification
- Molecular phylogeny (16S rRNA, DNA–DNA hybridization, ANI)

3. Microbial Cell Structure

- Prokaryotic cell structure: cell wall, capsule, pili, flagella, endospores
- Eukaryotic microbial cell structure: fungal and protozoan cells
- Viral structure and classification

4. Microbial Physiology

- Nutritional types of microbes
- Microbial growth kinetics and growth curves
- Factors influencing growth: temperature, pH, water activity, radiation, oxygen
- Biofilms and quorum sensing

UNIT II: Microbial Genetics, Pathogenicity & Immunology **(15 Hours)**

1. Microbial Genetics

- DNA replication, transcription, translation in prokaryotes
- Gene regulation: operon models
- Mutation and mutagenesis
- Horizontal gene transfer: transformation, transduction, conjugation
- Plasmids, transposons, integrons

2. Microbial Pathogenicity

- Mechanisms of microbial virulence
- Host–pathogen interactions
- Bacterial toxins (exotoxins, endotoxins)
- Principles of infection and disease transmission

3. Basics of Immunology

- Innate and adaptive immunity
- Antigens, antibodies and antigen–antibody interactions
- Vaccines: types and principles (live, killed, recombinant, mRNA)
- Diagnostic immunology: ELISA, agglutination, immunofluorescence

UNIT III: Industrial & Fermentation Microbiology **(15 Hours)**

1. Fermentation Technology

- Types of fermentation: submerged, solid-state, batch, fed-batch, continuous
- Bioreactors: types, components, design considerations
- Sterilization, inoculum development, media optimization

2. Industrial Microbial Products

- Microbial production of antibiotics, enzymes, organic acids, alcohol, vitamins
- Microbial polysaccharides and bioplastics
- Microbial biomass and single-cell protein

3. Food & Dairy Microbiology

- Microbial spoilage of food
- Food preservation techniques
- Fermented foods: cheese, yogurt, beverages, pickles
- Probiotics and prebiotics

UNIT IV: Environmental, Agricultural & Applied Microbial Technology **(15 Hours)**

1. Environmental Microbiology

- Microbial role in biogeochemical cycles: nitrogen, carbon, sulfur
- Biodegradation, bioremediation and biosensors
- Wastewater microbiology

2. Agricultural Microbiology

- Rhizosphere and soil microbes
- Nitrogen-fixing organisms
- Mycorrhizae and plant growth–promoting microbes
- Biofertilizers, biopesticides

3. Applied Microbial Technology

- Microbial biotechnology in aquaculture
- Microorganisms in animal health and probiotics
- Microbial biotechnology in pharmaceuticals
- Intellectual Property Rights: patents for microbial innovations

Practical Syllabus: Credits: 01 (30 Hours)

1. Basic Microbiological Techniques

- Laboratory safety, aseptic techniques.
- Cleaning and sterilization of glassware (autoclave, hot air oven).

2. Culture Media Preparation

- Preparation of nutrient agar and broth.
- Pour plate or streak plate for isolation of bacteria.

3. Microscopy & Staining

- Use of compound microscope.
- Simple staining and Gram staining of bacteria.

4. Microbial Count

- Serial dilution and total viable count (TVC) of bacteria.

5. Applied Microbiology

- Antibiotic sensitivity test (disc diffusion).

- Demonstration: MPN test for water quality **or** fermentation process.

6. Record & Viva

- Practical record submission and viva-voce.

Suggested Readings:

- Anantnarayan & Paniker. Textbook of Microbiology 13th Edition. 2024.University Press
- Prescott, Harley & Klein – ***Microbiology***
- Pelczar, Chan & Krieg – ***Microbiology***
- Roitt-Essential Immunology
- Tortora – *Microbiology: An Introduction*
- Stanbury, Whitaker & Hall – ***Principles of Fermentation Technology***
- Madigan &Martinko – ***Brock Biology of Microorganisms***

M.Sc. Zoology (Semester–I)
Elective Course 04
ZOO-20108-T-Principles of Endocrinology

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs)

- To understand the foundations of endocrine regulation across animal groups.
- To examine hormone chemistry, biosynthesis, secretion and mechanisms of action.
- To study the evolution, structure and function of major endocrine glands.
- To understand neuroendocrine integration and hormonal feedback.
- To explore endocrine disorders and applied endocrinology.

LEARNING OUTCOMES (LOs)

After completing the course, students will be able to:

- Explain principles and mechanisms of hormone action.
- Describe endocrine gland structure, evolution and regulation.
- Analyze neuroendocrine integration and feedback loops.
- Compare endocrine systems across animal groups.
- Identify endocrine disorders and environmental hormonal impacts.

Detailed Course Content

UNIT I: Foundations of Endocrinology (15 Hours)

- Definition, scope and evolution of endocrine systems
- Hormones: chemical nature, synthesis (peptides, steroids, thyroid hormones), storage & secretion
- Endocrine cells: cytology and histochemistry
- Hormone transport, half-life, clearance
- Hormone receptors: membrane & nuclear types
- Signal transduction pathways: G-protein, RTK, second messengers (cAMP, IP3/DAG, Ca^{2+})
- Genomic and non-genomic actions
- Feedback mechanisms: negative, positive, ultrashort loops

UNIT II: Neuroendocrinology & Major Endocrine Axes (15 Hours)

- Nervous–endocrine integration; neurosecretory cells
- Hypothalamus: nuclei, releasing/inhibiting hormones
- Hypophysis: structure & functions
- Hypothalamo–hypophyseal axis regulation
- Thyroid gland: biosynthesis, regulation, functions, dysfunctions
- Adrenal gland: cortex & medulla hormones; stress response
- Pancreas: insulin, glucagon; glucose homeostasis
- Calcium regulation: PTH, calcitonin, Vitamin D axis

UNIT III: Reproductive & Comparative Endocrinology (15 Hours)

- Gonadotropins, sex steroids, feedback regulation
- Menstrual/estrous cycles; HPO axis
- Endocrine control of gametogenesis & reproduction
- Comparative endocrinology: endocrine organs in invertebrates (arthropods, molluscs)
- Vertebrate endocrine evolution: fishes → amphibians → reptiles → birds → mammals
- Ecdysone& juvenile hormone systems
- GI hormones, melatonin, adipokines

UNIT IV: Endocrine Disorders, Environmental & Applied Endocrinology (15 Hours)

- Hypo-/hyper-function of major glands

- Diabetes, thyroid disorders, adrenal disorders, reproductive dysfunctions
- Neuroendocrine stress pathways (HPA axis)
- Endocrine disruptors: pesticides, plastics, pharmaceuticals
- Mechanisms and ecological/health impacts
- Applied endocrinology: aquaculture, livestock growth, biomedical hormone use
- Basics of hormone assays (RIA, ELISA)

Practical Syllabus: Credits: 01 (30 Hours)

1. Laboratory Safety & Basic Techniques
- Endocrine lab safety, handling biological samples
- Preparation of buffers and physiological solutions

2. Histology of Endocrine Glands
- Preparation of permanent slides (demonstration)
- Identification of: pituitary, thyroid, adrenal, pancreas, gonads
- Staining of endocrine tissues (H&E or special stains)

3. Hormone Assay Techniques (Demonstration/Practice)
- ELISA setup for a peptide hormone (e.g., insulin/TSH)
- Understanding RIA principles (demonstration/virtual)
- Interpretation of standard curves

4. Endocrine Physiology Experiments
- Blood glucose estimation (glucometer/biochemical method)
- Effect of hormones on metabolic rate (demonstration)
- Study of stress response indicators (e.g., heart rate changes)

5. Comparative Endocrinology Practical
- Identification of endocrine structures in invertebrates/vertebrates (museum specimens, slides)
- Study of molting glands, corpora allata, corpora cardiaca (arthropods)

6. Applied & Clinical Endocrinology
- Case study analysis: thyroid disorders, diabetes, adrenal disorders
- Interpretation of endocrine profiles (sample lab reports)

7. Records & Viva-Voce
- Practical notebook evaluation
- Viva on techniques, principles and interpretations

Suggested Readings:

1. Negi, C. S. Introduction to Endocrinology. PHI Private Learning Pvt. Ltd. New Delhi.
2. **Rastogi, S. C.** (Latest edition). *Endocrinology*. New Age International Publishers, New Delhi.
3. **Goyal, R. K., & Mehta, A.** (Latest edition). *A Textbook of Endocrinology*. CBS Publishers & Distributors, New Delhi.

4. **Turner, C. D., & Bagnara, J. T.** (Indian Edition). *General Endocrinology*. McGraw Hill Education (India).
5. **Norris, D. O.** (Indian Reprint). *Vertebrate Endocrinology*. Academic Press/Elsevier India.
6. **Hadley, M. E., & Levine, J. E.** (Indian Edition). *Endocrinology*. Pearson India.
7. **Gupta, P. K.** (Latest edition). *Animal Physiology and Endocrinology*. Rastogi Publications, Meerut.
8. **Guyton, A. C., & Hall, J. E.** (Indian Edition). *Textbook of Medical Physiology*. Elsevier India.
9. **Nelson, D. L., & Cox, M. M.** (Indian Edition). *Lehninger Principles of Biochemistry*. W. H. Freeman/Macmillan India.
10. **Prakash, A.** (Latest edition). *Comparative Endocrinology of Vertebrates*. Narosa Publishing House, New Delhi.
11. **Hall, J. E.** (Indian Edition). *Hormones: From Molecules to Disease*. Elsevier India.

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO-20109-T: Population and Evolutionary Genetics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs)

- To understand genetic variation within and between populations.
- To learn processes shaping gene frequencies and evolutionary change.
- To analyse the genetic basis of speciation, adaptation and natural selection.
- To apply population genetic models to real biological problems.
- To introduce molecular tools used in evolutionary and population genetic studies.

Learning Outcomes (LOs):

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

- **Analyse genetic variation within and between populations** using allele frequencies, Hardy–Weinberg equilibrium and evolutionary forces.
- **Evaluate quantitative genetic traits** through heritability, variance components and response-to-selection models.
- **Apply molecular markers and statistical tools** (LD, F-statistics, gene flow) to assess population structure and evolutionary change.
- **Interpret evolutionary processes** such as natural selection, genetic drift, molecular evolution and adaptation using theoretical models.
- **Explain patterns of speciation, phylogeography and genetic applications** in conservation, human health and forensic science.

Detailed Course Content

Unit I: Fundamentals of Population Genetics (15 hrs)

- Mendelian population and basic concepts: gene pool, allele & genotype frequencies.
- **Hardy–Weinberg Equilibrium:** assumptions, testing deviations, chi-square applications.
- **Forces of Evolution:** mutation, migration, selection, drift – qualitative & quantitative effects.
- Inbreeding & inbreeding coefficient; outbreeding &heterosis.
- Effective population size and its biological importance.

Unit II: Quantitative & Molecular Population Genetics (15 hrs)

- Polygenic inheritance; quantitative traits & variance components.
- Heritability: broad and narrow sense; response to selection.
- Molecular markers in population genetics: RFLP, RAPD, AFLP, microsatellites, SNPs.
- Linkage disequilibrium: measures, decay, significance in evolution.

- Gene flow, population structure (F-statistics: FIS, FST, FIT).

Unit III: Evolutionary Genetics & Adaptation (15 hrs)

- Natural selection: types (directional, stabilizing, disruptive, balancing).
- Fitness concepts; models of selection in haploids and diploids.
- Genetic drift & neutral theory; coalescent concepts (introductory).
- Molecular evolution: molecular clocks, rates of evolution.
- Evolution of sex, recombination and genomic conflict.

Unit IV: Speciation, Phylogeography& Applications (15 hrs)

- Modes of speciation: allopatric, sympatric, parapatric; hybrid zones.
- Reproductive isolating mechanisms; genetic basis of speciation.
- Phylogeography: haplotype networks, demographic history.
- Population bottlenecks, founder effects, extinction genetics.
- Applications: conservation genetics, disease gene mapping, forensic genetics.

Practical Syllabus (1 Credit) (30 Hours)

1. Estimation of Allele & Genotype Frequencies

- Calculation of allele and genotype frequencies from sample data.
- Testing Hardy–Weinberg equilibrium using chi-square.

2. Demonstration of Evolutionary Forces (Computer/Spreadsheet Simulations)

- Effect of **genetic drift** on small vs. large populations.
- Simulation of **natural selection** on allele frequencies.
- Effect of **migration** (gene flow) on population structure.

3. Quantitative Genetics Exercises

- Estimation of mean, variance, heritability (using provided datasets).
- Response to selection using breeder's equation.

4. Molecular Marker Data Analysis (Demonstration/Hands-on using sample datasets)

- Analysis of microsatellite/SNP datasets using basic population genetic software (e.g., POPGENE, GenAlEx).
- Calculation of F-statistics (FIS, FST) and interpretation.

5. Genetic Diversity &Phylogeographic Interpretation

- Construction of simple haplotype networks (paper/Excel or software).
- Interpretation of bottleneck/founder effect scenarios from provided data.

6. Laboratory Record & Viva Voce

- Submission of practical record book with calculations, graphs and interpretations.

Suggested Readings:

1. **Hartl, D. L., & Clark, A. G.** (2007). *Principles of Population Genetics* (4th ed.). Sinauer Associates, Sunderland, MA.

2. **Hedrick, P. W.** (2011). *Genetics of Populations* (4th ed.). Jones & Bartlett Learning, Burlington, MA.

3. **Futuyma, D. J., & Kirkpatrick, M.** (2017). *Evolution* (4th ed.). Sinauer Associates / Oxford University Press, Sunderland, MA.

4. **Halliburton, R.** (2004). *Introduction to Population Genetics*. Pearson Education, London.

5. **Li, W.-H.** (1997). *Molecular Evolution*. Sinauer Associates, Sunderland, MA.

6. **Templeton, A. R.** (2006). *Population Genetics and Microevolutionary Theory*. Wiley-Liss, Hoboken, NJ.

7. **Nei, M., & Kumar, S.** (2000). *Molecular Evolution and Phylogenetics*. Oxford University Press, New York.

8. **Allendorf, F. W., Luikart, G., & Aitken, S. N.** (2013). *Conservation and the Genetics of Populations* (2nd ed.). Wiley-Blackwell, Oxford.

9. **Verma, P. S., &Agarwal, V. K.** (2016). *Cell Biology, Genetics, Molecular Biology, Evolution & Ecology* (Revised ed.). S. Chand Publishing, New Delhi. *(Indian)*

10. **Gupta, P. K.** (2020). *Population and Evolutionary Genetics*. Rastogi Publications, Meerut. *(Indian)*

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO-20110-T Applied Zoology

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

- To introduce the applied branches of zoology relevant to industry, livelihoods and human welfare.
- To develop understanding of animal resources, their management and economic importance.
- To impart knowledge of technologies used in aquaculture, apiculture, sericulture and pest control.
- To understand principles of animal breeding, disease management and environmental applications of zoology.
- To promote entrepreneurship skills in bio-resource-based sectors.

LEARNING OUTCOMES (LOs):

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

- Apply zoological knowledge to economically important sectors such as apiculture, sericulture, poultry, dairy and aquaculture.
- Identify major pests and vectors and recommend appropriate biological and integrated management strategies.
- Demonstrate understanding of breeding, nutrition, health and management practices in animal resource industries.
- Explain eco-friendly technologies such as vermiculture, waste management and biocontrol.
- Develop entrepreneurial and applied skills relevant to zoology-based industries and public health.

Detailed Course Content

UNIT I: Insect Resources & Pest Management (15 hrs)

Insect Resources

- Beneficial insects: honey bees, lac insects, silkworms.
- Commercial products: honey, wax, royal jelly, lac, silk.
- Basic biology, rearing, diseases and management.

Pest Management

- Agricultural & household pests: biology and impact.
- IPM (Integrated Pest Management): cultural, biological, mechanical & chemical methods.
- Biological control: predators, parasitoids, microbial control agents.

UNIT II: Aquaculture & Fisheries (15 hrs)

- Principles of aquaculture: pond management, seed production, water quality.
- Types of aquaculture: freshwater, brackish, mariculture.
- Induced breeding: hypophysation, hormonal induction.
- Fish nutrition, growth, health management.
- Ornamental fish culture & aquarium technology.
- Fisheries by-products & value addition.

UNIT III: Animal Breeding, Dairy & Poultry Science (15 hrs)

Animal Breeding

- Selection, inbreeding, outbreeding, crossbreeding, hybrid vigour.
- Artificial insemination and reproductive technologies.

Dairy Science

- Dairy animals: breeds, housing, feeding, management.
- Milk production, composition, mastitis & disease control.
- Clean milk production & value-added dairy products.

Poultry Science

- Breeds, hatchery management, broiler & layer production.
- Health management: common diseases & vaccination.
- Economics of small-scale poultry farming.

UNIT IV: Environmental & Applied Health Zoology (15 hrs)

- Vermiculture and organic waste management.
- Zoo, wildlife management & captive breeding basics.
- Vector biology: mosquitoes, flies, ticks; principles of vector control.
- Public health importance of parasites (protozoans, helminths).
- Toxicology basics: bioaccumulation, biomagnification.
- Applications of biotechnology in applied zoology: probiotics, biofertilizers, biopesticides.

PRACTICAL SYLLABUS (1 Credit)(30hrs)

1. Identification of beneficial insects: honey bee castes, lac insect stages, silkworm stages.
2. Identification of major agricultural pests and their natural enemies.
3. Study of aquaculture systems & water quality parameters (pH, DO, hardness).
4. Identification of fish breeds and induced breeding apparatus (models/charts).
5. Identification of poultry and dairy breeds (charts/photographs).
6. Demonstration: vermicomposting method & earthworm culture.
7. Identification of major vectors (mosquito, housefly, tick).
8. Field/industry visit report (apiary/fish farm/poultry unit).

Suggested Readings:

1. **Gullan, P. J., & Cranston, P. S.** (2014). *The Insects: An Outline of Entomology* (5th ed.). Wiley-Blackwell.

2. **Pedigo, L. P., & Rice, M. E.** (2009). *Entomology and Pest Management* (6th ed.). Pearson Education.

3. **Roy, S., & Ray, D.** (2018). *A Textbook of Applied Entomology*. Kalyani Publishers.

4. **Jhingran, V. G.** (1991). *Fish and Fisheries of India* (3rd ed.). Hindustan Publishing Corporation.

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

6. **Banerjee, G. C.** (2018). *Animal Husbandry* (9th ed.). Oxford & IBH Publishing.

7. **Scanes, C. G.** (2015). *Poultry Science* (1st ed.). Academic Press.

8. **Kumar, N., &Vipin, S.** (2014). *Vermicomposting for Sustainable Agriculture*. Discovery Publishing House.

9. **Park, K.** (2021). *Preventive and Social Medicine* (26th ed.). Bhanot Publishers. *(For vector biology & public health relevance)*

10. **Gupta, P. K.** (2019). *Textbook of Toxicology*. Oxford Book Company. *(For toxicology basics, bioaccumulation, biomagnification)*

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO-20111-T- Genetics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

By the end of the course, students will:

- Understand the fundamental principles of classical, molecular and cytogenetics.
- Gain knowledge of chromosome structure, behaviour and abnormalities.
- Study genetic linkage, mapping, recombination and gene interactions.
- Develop skills in analyzing chromosomal aberrations, karyotyping and cytogenetic techniques.
- Learn the applications of genetics and cytogenetics in evolution, medicine, biodiversity and biotechnology.

Learning Outcomes (LOs):

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

- Explain chromosome organization, gene structure and patterns of inheritance.
- Perform and interpret genetic crosses, linkage data and recombination frequencies.
- Analyze chromosomal aberrations using modern cytogenetic tools.
- Apply genetic and cytogenetic concepts to study diseases, taxonomy and population variation.
- Evaluate the role of genetic mechanisms in evolution, genome stability and applied biology.

Detailed Course Content

Unit I: Fundamentals of Genetics (15 Hours)

- Mendelian principles: dominance, segregation, independent assortment
- Extensions of Mendelian genetics: incomplete dominance, codominance, epistasis, pleiotropy
- Chromosomal theory of inheritance
- Extra-chromosomal inheritance: maternal effects, mitochondrial inheritance
- Quantitative inheritance and polygenic traits
- Linkage, recombination & genetic mapping principles

Unit II: Chromosome Biology (15 Hours)

- Structure and organization of chromosomes: euchromatin/heterochromatin
- Types of chromosomes: monocentric, holocentric, polytene, lampbrush
- Karyotyping and idiogram preparation
- Chromosomal banding techniques: G-banding, C-banding, Q-banding
- Chromatin remodeling and epigenetic regulation
- Human chromosome classification and nomenclature (ISCN)

Unit III: Chromosomal Variations & Cytogenetic Disorders (15 Hours)

- Numerical chromosomal anomalies: aneuploidy, polyploidy
- Structural chromosomal anomalies: deletion, duplication, inversion, translocation
- Autosomal and sex-chromosome abnormalities: Down, Edward, Patau, Turner, Klinefelter syndromes
- Chromosome breakage, mutagens and clastogens

- Cancer cytogenetics and chromosomal instability
- Population cytogenetics and evolutionary implications

Unit IV: Applied & Molecular Cytogenetics (15 Hours)

- Molecular cytogenetics: FISH, GISH, SKY
- PCR-based cytogenetic applications
- Cell cycle, mitosis & meiosis—molecular control and checkpoints
- Genome organization and chromosomal territories
- Cytogenetics in animal breeding
- Clinical cytogenetics: diagnosis, genetic counseling, prenatal screening

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Study of mutant phenotypes of *Drosophila.*
2. Demonstration of law of segregation and independent assortment using *Drosophila* mutants
3. Study of autosomal and sex- linked inheritance using *Drosophila* mutant lines
4. Statistical analysis of genetic crosses
5. Empirical assessment of dosage compensation using *white apricot* (w^a) mutation in *Drosophila*
6. Targeted expression of genes using Ga14 - UAS System in *Drosophila*
7. Preparation and detailed observation of polytene chromosome from *Drosophila* salivary gland.
8. Study of transcriptional activity in polytene chromosome of *Drosophila* upon heat shock.
9. Preparation and study of metaphase chromosomes: Chromosome banding (C, G, H banding).
10. Simulation of genetic crosses using DrosophiLabprogram/Classic Genetics Simulator

Suggested Readings

1. Snustad, D. P., & Simmons, M. J. (2019).***Principles of Genetics*** **(8th ed.). Wiley.**
2. Klug, W. S., Cummings, M. R., Spencer, C. A., &Palladino, M. A. (2021).***Concepts of Genetics*** **(12th ed.). Pearson.**
3. Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., &Doebley, J. (2020).***Introduction to Genetic Analysis*** **(12th ed.). W.H. Freeman.**
4. Russell, P. J. (2017).***iGenetics: A Molecular Approach*** **(4th ed.). Pearson.**
5. Pardo-Manuel de Villena, F., &Sapienza, C. (Eds.). (2021).***Current Protocols in Cytogenetics.*** **John Wiley & Sons.**
6. Gardner, E. J., Simmons, M. J., &Snustad, D. P. (2017).***Genetics*** **(12th ed.). Wiley.**
7. Henderson, S. A., &Bardoni, B. (2019).***Human Cytogenetics: Constitutional Analysis*** **(4th ed.). Oxford University Press.**
8. Sumner, A. T. (2018).***Chromosomes: Organization and Function.*** **Blackwell.**
9. Jobling, M., Hollox, E., Hurles, M., Kivisild, T., & Tyler-Smith, C. (2019).***Human Evolutionary Genetics*** **(2nd ed.). Garland Science.**
10. Lewin, B. (2018).***Genes XII.*** **Jones & Bartlett.**

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO-20112-T Environmental Pollution and Management

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

- To understand major types, sources and impacts of environmental pollutants.
- To study ecological, physiological and toxicological effects of pollution on organisms.
- To learn monitoring methods, environmental standards and analytical techniques.
- To develop knowledge of pollution control, mitigation and sustainable management strategies.
- To promote skills for environmental assessment, conservation and policy awareness.

LEARNING OUTCOMES (LOs):

Upon completion of this course, students will be able to:

1. Identify major pollutants, their sources and their ecological and health impacts.
2. Explain toxicological mechanisms and evaluate pollutant effects using biological indicators.
3. Perform basic environmental sampling and interpret pollution-related data.
4. Understand pollution control technologies, waste management and mitigation strategies.
5. Apply environmental principles in conservation, sustainability and policy contexts.

Detailed Course Content

UNIT I: Fundamentals of Environmental Pollution (15 hrs)

- Concept of pollution: definitions, sources, pathways, biomonitoring.
- **Air pollution:** primary & secondary pollutants, smog, particulates, greenhouse gases.
- Air quality standards, AQI, dispersion models.
- **Water pollution:** physical, chemical, biological pollutants; eutrophication.
- **Soil pollution:** agrochemicals, heavy metals, plastics, industrial waste.
- Bioaccumulation, bio-magnification& biotransformation of pollutants.

UNIT II: Toxicology & Biological Effects of Pollutants (15 hrs)

- Introduction to environmental toxicology: dose–response, LD50, NOAEL.
- Mechanisms of toxicity: oxidative stress, endocrine disruption, neurotoxicity.
- Heavy metals (Hg, Pb, Cd, As) – sources & impacts.
- Pesticides, PAHs, microplastics& emerging contaminants (pharmaceuticals, nanoparticles).
- Effects on wildlife: behavioural, reproductive, developmental and genetic impacts.
- Environmental health issues: air pollution diseases, waterborne pathogens.

UNIT III: Environmental Monitoring & Assessment (15 hrs)

- Sampling methods: water, air, soil, biological samples.
- **Analytical techniques:** spectrophotometry, chromatography (GC, HPLC), AAS, biosensors.
- Biomarkers & bio-indicators: algae, invertebrates, fish.
- Eco-toxicological tests: LC50, toxicity bioassays, micronucleus test.
- Environmental Impact Assessment (EIA): principles & process.
- Environmental legislation: EPA (India), Wildlife Protection Act, Water & Air Acts, CPCB/PCB norms.

UNIT IV: Pollution Control, Mitigation & Management (15 hrs)

- **Air pollution control:** filters, scrubbers, catalytic converters, green technologies.
- **Water treatment:** primary–secondary–tertiary treatments, bioremediation, phytoremediation.
- **Solid waste management:** composting, vermitechnology, waste-to-energy, plastic alternatives.
- Climate change mitigation: carbon sequestration, renewable energy, adaptation strategies.
- Biodiversity conservation & habitat restoration.
- Sustainable development: SDGs, circular economy & environmental ethics.

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Water quality analysis (pH, DO, BOD, hardness – basic parameters).
2. Air quality monitoring: particulate matter, dust fall (demonstration/field).
3. Soil analysis: texture & organic matter.
4. Identification of bioindicator species (algae, insects, fish).
5. Study of EIA format and environmental regulation case study.
6. Demonstration of bioremediation/ phytoremediation models.
7. Toxicity test (LC50) – demonstration/problem-solving.
8. Field visit report (STP, solid waste plant, polluted habitat, etc.).

Suggested Readings

1. Connell, D. W., & Miller, G. J. (2012). ***Chemistry and Ecotoxicology of Pollution***. Wiley-Blackwell.
2. Waisberg, M., Joseph, P., Hale, B., &Beyersmann, D. (2003). "**Molecular and cellular mechanisms of cadmium carcinogenesis**." *Toxicology*, 192(2–3), 95–117.
3. Alloway, B. J. (2013). *Heavy Metals in Soils:* ***Trace Metals and Metalloids in Soils and Their Bioavailability*** (3rd ed.). Springer.
4. Manahan, S. E. (2017). ***Environmental Chemistry*** (10th ed.). CRC Press.
5. Nathanson, J. A., & Schneider, D. (2021). ***Basic Environmental Technology: Water Supply, Waste Management and Pollution Control*** (7th ed.). Pearson.
6. Walker, C. H., Sibly, R., Hopkin, S., &Peakall, D. (2012). ***Principles of Ecotoxicology*** (4th ed.). CRC Press.
7. Connell, D. W. (2009). ***Bioaccumulation of Xenobiotic Compounds***. CRC Press.
8. Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). ***Principles of Instrumental Analysis*** (7th ed.). Cengage.

9. Peavy, H. S., Rowe, D. R., &Tchobanoglous, G. (2013). ***Environmental Engineering***. McGraw-Hill.
10. Goel, P. K. (2017). ***Water Pollution: Causes, Effects and Control*** (New Age International).
11. Rao, M. N., &Datta, A. K. (2017). ***Wastewater Treatment***. Oxford & IBH.
12. UNEP. (2019). *Global Environment Outlook 6 (GEO-6): Healthy Planet, Healthy People*. United Nations Environment Programme.
13. IPCC. (2021). *Climate Change 2021: The Physical Science Basis*. Cambridge University Press.
14. Rockström, J., et al. (2009). "Planetary boundaries: Exploring the safe operating space for humanity." *Ecology and Society*, 14(2).
15. MoEFCC. (2006). ***National Environmental Policy (NEP)***, *Government of India*.
16. Central Pollution Control Board (CPCB). (2022). ***National Air Quality Status & Trends Report***.
17. Sharma, B. K. (2019). ***Environmental Chemistry*** (16th ed.). Goel Publishing House, India.

M.Sc. Zoology (Semester–I)
Elective Course 05
ZOO -2013-T- Stem Cell Biology

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):
By the end of the course, students will be able to:

- Understand fundamental concepts of stem cells, their characteristics and potency.
- Learn the biology of embryonic, adult and induced pluripotent stem cells.
- Examine stem cell niches, signaling pathways and differentiation mechanisms.
- Study methods of stem cell culture, maintenance, cryopreservation and characterization.
- Explore applications of stem cells in regenerative medicine, disease modelling and biotechnology.
- Evaluate ethical, legal and policy issues associated with stem cell research.

Learning Outcomes (LOs):

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

- Describe the properties, types and developmental origins of stem cells.
- Demonstrate understanding of stem cell self-renewal, potency and lineage commitment.
- Explain in vitro culture systems and experimental strategies used in stem cell biology.
- Analyze the role of stem cells in tissue regeneration, repair and therapeutic approaches.
- Critically assess ethical concerns, regulatory frameworks and translational research challenges.

Detailed Course Content

Unit I: Fundamentals of Stem Cell Biology(15 Hours)

- Definition and properties of stem cells: self-renewal, potency
- Types of stem cells: totipotent, pluripotent, multipotent, unipotent
- Embryonic stem cells (ESCs): origin, isolation, characteristics
- Adult stem cells: hematopoietic, mesenchymal, neural, epithelial
- Stem cell niche: components, microenvironment and regulation
- Overview of developmental signaling pathways: Wnt, Hedgehog, Notch, BMP

Unit II: Stem Cell Techniques and Characterization(15 Hours)

- In vitro stem cell culture methods: feeder layer systems, 3D culture, organoids
- Techniques: cell sorting (FACS, MACS), colony-forming assays
- Stem cell markers: surface markers, transcription factors (Oct4, Sox2, Nanog)
- Induced pluripotent stem cells (iPSCs): reprogramming factors, methods
- Cryopreservation and stem cell banking

- Genome editing in stem cells: CRISPR-Cas applications

Unit III: Differentiation, Development &Regeneration(15 Hours)

- Mechanisms of differentiation: lineage commitment and plasticity
- Directed differentiation to major lineages: neural, cardiac, blood, germ cells
- Stem cells in tissue homeostasis and regeneration
- Regenerative biology: salamanders, planarians, zebrafish models
- Stem cells in aging and cancer stem cells
- Organoid technology and disease modelling

Unit IV: Applied Stem Cell Biology &Ethics(15 Hours)

- Clinical applications: stem cell therapy, transplantation, tissue engineering
- Stem cells in drug screening and toxicology testing
- Stem cell-based approaches in neurodegeneration, diabetes, cardiac repair
- Regulatory and ethical issues: ICMR, ISSCR guidelines
- Stem cell patents, commercialization and translational challenges
- Future prospects: personalized medicine and cell-based therapies

PRACTICAL SYLLABUS (1 Credit)(30 Hours)

1. Identification of ESCs, MSCs, NSCs (charts, microphotographs).
2. Demonstration of stem cell culture methods (virtual/real).
3. Study of stem cell markers using immune staining images.
4. Observation of reprogramming workflow for iPSC development.
5. Organoid culture basics (demonstration/model).
6. Case studies: stem cell therapy applications (blood, cornea, skin).
7. Assignment on ethical issues and regulatory guidelines.
8. Visit report: hospital/research lab/tissue culture facility (if available).

Suggested Readings:

1. Lodish, H., Berk, A., Kaiser, C. A., et al. (2016). *Molecular Cell Biology* (8th ed.). W.H. Freeman.
2. Lanza, R., Atala, A., & Thomson, J. A. (Eds.). (2019). *Essentials of Stem Cell Biology* (4th ed.). Academic Press.
3. Slack, J. M. W. (2018). *Essential Developmental Biology* (4th ed.). Wiley-Blackwell.
4. Freshney, R. I. (2015). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications* (7th ed.). Wiley-Blackwell.
5. Alberts, B. et al. (2017). *Molecular Biology of the Cell* (6th ed.). Garland Science.
6. Singh, V. K. &Verma, V. (2020). *Stem Cells and Regenerative Medicine*. Springer.
7. Potten, C. S. &Loeffler, M. (1990). *Stem Cells: Their Identification and Characterization*. Churchill Livingstone.
8. Yu, J. & Thomson, J. A. (2017). *Pluripotent Stem Cells* (2nd ed.). Humana Press.
9. Ranga, A. &Lutolf, M. (2018). *Stem Cells in Organoid Biology*. Cambridge University Press.
10. ICMR. (2017). *National Guidelines for Stem Cell Research* (India).

Skill Enhancement Courses (SEC) for M.Sc. Zoology Students

M.Sc. ZOOLOGY I SEMESTER

SEC-20124-T

Type: Skill Enhancement Course (SEC)

Credits: 04 **Total Hours:** 60 (Theory + Practical)

1: PARASITOLOGY

Max. Marks: 100 **Total** Hours: 60

Course Objectives (COs):

- Introduce the basic principles of parasitology and life cycles of important parasites.
- Develop understanding of pathogenic mechanisms, host–parasite interactions, and epidemiology.
- Train students in identification and diagnosis of protozoan, helminthic and arthropod parasites.
- Familiarize students with classification, nomenclature and control measures of medically important parasites.
- Provide hands-on skills in microscopic examination and parasitological techniques.

Learning Outcomes (LOs):

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

- Explain life cycles, pathology, transmission and management of major human and animal parasites.
- Identify protozoan, helminthic and arthropod parasites using permanent slides and smear preparations.
- Perform blood smear examination and detection of parasitic infections.
- Describe taxonomic classification and nomenclature of parasites.
- Understand public health significance and control strategies of parasitic diseases.

Detailed Course Content (60 Hours)

UNIT I — Introduction to Parasitology

- History and scope of parasitology
- General life cycle patterns of parasites
- Types of development and alternation of generation
- Development of parasites in host tissues
- Mechanisms of pathogenicity
- International Zoological Nomenclature for parasites
- Economic importance of taxonomy in parasitology

UNIT II — Classification of parasitic protozoa.

- Structure, life history, pathogenicity, treatment and management of: Trypanosomabruceigambiense, T.b.rhodensiense, T.cruzi, T.lewisi, Leishmaniadonovani, Giardia lamblia, Trichomonastenax and Trichomonasvaginalis.
- Structure, lifehistory, pathogenicity, treatment and management of: Entamoeba coli, E. gingivalis, E. histolytica and E. muris.
- Structure, life history, pathogenicity, treatment and management of Eimeratenella, Gregarinia, Monocystislumbrici, Plasmodium vivax, P. ovale, P. malaria and P. falciparum.

UNIT III — Parasitic Helminths

- Classification of parasitic helminthes
- Trematodes: *Fasciola hepatica, Fasciolopsisbuski, Schistosomahaematobium, S. mansoni, S. japonicum*
- Cestodes: *Taeniasolium, Taeniasaginata*
- Nematodes: *Ascarislumbricoides, Trichinellaspiralis, Trichuristrichiura, Dracunculusmedinensis, Wuchereriabancrofti*(Structure, life cycle, pathogenicity, symptoms, diagnosis & management)

UNIT IV — Parasitic Annelids and Arthropods

- Classification of parasitic Annelids and Arthropods.
- Structure, life history, pathogenicity, treatment and management of: Glossiphonia,Pontobdella and Hirudomedicinalis.
- Structure, life history, pathogenicity, treatment and management of: Pediculushumanuscapitis,Pediculushumanuscorporis, Phthirus pubis, Cimaxlectularius, Mites, Ticks, Cattle louse and Xenopsyllacheopis.

Practicals:

1. Examination of blood for parasites.
2. Detection of exflagellation (microgamete formation in Plasmodium).
3. Examination of blood for inicic filarial infection (Papanicaulouhematoxylin and eosin).
4. Permanent slides: Trypanosoma, Leishmania, Giardia.,Trichomonas, Entamoeba, Ehrlichia, Eimera, Gregarinia, Monocystis , Plasmodium, Fasciola, Schistosoma, Taenia, Ascaris, Trichinella, Trichuris, Dracunculus, Wuchereria, Glossiphonia, Pontobdella, Hirudo, Pediculus, Phthirus, Cimax, Mites, Ticks, Cattle louse and Xenopsylla.

Suggested Books

1. Chakraborty P. — *Textbook of Medical Parasitology*, New Central Book Agency
2. Chatterjee K.D. — *Parasitology*
3. Dasgupta B. — *Parasitology*, Books and Allied Pvt. Ltd.
4. Schmidt G.D. — *Essentials of Parasitology*, Universal Book Stall

(2) Ornithology

Max. Marks: 100Total Hours: 60

Course Objectives (COs):

- Provide foundational and advanced concepts of avian biology and diversity.
- Familiarize students with anatomy, physiology, ecology, migration and evolution of birds.
- Develop understanding of bird behavior, breeding strategies and communication.
- Promote conservation awareness with reference to Indian threatened birds.
- Train students in field identification and bird documentation.

Learning Outcomes (LOs):

Students will be able to:

- Identify major bird groups and explain their diversity and evolutionary relationships.
- Understand internal anatomy, physiology, flight mechanisms and adaptations.
- Analyze bird behavior including courtship, nesting and social patterns.
- Explain migration patterns, threats and conservation approaches.
- Apply knowledge in birdwatching, species documentation and conservation projects.

Detailed Course Content (60 Hours)

Unit-1: Ornithology and Diversity

1. Introduction to Ornithology and Avian Diversity
2. Origin, classification and nomenclature of Aves.
3. Avian Diversity across the country and in special context to Rajasthan.
4. Evolution and Speciation of Aves.

Unit-2: Anatomy and Physiology of birds.

1. Basic anatomy of birds and physiology of various systems.
2. Laryngeal mechanism in sound note emission.
3. Flight adaptations and beak modifications.
4. Development, molting and coloration of feathers.

Unit-3: Ecology and Ethology of Birds.

1. Habitats of different types of birds.
2. Courtship, mating and breeding behavior.
3. Nesting and parental care in birds.
4. Social behaviour: communication, flocking and defence.

Unit-4: Migration and Avian Conservation Concepts.

1. Causes, challenges and significance of migration.
2. Major threats to Avian Diversity in India

3. Advantages and disadvantages of various types of migration.
4. Conservation and breeding Programmes w.s.r.t. Great Indian Bustard and Vultures

SUGGESTED READINGS:

1. **Ali, S., & Ripley, S. D.** (1971–1987). *Handbook of the Birds of India and Pakistan: Together with Those of Bangladesh, Nepal, Sikkim, Bhutan and Sri Lanka* (10 Vols.). Oxford University Press.
2. **Bischof, H.-J., & Zeigler, H. P.** (Eds.). (1993). *Vision, Brain, and Behaviour in Birds*. MIT Press.
3. **Bock, W.** (2009). *The Origin and Evolution of Birds* (2nd ed.). Oxford University Press.
4. **BNHS.** (2018). *Indian Bird Migration Atlas*. Bombay Natural History Society.
5. **Burton, R.** (1985). *Bird Behavior*. Alfred A. Knopf.
6. **Cavanagh, P.** (2024). *How Birds Fly: The Science and Art of Avian Flight*. Firefly Books.
7. **Dyke, G., & Kaiser, G.** (Eds.). (2011). *Living Dinosaurs: The Evolutionary History of Modern Birds*. Wiley-Blackwell.
8. **Elphick, J., & Lovejoy, T. E.** (2011). *The Atlas of Bird Migration: Tracing the Great Journeys of the World's Birds*. Penguin Random House.
9. **Futuyma, D. J.** (2021). *How Birds Evolve: What Science Reveals About Their Origin, Lives, and Diversity*. Princeton University Press.
10. **Grimmett, R., Inskipp, C., &Inskipp, T.** (2016). *Birds of the Indian Subcontinent*. Bloomsbury.
11. **Kricher, J.** (2020). *Peterson Reference Guide to Bird Behavior*. Mariner Books.
12. **Lovette, I. J., & Fitzpatrick, J. W.** (Eds.). (2016). *Handbook of Bird Biology* (3rd ed.). Wiley–Blackwell (Cornell Lab of Ornithology).
13. **Newton, I.** (2003). *Speciation and Biogeography of Birds*. Academic Press.
14. **Newton, I.** (2020). *Bird Migration*. William Collins.
15. **Sibley, C. G.** (1990). *Phylogeny and Classification of Birds*. Oxford University Press.
16. **Sibley, D. A.** (2001). *The Sibley Guide to Bird Life &Behavior*. Alfred A. Knopf.
17. **Solway, A.** (2009). *Classifying Birds*. Raintree Publishers.
18. **Stokes, D., & Stokes, L.** (1983). *Stokes Guide to Bird Behavior* (Vols. 1–3). Little, Brown & Co.
19. **Striedter, G. F., &Iwaniuk, A. N.** (2025). *Bird Brains and Behavior: A Synthesis*. MIT Press.
20. **Sutherland, W., Newton, I., & Green, R.** (Eds.). (2004). *Bird Ecology and Conservation: A Handbook of Techniques*. Oxford University Press.
21. **Tong, W., & Sheldon, B.** (2020). *Understanding Bird Behavior: An Illustrated Guide to What Birds Do and Why*. Princeton University Press.

3. Apiculture (Honey Bee Keeping)

1. Course Overview

This course imparts hands-on skills in scientific beekeeping, including honeybee biology, hive management, queen rearing, honey extraction, and disease control. It prepares students for employment and entrepreneurship in apiculture, honey processing, and pollination services.

2. Course Objectives (COs)

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

- Understand honeybee species, biology, and colony organization.
- Develop skills in hive construction, inspection, and maintenance.
- Apply scientific methods for queen rearing and colony management.
- Demonstrate skills in honey extraction, processing, and storage.
- Identify and control major bee pests and diseases.
- Acquire entrepreneurship skills for small-scale and commercial beekeeping.

3. Learning Outcomes (LOs)

Students will be able to:

- Identify different honeybee species and castes.
- Manage apiaries, maintain colonies, and ensure optimum productivity.
- Extract and process honey using standard hygienic methods.
- Prevent and manage diseases and pests of bees.
- Prepare business models for beekeeping enterprises.

Course Content (60 Hours)

Unit I: Introduction to Apiculture(15 Hours)

- History and scope of beekeeping in India
- Species of honeybees: *Apismellifera, A. cerana, A. dorsata, A. florea*
- Colony structure: queen, worker, drone
- Social behaviour and communication in bees
- Basic requirements for establishing an apiary: site selection, climate, flora
- Bee products: honey, wax, royal jelly, propolis, pollen, bee venom

Unit II: Apiary Equipment & Hive Management(15 Hours)

- Types of hives: Langstroth, Indigenous hives
- Hive components: brood chamber, frames, supers, foundation sheets
- Hive construction and maintenance
- Seasonal management of colonies
- Feeding of bees and nutritional requirements
- Swarming, supersedure, absconding – causes and management
- Migration and apiary layout design

Unit III: Queen Rearing, Honey Extraction &Processing(15 Hours)

- Queen rearing techniques: grafting, supersedure, colony splitting
- Role of queen and brood cycle
- Honey flow season and colony strengthening
- Methods of honey extraction: manual, centrifugal extractor
- Honey processing: filtration, dehydration, storage
- Quality control, FSSAI standards, adulteration testing
- Wax extraction and purification

Unit IV: Bee Pests, Diseases & Apiculture Entrepreneurship(15 Hours)

- Major pests: wax moth, mites (Varroa), ants, wasps, birds
- Diseases: American foulbrood, European foulbrood, Nosema, viral infections
- Preventive and curative measures
- Integrated Pest Management (IPM) in apiaries
- Economics of beekeeping: cost analysis, marketing strategies
- Value-added products: comb honey, flavoured honey, wax crafts
- Beekeeping as a startup: business plan, government schemes, NABARD support

5. Practical Components:

1. Identification of honeybee species and castes
2. Study of apiary tools and equipment
3. Hive inspection techniques
4. Preparation of artificial foundation sheets
5. Queen rearing demonstration
6. Honey extraction using a centrifugal honey extractor
7. Wax extraction and purification
8. Identification of diseases and pests in colonies
9. Preparation of a small apiary project report
10. Visit to bee farm / KVIC / beekeeping training centre

6. Assessment Pattern

Internal Assessment (40 Marks)

- Practical performance
- Field visit report
- Class tests / assignments
- Project / business model preparation

End Semester Exam (60 Marks)

- Theory examination covering Units I–IV

7. Suggested Readings:

- Singh, S. (2010). *Beekeeping in India*. ICAR.
- Crane, E. (1990). *Bees and Beekeeping: Science, Practice and World Resources*. Heinemann.
- Winston, M.L. (1992). *The Biology of the Honey Bee*. Harvard University Press.

4. HISTOLOGY AND HISTOPATHOLOGY

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

- Provide fundamental principles of histology and histopathology.
- Train students in tissue processing, sectioning, staining and microscopic analysis.
- Develop understanding of normal and pathological structures of organ systems.
- Equip students with basic diagnostic skills in cellular pathology.
- Build laboratory skills for fixation, histochemical techniques and slide interpretation.

Learning Outcomes (LOs):

Students will be able to:

- Perform tissue processing, embedding, sectioning and staining.
- Identify normal histological features of major tissues and organs.
- Recognize pathological changes such as necrosis, fatty degeneration, inflammation etc.
- Execute histochemical tests and in-situ detection techniques.
- Analyze pathological slides with professional accuracy.

Detailed Course Content

UNIT I: Tools & Techniques in Histology

- **Definition and scope** of histology and histopathology
- **Tools in histology:** Principles, design and functioning of microtomes, automated microtomes,ultramicrotome, problems and trouble shooting.
- **Techniques in histology:** Sample preparation, obtaining tissue samples, handlingreagents, fixatives, processing of fixed samples, dehydration, embedding, block making and slide preparation
- **Tissue preparation:** fixation, dehydration, embedding, block making, sectioning
- **Stainingprinciplesanddemonstrationtechniques:**Stains, Reactivegroups,mordantsandmordanting.

UNIT II — Cellular Pathology & Basic Tissues

- **Cellular Pathology:**Necrosis, apoptosis, nuclear fragmentation, fatty degenerationetc.
- **Fundamentalsofhistology:**Epithelial, connective, muscular, nervous and other specializedtissues,
- Skin
- Histology and histopathology of blood,spleen andthymus.

UNIT III — Endocrine & Reproductive Systems

- Histologyandhistopathology: Thyroid, parathyroid, pituitary, adrenal glands
- Reproductivesystem: Male & female

UNIT IV — Digestive System

- Histologyandhistopathology: Esophagus, stomach, intestine, colon, rectum
- Liver & pancreas (normal & pathological features)

Practicals

1. Permanentmountingoftissues and histology:Fixation, dehydration, embedding, sectioning & staining
2. Micrometry:
   Microscopicmeasurementsofhistologicalsamplesusingmicrometersandplanimeters
3. PAS staining, Alcian blue technique
4. Alkaline phosphatase detection
5. Feulgen reaction
6. Sudan Black B staining for lipids
7. Methyl green–pyroninG staining
8. Study of pathological tissues (permanent slides)

Note:**Itshouldbeensured**thatanimals**usedinthe**practical**exercisesarenotcovered under the** Wildlife Act 1972 and amendments made subsequently.

Suggested Readings:

1. **Kiernan, J. A. (2008).** ***Histological and Histochemical Methods: Theory and Practice*** **(4th ed.).**Scion Publishing Ltd., Oxfordshire.
2. **Gartner, L. P., & Hiatt, J. L. (2000).** ***Color Atlas of Histology*** **(3rd ed.).**Lippincott Williams & Wilkins, Baltimore.
3. **Ross, M. H., Reith, E. J., &Romrell, L. J. (1995).** ***Histology: A Textbook and Atlas*** **(2nd ed.).**Williams & Wilkins, Baltimore.
4. **Copenhaver, W. M. (1964).** ***Bailey's Textbook of Histology*** **(15th ed.).**The Williams & Wilkins Company, Baltimore.
5. **Bloom, W., & Fawcett, D. W. (1975).** ***A Textbook of Histology.***W. B. Saunders Company, Philadelphia.
6. **Kierszenbaum, A. L. (2002).** ***Histology and Cell Biology: An Introduction to Pathology.***Mosby Inc., St. Louis, USA.
7. **Orchard, G., & Nation, B. (2012).** ***Histopathology.***Oxford University Press.

M.Sc. Zoology (Semester–II)
Core Course 08
ZOO-2021-T Chordata

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

By the end of the course, students will:

- Develop a deep appreciation of chordate diversity from protochordates to mammals.
- Understand comparative structural and functional organization within major chordate groups.
- Learn key evolutionary transitions across chordate lineages and their phylogenetic relationships.
- Analyze adaptive radiations and ecological specializations across vertebrates.
- Build foundational knowledge for advanced studies in vertebrate morphology, evolution and systematics.

Learning Outcomes (LOs):

Upon successful completion, learners will be able to:

- Identify major chordate groups and describe diagnostic features with scientific accuracy.
- Compare structural organization of various classes of chordates and explain their functional significance.
- Illustrate evolutionary trends and construct basic phylogenetic relationships among chordate groups.
- Explain adaptive radiation patterns in fishes, amphibians, reptiles, birds and mammals.
- Interpret vertebrate evolutionary history using morphological, paleontological and molecular evidences.

Detailed Course Content

UNIT I – Origin of Chordates, Protochordates and Fishes (15 Hours)

A. Origin of Chordates & Protochordates

- **Origin and evolution of chordates**
- **Hemichordata** – General organization, systematic position, evolutionary significance.
- **Urochordata** – General organization, life cycle, retrogressive metamorphosis, affinities.
- **Cephalochordata** – General organization, notochord, feeding mechanism, affinities.

B. Pisces (Fishes)

- **General organization of fishes** – Integument, skeletal system, respiration, circulation, excretion, reproduction.
- **Origin and evolution of fishes** – Early chordates to Ostracoderms.
- **Ostracoderms** – Structure, evolution and affinities.

प्रभारी अकादमिक प्रथम

- **Dipnoi and Holocephali** – General features, evolutionary importance.
- **Coelacanthiformes** – Characteristics, significance as a "living fossil," phylogenetic position.

UNIT II – Amphibia(15 Hours)

- **Origin and Evolution of Tetrapods** – Transition from water to land; evolutionary innovations.
- **General organization of Anura** – Comparative anatomy and physiology.
- **Neoteny** – Mechanism, examples, evolutionary implications.
- **Peculiarities of Urodela** – Morphological and physiological characteristics.
- **Peculiarities of Apoda (Gymnophiona)** – Unique features, burrowing adaptations.
- **Adaptive radiation in Amphibia** – Habitat diversification and ecological strategies.
- **Extinct Amphibians** – Fossil forms and evolutionary insights.
- **Parental care in Amphibia**

UNIT III – Reptilia(15 Hours)

- **Origin and Evolution of Reptiles** – Stem reptiles, evolutionary radiation.
- **Adaptive Radiation** – Aerial, aquatic, fossorial and terrestrial adaptations.
- **Dinosaurs** – Classification, evolution, extinction theories.
- **General organization, skull types and affinities of:**
    1. **Chelonia** – Turtles and tortoises; shell structure; evolution.
    2. **Crocodilia** – Morphology, sensory biology, phylogenetic relations.
    3. **Squamata** – Lizards, snakes; structural adaptations.
    4. **Rhynchocephalia** – Sphenodon; primitive features and evolutionary importance.

UNIT IV – Aves and Mammalia (15 Hours)

A. Aves

- **Origin and Evolution of Birds** – From theropod dinosaurs to modern birds.
- **Flightless Birds** – Ratites and penguins; adaptations and evolution.
- **Adaptations for Flight** – Feathers, skeleton, muscles, respiration; aerodynamic principles.
- **Adaptive Radiation in Birds** – Feeding adaptations, niches, beak and foot modifications.

B. Mammalia

- **Origin and evolution of Mammals** – Synapsid evolution, early mammals.
- **Adaptive Radiation in Mammals** – Aquatic, aerial, arboreal, terrestrial forms.
- **Prototheria and Metatheria** – Structural peculiarities and phylogenetic relations.
- **Dentition in Mammals** – Types, evolutionary significance.
- **Stomach modifications** – Monogastric, ruminant adaptations.
- **Uterine modifications** – Duplex, bipartite, bicornuate, simplex.

- **Aquatic Mammals** – Adaptations and evolution.

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Study of Protochordates (Slides/Charts/Models)

- Identification and comparison of *Balanoglossus, Herdmania, Ascidia, Branchiostoma.*
- Observation of notochord, pharyngeal gill slits, tunicate life cycle stages.

2. Comparative Study of Fish Morphology

- External characters of cartilaginous and bony fishes.
- Observation of scales (placoid, cycloid, ctenoid, ganoid).
- Study of fins and coloration patterns.

3. Osteology of Fishes, Amphibia, Reptiles, Birds and Mammals

- Identification of major bones: skull, vertebrae, limbs & girdles.
- Comparison of homologous structures across classes.

4. Study of Accessory Respiratory Organs in Fishes

- Observation using charts/models: air bladder, labyrinth organ, cutaneous respiration.
- Comparative interpretation with environmental adaptations.

5. Comparative Anatomy of Urochordates and Cephalochordates

- Slides of *Herdmania* spicules, test structure, retrogressive metamorphosis diagrams.
- Branchiostoma transverse sections: myotomes, nerve cord, notochord.

6. Identification and Study of Amphibian Groups

- Morphological comparison of Anura, Urodela and Apoda using charts/models.
- Observation of neoteny (Axolotl), adaptations, amphibian lung/trachea structures.

7. Study of Reptilian Diversity

- Identification (charts/models/preserved specimens) of Chelonians, Crocodiles, Lizards, Snakes, Sphenodon.
- Study of adaptations: limbs, scutes, skull types.

8. Study of Beaks, Feet and Feather Types in Birds

- Identification of feeding and locomotory adaptations.
- Observation of flight adaptations: wing types, feather structure.

9. Identification of Mammalian Orders and Adaptations

- Representative specimens/charts: Chiroptera, Cetacea, Carnivora, Rodentia, Primates, etc.
- Study of evolutionary adaptations (aquatic, aerial, arboreal, fossorial).

10. Mammalian Specializations: Dentition, Stomach & Uterine Types

- Study of mammalian skulls for dentition patterns (herbivore, carnivore, omnivore).
- Charts/models of monogastricvs ruminant stomach.
- • Comparisons of uterine modifications across mammalian groups.

11. **Edible Fish** (Dissection)– External morphology, gills, Internal ear, eye muscles, digestive, reproductive and branchial systems

SUGGESTED READINGS:

1. Kardong, K. V. (2015). ***Vertebrates: Comparative Anatomy, Function, Evolution***. McGraw-Hill.
2. Harvey, P., Romer, A., McFarland, W., & others. (2006). ***The Vertebrate Life***. Pearson.
3. Colbert, E. H., Morales, M., & Minkoff, E. C. (2002). ***Colbert's Evolution of the Vertebrates*** (5th ed.). Wiley-Liss.
4. Hildebrand, M., &Goslow, G. (1995). ***Analysis of Vertebrate Structure*** (4th ed.). John Wiley & Sons.
5. Romer, A. S., & Parsons, T. S. (1986). ***The Vertebrate Body*** (6th ed.). Saunders/ CBS Publishing.
6. Young, J. Z. (2006). ***The Life of Vertebrates*** (3rd ed.). Oxford University Press.
7. Parker, T. J., & Haswell, W. A. (1978). ***A Textbook of Zoology, Vol. II***. ELBS.
8. Nielsen, C. (2012). ***Animal Evolution: Interrelationships of the Living Phyla***. Oxford University Press.
9. Kent, G. C. Comparative Anatomy of the Vertebrates. The C. V. Mosby Company.

M.Sc. Zoology (Semester–II)
Core Course 09
ZOO-20202-T-Biochemistry

Credits: 04 **Total Hours:** 60 (Theory)

COURSE OBJECTIVES (COs):

The course aims to:

- Develop a comprehensive understanding of biomolecules and their structural–functional relationships.
- Explain enzyme kinetics, regulation and thermodynamic principles governing biological processes.
- Impart in-depth knowledge of carbohydrate, lipid, amino acid and nucleotide metabolism.
- Provide analytical skills for interpreting biochemical reactions and metabolic pathways.
- Build competency for advanced research, experimental design and biochemical data analysis.

LEARNING OUTCOMES (LOs):

After completion, learners will be able to:

- Describe and classify major biomolecules and evaluate their structural significance.
- Apply enzyme kinetic principles and calculate kinetic parameters.
- Explain metabolic pathways, their regulation and biochemical energy transduction.
- Analyze metabolic disorders using biochemical reasoning.
- Integrate biochemical concepts for research in molecular biology, physiology and biotechnology.

DETAILED SYLLABUS

UNIT I: Biomolecules and Molecular Architecture (15 Hours)

1. Introduction to Biomolecules

- Classification and general properties of carbohydrates, lipids, proteins, nucleic acids
- Functional groups and chemical basis of biological activity

2. Stabilizing Interactions in Biological Systems

- Van der Waals forces, electrostatic interactions, H-bonding
- Hydrophobic interactions, aromatic stacking
- Role of weak forces in protein/nucleic acid stability

3. Amino Acids and Proteins

- Structure and chemistry of amino acids
- Ionization and titration curves, zwitterion concept
- Peptide bond and its properties
- Covalent modification of proteins, protein sequencing and splicing

4. Protein Structure

- **Secondary structure:** α-helix, β-sheet, turns, motifs
- **Ramachandran plot:** allowed and disallowed conformations
- **Tertiary and quaternary structure:** folding, domains, oligomerization
- **Globular and fibrous proteins**
- Haemoglobin and myoglobin structure, Hill coefficient, haemoglobin subunit cooperativity and oxygen binding
- Protein folding pathways; denaturation &renaturation. Levinthal paradox

UNIT II: Enzyme Kinetics and Bioenergetics (15 Hours)

1. Introduction to Enzymes

- Enzyme classification (EC system)
- Apoenzyme, holoenzyme
- Cofactors, coenzymes, prosthetic groups
- Abzymes, ribozymes

2.Bioenergetics

- Laws of thermodynamics
- Standard free energy ($\Delta G^{\circ\prime}$), actual free energy (ΔG)
- Relationship between ΔG, Keq
- ATP and high-energy compounds
- Redox reactions in metabolism

3. Enzyme Kinetics

- Michaelis–Menten equation, assumptions
- Km, Vmax determination
- Lineweaver–Burk plot and other linear transformations
- Types of enzyme inhibition: competitive, non-competitive, uncompetitive
- Enzyme activity calculations

4. Enzyme Regulation

- Allosteric enzymes: models (MWC, KNF)
- Covalent modification
- Zymogens and activation mechanisms
- Isozymes

UNIT III: Carbohydrate, Lipid, Amino Acid and Nucleotide Metabolism (15 Hours)

1. Carbohydrate Metabolism

- Glycolysis, gluconeogenesis
- Citric Acid Cycle: steps, regulation, amphibolic nature
- Glycogenesis, glycogenolysis
- Pentose phosphate pathway
- Oxidative phosphorylation and electron transport chain
- Metabolic integration

2. Lipid Metabolism

- Biosynthesis of saturated and unsaturated fatty acids
- β-oxidation of fatty acids
- Ketogenesis and ketone body utilization
- Regulation of lipid metabolism

3. Amino Acid Metabolism

- Transamination, deamination
- Urea cycle and regulation

- Disorders of amino acid metabolism (overview)

4. Nucleotide Metabolism

- De novo and salvage pathways of purine and pyrimidine synthesis
- Regulation and feedback control
- Disorders: gout, SCID (overview)

UNIT IV: Molecular Integration, Regulation and Clinical Biochemistry (15 Hours)

1. Metabolic Coordination

- Interrelationship of carbohydrate, lipid and protein metabolism
- Fed and fasting states
- Hormonal regulation (insulin, glucagon, epinephrine)

2. Oxidative Stress & Antioxidant Systems

- ROS, RNS, oxidative damage
- Antioxidants: enzymatic and non-enzymatic

3. Clinical Biochemistry

- Liver function tests (LFT) and renal biomarkers
- Metabolic disorders overview: diabetes, lipid disorders
- Inborn errors of metabolism

4. Vitamins

- Classification, structure and functions of fat soluble vitamins
- Classification, structure and functions of water soluble vitamins
- Phenolics and alkaloids structure and function

PRACTICAL SYLLABUS (1 Credit) **(30 hrs)**

1. VerificationofBeerLambert'sLawusinganycoloursolution
2. Determinationofabsorptionmaximaofacolouredsolution
3. Standardcurve—cholesterol,protein
4. DeterminationofpHofdifferentsolutions.
5. Quantitiesestimationofthefollowinginvarioustissues.
   - Carbohydrates:Glycogen,&Glucose
   - Proteins- total protein.
   - Lipids:TotalLipid&Cholesterol
   - NucleicAcid:DNAandRNA
   - Enzymes;AcidandAlkalinePhosphatase
6. Paper chromatography: unidimensional chromatography using amino acids from purified samples and biological materials.(Ascending & Descending)
7. Determination of serum protein through paper / PAGE electrophoresis.

SUGGESTED READINGS:

1. Berg, J.M., Tymoczko, J.L., Gatto, G.J. &Stryer, L. (2015).***Biochemistry*** **(8th ed.). W.H. Freeman and Company.**
2. Lehninger, A.L., Nelson, D.L. & Cox, M.M. (2017).***Lehninger Principles of Biochemistry*** **(7th ed.). W.H. Freeman.**
3. Voet, D. &Voet, J.G. (2011).***Biochemistry*** **(4th ed.). Wiley.**

4. Mathews, C.K., Van Holde, K.E., Appling, D.R. & Anthony-Cahill, S.J. (2012).***Biochemistry*** **(4th ed.). Pearson.**
5. Boyer, R. (2012).***Concepts in Biochemistry*** **(3rd ed.). Wiley.**
6. Garrett, R.H. & Grisham, C.M. (2012).***Biochemistry*** **(5th ed.). Brooks/Cole.**
7. Devlin, T.M. (2010).***Textbook of Biochemistry with Clinical Correlations*** **(7th ed.). Wiley-Liss.**

M.Sc. Zoology (Semester-II)
Core Course 10
Introduction to Research Methodology

Credits: 04 **Total Hours:** 60 (Theory) IRM-20203-T

Course Objectives (COs):

The course aims to:

1. Develop understanding of scientific research principles, ethics and methodologies.
2. Equip students with skills to formulate hypotheses, research questions and experimental designs.
3. Train students in data collection, statistical analysis and scientific writing.
4. Develop competence in handling research tools: referencing, plagiarism checks and data presentation.
5. Prepare students for dissertation/project work using modern research practices.

Learning Outcomes (LOs):

After successful completion, students will be able to:

1. Explain concepts, types and approaches of biological research.
2. Formulate research problems, hypotheses and suitable methodologies.
3. Apply statistical tools for data analysis and interpretation.
4. Prepare scientific reports, theses and research articles using standard formats.
5. Demonstrate ethical and responsible conduct in research and publication.

DETAILED SYLLABUS

UNIT I: Foundations of Research (15 hours)

1. **Introduction to Research**
   - Meaning, nature, scope and significance of research
   - Types of research: basic, applied, qualitative, quantitative, interdisciplinary
   - Scientific temper and scientific method
2. **Research Problem & Hypothesis**
   - Identification of research problem
   - Criteria of good research problem
   - Types of hypotheses, characteristics, formulation
3. **Research Design**
   - Experimental, descriptive, exploratory, diagnostic, cross-sectional & longitudinal designs
   - Variables: independent, dependent, controlled, confounding
4. **Sampling Methods**
   - Probability & non-probability sampling
   - Sample size determination
   - Errors in sampling
5. **Laboratory and Field Research in Zoology**
   - Experimental setups, field surveys, population studies
   - Safety, ethics, biosafety levels, permits

UNIT II: Data Collection & Analysis (15 hours)

1. **Data Collection Techniques**
   - Primary and secondary data
   - Questionnaires, interviews, surveys

- Observational methods
- Experimental data acquisition

2. **Measurement & Scaling Techniques**
   - Nominal, ordinal, interval, ratio scales
   - Reliability and validity
3. **Introduction to Biostatistics**
   - Types of data, sampling distribution
   - Measures of central tendency (mean, median, mode)
   - Measures of dispersion (SD, variance, SE)
4. **Statistical Tests**
   - t-test, chi-square test, ANOVA (conceptual understanding)
   - Correlation & regression
   - Non-parametric tests (Mann–Whitney, Kruskal–Wallis)
5. **Data Representation**
   - Tables, graphs, charts
   - Histogram, polygon, scatter plot

UNIT III: Research Tools & Scientific Writing (15 hours)

1. **Research Tools & ICT in Research**
   - Reference management tools: Zotero, Mendeley
   - Plagiarism detection tools: Turnitin, iThenticate
   - Data analysis software: Excel, SPSS/R (conceptual)
2. **Scientific Writing**
   - Structure of thesis & dissertation
   - Writing research papers: IMRAD format
   - Abstract, introduction, methods, results, discussion formatting
3. **Referencing Styles**
   - APA, MLA, Chicago, Vancouver
   - Citation rules, bibliography preparation
4. **Presentation Skills**
   - Seminar and conference presentation
   - Poster presentation techniques
5. **Communication Skills in Research**
   - Technical reports
   - Review articles, short communications

UNIT IV: Research Ethics, Intellectual Property & Project Management (15 hours)

1. **Research Ethics**
   - Ethical principles in biological sciences
   - Animal ethics: CPCSEA guidelines
   - Human ethics: Informed consent, confidentiality
2. **Plagiarism & Academic Integrity**
   - Types of plagiarism
   - Preventive strategies
   - Ethical authorship and contribution
3. **Intellectual Property Rights (IPR)**
   - Patents, copyrights, trademarks
   - Patent filing basics
   - Biological materials & patent issues
4. **Funding & Research Project Management**
   - Grant writing
   - Funding agencies (DST, DBT, CSIR, UGC, SERB, ICAR)
   - Budgeting, timeline development
   - Maintaining lab records, research notebooks

5. **Research Dissemination**
    - Ph.D process
    - Peer review process
    - Journal selection, impact factor, h-index, i-index
    - Open access, predatory journals

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Research and its types
2. Role of research in development and advancement of nation.
3. Process of identifying research problem- objective, aims, rationale/justification.
4. Components of research paper.
5. Writing Abstract, Introduction, Literature review, Summary and Research proposal and Research report.
6. Preparation of Power Point Presentation for seminar and conference.
7. Process of publishing research work.
8. Biosafety measures and ethical aspects of research.
9. Null and alternative hypothesis.
10. Data collection and Sampling methods in research.
11. Calculation of central tendencies, standard deviation, standard error, t-test and ANOVA.

Suggestive Readings:

1. Kothari, C.R. &Garg, G. **(2019).** ***Research Methodology: Methods and Techniques.*** **New Age International Publishers.**
2. Creswell, J.W. & Creswell, J.D. **(2017).** ***Research Design: Qualitative, Quantitative and Mixed Methods Approaches.*** **Sage Publications.**
3. Sokal, R.R. &Rohlf, F.J. **(2012).** ***Biometry: The Principles and Practice of Statistics in Biological Research.*** **W.H. Freeman & Co.**
4. Wayne W. Daniel & Chad L. Cross. **(2018).** ***Biostatistics: A Foundation for Analysis in the Health Sciences.*** **Wiley.**
5. Day, R. &Gastel, B. **(2012).** ***How to Write and Publish a Scientific Paper.*** **Cambridge University Press.**
6. Laurel D. Hansen & Mark VanBaalen. **(2015).** ***Research Methods in Biology.*** **Cambridge Scholars Publishing.**
7. Graf, J. **(2004).** ***Introduction to Research Methods: A Hands-On Approach.*** **Sage Publications.**
8. Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA). **Guidelines for Laboratory Animal Facility (Latest Edition).**
9. Open-access Manuals:
    - *UGC Research and Publication Ethics (RPE) Guidelines*
    - *DBT/ICMR Ethical Guidelines for Biomedical Research*

M.Sc. Zoology (Semester–II)
Elective Course 12
ZOO.-20205-T-Animal Behaviour and Neurobiology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- Introduce foundational principles of animal behaviour and neural mechanisms.
- Develop understanding of behavioural evolution, ecological relevance and survival strategies.
- Explain the structure, function and integration of nervous system components.
- Explore hormonal, neural and genetic regulation of behaviour.
- Build analytical skills for behavioural experiments, observation and research methodology.

Learning Outcomes (LOs)

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

- Identify and explain major types, patterns and mechanisms of animal behaviour.
- Describe neurobiological structures and processes underlying behaviour.
- Analyse physiological, ecological and evolutionary bases of behavioural adaptations.
- Evaluate hormonal, genetic and environmental influences on behaviour.
- Apply behavioural research methods, observational tools and data interpretation.

DETAILED SYLLABUS

UNIT I: Principles of Animal Behaviour **(15 Hours)**

- **Introduction to Animal Behaviour:** Scope, historical background (ethology vs behavioural ecology), proximate and ultimate causes.
- **Behavioural Ontogeny:** Instinct, imprinting, learning (habituation, classical conditioning, operant conditioning, insight learning).
- **Motivation and Conflict Behaviour:** Drives, displacement activities, ritualization, communication and signalling.
- **Behavioural Genetics:** Heritability of behaviour; role of gene-environment interaction; knockout genes and behaviour.
- **Social Behaviour:** Group living, dominance hierarchy, cooperation, altruism, kin selection, eusociality.

UNIT II: Neurobiology of Behaviour **(15 Hours)**

- **Neurons and Neural Signalling:** Neuron structure, types, action potential, synaptic transmission, neurotransmitters.
- **Nervous System Organization:** CNS and PNS, reflex arcs, sensory processing, motor coordination.
- **Neural Circuits and Behaviour Patterns:** Central pattern generators (CPGs), fixed action patterns.
- **Sensory Physiology:** Vision, hearing, mechanoreception, thermo- and chemoreception; sensory coding.
- **Learning and Memory – Neural Basis:** Long-term potentiation (LTP), hippocampal circuits, associative learning pathways.

UNIT III: Neuroendocrinology and Physiological Regulation **(15 Hours)**

- **Hormonal Control of Behaviour:** Hormones and behavioural modulation: aggression, mating, parental care.
- **Stress Physiology:** HPA axis, neuroendocrine responses to environmental stress.
- **Biological Rhythms:** Circadian rhythms, ultradian rhythms, entrainment, melatonin and clock genes.
- **Reproductive Behaviour:** Courtship, mating systems, sexual selection, mate choice, pheromonal control.
- **Feeding, Migration and Orientation Behaviour:** Neural and hormonal regulation of hunger, navigation (solar, geomagnetic, olfactory cues).

UNIT IV: Applied Animal Behaviour (15 Hours)

- **Behavioural Ecology and Adaptations:** Foraging theory, optimality theory, anti-predator strategies, habitat selection.
- **Human and Primate Behaviour:** Evolution of cognition, communication, social bonding.
- **Behavioural Evolution:** Natural and sexual selection shaping behaviours; comparative ethology.
- **Applied Aspects:** Wildlife management, conservation behaviour, zoo animal behaviour, animal welfare.
- **Behavioural Research Methods:** Sampling methods (focal, scan, ad libitum), ethograms, experimental design, data analysis.

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Preparation of Ethogram

- Observe a selected animal (fish, bird, ant, or insect) and prepare a **complete ethogram**.
- Includes classification into: maintenance, social, agonistic, reproductive behaviours.

2. Behaviour Sampling Techniques

- Practice **focal sampling**, **scan sampling** and **ad libitum sampling** using video clips or live animals.
- Compare datasets and interpret behavioural frequencies.

3. Learning and Conditioning Experiment (Invertebrate)

- Demonstrate **classical conditioning** in *Planaria* or *Drosophila* using light/chemical stimuli.
- Record latency, response frequency and learning curves.

4. Aggression and Dominance Behaviour in Fish

- Observe **Bettasplendens** (Siamese fighting fish) or guppies.
- Record display patterns: fin spreading, chasing, territoriality.

5. Phototaxis and Geotaxis in Insects

- Study **positive/negative phototaxis** in houseflies/ants and **geotaxis** in *Drosophila*.
- Measure directional movement, response strength and activity index.

6. Neural Anatomy: Dissection & Identification

- Dissection of **cockroach / fish / frog brain**.
- Identify major regions: olfactory lobes, optic lobes, cerebellum, medulla, ganglia.

7. Reflex Arc Demonstration

- Demonstrate **knee-jerk reflex** or spinal reflex in frog (virtual simulation acceptable).
- Identify sensory, interneuron and motor pathways.

8. Hormonal Regulation of Behaviour (Case Study/Experiment)

- Demonstrate effect of hormones such as:
  - **Ecdysone** on insect behaviour (larval activity).
  - **Thyroxine** on frog metamorphic behaviour.
- Alternatively, use **video data** for analysis.

9. Circadian Rhythm Observation

- Monitor daily activity pattern of ants, birds, or lab rodents.
- Create an **actogram** and analyse rhythmicity, peak activity, entrainment, etc.

10. Foraging Behaviour Analysis

- Set up a foraging experiment with ants:
  - Vary food distance, type, or density.
  - Analyse decision-making, cost–benefit patterns, trail formation.

SUGGESTED READINGS:

1. Alcock, J. (2013).***Animal Behavior: An Evolutionary Approach*** **(10th ed.). Sinauer Associates.**
2. Krebs, J. R., & Davies, N. B. (1997).***Behavioural Ecology: An Evolutionary Approach*** **(4th ed.). Blackwell Publishing.**
3. Breed, M. D., & Moore, J. (2016).***Animal Behavior*** **(2nd ed.). Academic Press.**
4. Goodenough, J., McGuire, B., & Wallace, R. A. (2014).***Perspectives on Animal Behavior*** **(3rd ed.). Wiley.**
5. Kandel, E. R., Schwartz, J. H., &Jessell, T. M. (2013).***Principles of Neural Science*** **(5th ed.). McGraw-Hill.**
6. Bear, M. F., Connors, B. W., &Paradiso, M. A. (2015).***Neuroscience: Exploring the Brain*** **(4th ed.). Wolters Kluwer.**
7. Sheriff, M. J., &Dantzer, B. (2020). ***Behavioral Ecology of Stress*** **(Oxford Univ. Press).**
8. Johnston, T. D., & Gottlieb, G. (1990).***Neurobiology of Comparative Cognition.*** **Psychology Press.**
9. Lehner, P. N. (1996).***Handbook of Ethological Methods*** **(2nd ed.). Cambridge Univ. Press.**

M.Sc. Zoology (Semester–II)

Elective Course 12

ZOO-20206-T Biostatistics and Bioinformatics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- Develop conceptual understanding of statistical principles applied to biological sciences.
- Train students to analyze biological data using descriptive and inferential statistics.
- Introduce core concepts and tools of bioinformatics.
- Provide hands-on understanding of sequence analysis, databases and computational methods.
- Enable students to apply statistical and bioinformatics approaches in modern biological research.

Learning Outcomes (LOs):

Upon successful completion, students will be able to:

- Apply appropriate statistical tools to analyze biological datasets.
- Interpret hypothesis-testing results and perform probability-based analyses.
- Utilize major biological databases for sequence retrieval and comparison.
- Conduct sequence alignment, phylogenetic analysis and molecular modelling.
- Integrate statistical and bioinformatics tools for solving research problems in zoology.

Detailed Syllabus

Unit I: Fundamentals of Biostatistics (15 Hours)

- **Introduction to Biostatistics:** Types of biological data; variables; scales of measurement.
- **Data Presentation:** Frequency distribution, tabulation, graphical representation (histograms, bar diagrams, pie charts, box plots).
- **Measures of Central Tendency:** Mean, median, mode, geometric and harmonic mean.
- **Measures of Dispersion:** Range, variance, standard deviation, coefficient of variation, standard error.
- **Probability and Distribution:** Basic probability rules; binomial, Poisson and normal distribution.
- **Correlation and Regression:** Pearson and Spearman correlation; linear regression.

Unit II: Inferential Statistics (15 Hours)

- **Sampling Methods:** Random sampling techniques; sampling errors; sample size determination.
- **Hypothesis Testing:** Null and alternate hypotheses, p-values, levels of significance.
- **Parametric Tests:** t-test (one sample, two sample, paired), Z-test, F-test, ANOVA (one-way and two-way).
- **Non-Parametric Tests:** Chi-square test; Mann–Whitney U test; Kruskal–Wallis test.
- **Statistical Software:** Introduction to SPSS/R; analysis and interpretation of biological datasets.

Unit III: Introduction to Bioinformatics (15 Hours)

- **Scope and Applications of Bioinformatics:** Importance in genomics, proteomics, evolution, drug design.
- **Biological Databases:**
  - **Primary databases:** GenBank, EMBL, DDBJ

- **Protein databases:** UniProt, PDB
- **Specialized databases:** Pfam, KEGG, OMIM

- **File Formats:** FASTA, GenBank format; sequence submission.
- **Sequence Alignment:** Pairwise alignment (global and local), scoring matrices (PAM, BLOSUM).
- **BLAST and FASTA:** Working principles, interpretation of outputs.

Unit IV: Advanced Bioinformatics & Computational Analysis **(15 Hours)**

- **Multiple Sequence Alignment:** ClustalW, MUSCLE; conserved regions and motif identification.
- **Phylogenetic Analysis:** Tree construction methods (UPGMA, NJ, maximum parsimony); bootstrapping.
- **Genomics and Proteomics Tools:** ORF prediction, gene annotation, protein structure prediction.
- **Molecular Modelling:** Homology modelling, visualization (PyMOL, Rasmol).
- **Systems Biology Basics:** Pathway analysis; metabolic networks; introduction to machine learning in biology.

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. Data Presentation & Descriptive Statistics

- Use a biological dataset (e.g., body weight, enzyme activity).
- Prepare tables and graphs: histogram, bar chart, box plot.
- Calculate mean, median, mode, SD, SE, CV.

2. Probability Distributions

- Plot **binomial, Poisson** and **normal** distributions using R/SPSS/Excel.
- Demonstrate fitting of biological data to a normal curve.

3. Correlation and Regression Analysis

- Perform **Pearson** and **Spearman** correlations using real biological data (e.g., length–weight relationship in fish).
- Generate a linear regression equation and interpret R^2.

4. Hypothesis Testing (Parametric Tests)

- Apply **t-tests** (one-sample, paired, unpaired), **F-test**, **one-way ANOVA** on a sample biological dataset.
- Interpret p-values and significance.

5. Chi-Square and Non-Parametric Tests

- Perform **Chi-square test** for goodness-of-fit or association using genetic or ecological data.
- Use **Mann–Whitney U Test / Kruskal–Wallis Test** for non-normal data.

6. Use of Statistical Software (R / SPSS / Excel)

- Import biological data, generate summary statistics, plots and run inferential tests.

- Interpretation of computer output.

7. Database Retrieval & Sequence Handling

- Retrieve gene/protein sequences from **NCBI GenBank, UniProt.**
- Save in **FASTA format**; understand GenBank flat file.

8. Pairwise Sequence Alignment

- Perform **BLAST (NCBI)** for nucleotide/protein sequences.
- Compare global vs. local alignment using EMBOSS/online tools.
- Interpret score, E-value, identity, query cover.

9. Multiple Sequence Alignment & Phylogeny

- Use **ClustalW/MUSCLE** to align sequences.
- Construct phylogenetic trees using **UPGMA / Neighbor-Joining.**
- Interpret bootstrap values and clustering.

10. Protein Structure & Functional Analysis

- Retrieve a protein structure from **PDB.**
- Visualize in **PyMOL/RasMol** to identify domains and active sites.
- Demonstrate ORF finding and motif prediction using **ORF Finder / Pfam.**

Suggested Readings:

Biostatistics

1. Zar, J.H. ***Biostatistical Analysis***. 5th Ed., Pearson Education, 2010.
2. Sokal, R.R., &Rohlf, F.J. ***Biometry: The Principles and Practice of Statistics in Biological Research***. 4th Ed., W.H. Freeman, 2012.
3. Prasad, S. ***Elements of Biostatistics***. Rastogi Publications, 2015.
4. Khan, I.A., &Khanum, A. ***Fundamentals of Biostatistics***. Ukaaz Publications, 2014.

Bioinformatics

5. Mount, D.W. ***Bioinformatics: Sequence and Genome Analysis***. 2nd Ed., Cold Spring Harbor Laboratory Press, 2004.
6. Singh, R. ***Bioinformatics: Concepts, Skills and Applications***. CBS Publishers, 2015.
7. Baxevanis, A.D., & Ouellette, B.F.F. ***Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins***. 3rd Ed., Wiley-Blackwell, 2005.
8. Lesk, A.M. ***Introduction to Bioinformatics***. 5th Ed., Oxford University Press, 2019.
9. Gromiha, M.M. ***Protein Bioinformatics: From Sequence to Function***. Academic Press, 2010.

M.Sc. Zoology (Semester–II)
Elective Course 12
ZOO-20207-T- Immunology

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

This course aims to:

- Provide foundational and advanced understanding of immune system organization and function.
- Explain cellular and molecular components involved in innate and adaptive immunity.
- Familiarize students with antigen–antibody interactions and major immunological techniques.
- Develop understanding of immune responses, immunoglobulin structure/function and gene rearrangements.
- Introduce clinical immunology including vaccines, hypersensitivity, autoimmunity and transplantation.

Learning Outcomes (LOs):

On successful completion, learners will be able to:

- Describe innate and adaptive immune mechanisms and their biological significance.
- Identify immune cells, tissues, organs and their functional roles.
- Explain antigen processing, presentation, immunoglobulin structure and antibody diversity.
- Apply principles of immunological techniques including ELISA, flow cytometry, immunofluorescence, RIA and blotting methods.
- Interpret immunological processes involved in hypersensitivity, autoimmunity, immunodeficiency and vaccination.

DETAILED SYLLABUS

UNIT I: Fundamentals of Immunology (15 Hours)

1. Introduction to Immunology
- Historical perspectives, scope and applications
- Innate vs. Adaptive immunity: characteristics and components

2. Antigens and Immunogenicity
- Properties of antigens, epitopes &haptens
- Factors influencing immunogenicity

3. Cells of the Immune System
- B lymphocytes, T lymphocytes
- Phagocytes: macrophages & neutrophils
- Granulocytes, mast cells, dendritic cells and NK cells

4. Organs of Immune System
- Primary lymphoid organs: thymus, bone marrow
- Secondary lymphoid organs: lymph nodes, spleen, MALT, GALT

UNIT II: Immune Recognition & Immune Responses (15 Hours)

1. Immunoglobulins (Ig)
- Structure, types/classes, functions
- Antibody affinity and avidity

2. BCR & TCR: Structure and Function
- Development, maturation, activation

- Signaling through BCR & TCR

3. Generation of Immune Responses

- Humoral and cell-mediated immunity
- Clonal selection theory
- Generation of B- and T- cell responses

4. Antibody Diversity

- Organization & expression of Ig genes
- V(D)J recombination, somatic hypermutation, class-switch recombination

UNIT III: Antigen Processing, MHC & Immune Mechanisms (15 Hours)

1. Antigen Processing and Presentation

- Endogenous and exogenous pathways
- Professional antigen-presenting cells (APCs)

2. Major Histocompatibility Complex (MHC)

- MHC class I & II: structure, expression
- HLA system, disease susceptibility
- Immune responsiveness

3. Complement System

- Classical, alternative and lectin pathways
- Complement activation, regulation & biological effects

4. Antigen–Antibody Interactions

- Agglutination, precipitation, cross-reactivity

UNIT IV: Immunological Techniques & Applied Immunology (15 Hours)

1. Immunological Techniques

- ELISA (types)
- Radioimmunoassay (RIA)
- Western blotting
- Immunofluorescence
- Flow cytometry
- Immunoelectron microscopy

2. Vaccines and Immunoprophylaxis

- Types of vaccines: live, attenuated, killed, subunit, toxoid, recombinant, mRNA
- Vaccine development and evaluation

3. Clinical Immunology

- Hypersensitivity (Types I–IV)
- Autoimmunity and autoimmune disorders
- Immunodeficiency (primary & secondary)
- Transplantation immunology and graft rejection
- Monoclonal and polyclonal antibodies: production & applications

PRACTICAL SYLLABUS (1 Credit) (30hrs)

1. Identification of Immune Cells (Blood Smear)

- Preparation and staining (Leishman/Giemsa) of blood smears.
- Identification of lymphocytes, neutrophils, eosinophils, basophils, monocytes.

2. Study of Lymphoid Organs (Slides/Images/Dissection)

- Microscopic examination of **thymus, spleen, lymph node** histology.
- Identification of cortex, medulla, white pulp, red pulp, germinal centers.

3. Qualitative Tests for Antigen–Antibody Reactions

- **Precipitation** in agar gel (Ouchterlony double diffusion).

- **Agglutination** test using RBC or latex particles.

4. ELISA – Demonstration/Hands-On

- Indirect or sandwich ELISA.
- Detection of antigen or antibody; reading absorbance using ELISA plate reader.

5. Immunoelectrophoresis

- Demonstration of protein separation followed by antigen-antibody diffusion.
- Identification of precipitin arcs.

6. Western Blotting (Demonstration)

- Protein separation by SDS–PAGE and immunodetection using primary and secondary antibodies.

7. Flow Cytometry – Data Interpretation

- Identification of gated populations (lymphocytes, monocytes).
- Interpretation of dot plots, histograms and fluorescence intensity.

8. Complement Fixation Test (CFT) – Demonstration

- Principles of classical complement pathway activation.
- Hemolytic assay or CH50 determination (even simulated data acceptable).

9. Study of Hypersensitivity Reactions (Models/Simulations)

- Observation of prepared slides/models:
  - Type I (mast cell degranulation),
  - Type II (antibody-mediated cytotoxicity),
  - Type III (immune complex deposition),
  - Type IV (delayed-type hypersensitivity).
- Case study interpretation.

10. Production of Polyclonal Antibodies – Demonstration/Virtual

- Steps in immunization protocol, booster dosing, serum collection.
- Purification by ammonium sulphate precipitation (demo).

SUGGESTED READINGS:

1. Abbas, A.K., Lichtman, A.H., &Pillai, S. (2022). **Cellular and Molecular Immunology** (10th ed.). Elsevier.
2. Murphy, K., Weaver, C. (2016). **Janeway'sImmunobiology** (9th ed.). Garland Science.
3. Kuby, J., Punt, J., Stranford, S. (2019). **Kuby Immunology** (8th ed.). W.H. Freeman.
4. Goldsby, R., Kindt, T.J., Osborne, B.A. (2000). **Immunology** (4th ed.). W.H. Freeman.
5. Male, D., Brostoff, J., Roth, D., &Roitt, I. (2013). **Immunology** (8th ed.). Mosby/Elsevier.
6. Paul, W. (Ed.). (2013). **Fundamental Immunology** (7th ed.). Lippincott Williams & Wilkins.
7. Delves, P.J., Martin, S.J., Burton, D.R., &Roitt, I. (2017). **Roitt's Essential Immunology** (14th ed.). Wiley-Blackwell.
8. Owen, J., Punt, J., Stranford, S. (2020). **Immunology: A Short Course** (7th ed.). Wiley.

M.Sc. Zoology (Semester-II)
Elective Course 12
ZOO-20208-T-Biosafety and Bioethics

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

- Develop conceptual understanding of biosafety levels, laboratory practices and risk assessments.
- Explain regulatory frameworks and national/international guidelines for safe biological research.
- Build ethical reasoning skills for responsible biotechnology use and animal research.
- Introduce biosecurity, dual-use concerns and bioterrorism threats.
- Enable students to critically evaluate ethical, legal and social implications (ELSI) of modern biological technologies.

Student Learning Outcomes (LOs):

After completing the course, students will be able to:

- Identify and classify biosafety hazards and implement safe laboratory practices.
- Explain biosafety levels, containment facilities and waste management procedures.
- Apply ethical frameworks in biotechnology, biomedical research and wildlife conservation.
- Interpret national and international biosafety/bioethics guidelines and regulatory processes.
- Analyze case studies involving GMOs, cloning, stem cells, gene editing, IPR and dual-use issues.

DETAILED SYLLABUS

UNIT I: Introduction to Biosafety(15 Hours)

1. **Concept and Need of Biosafety**
   - Definitions: biohazards, containment, exposure, risk groups
   - Importance in microbiology, biotechnology, medicine, zoology
2. **Biosafety Levels (BSL-1 to BSL-4)**
   - Design features, equipment and containment
   - Animal biosafety levels (ABSL-1 to ABSL-4)
3. **Risk Assessment & Risk Management**
   - Hazard identification, exposure assessment
   - Risk characterization and mitigation
4. **Laboratory Practices & Safety Measures**
   - PPE, biological cabinets (Class I–III), aseptic practices
   - Sterilization & disinfection methods
5. **Biological Waste Management**
   - Biomedical waste: segregation, disposal, color-coding system
   - National guidelines (BMW Rules 2016 & amendments)

UNIT II: Regulatory Frameworks &Biosecurity(15 Hours)

1. **National Biosafety Regulations (India)**
   - DBT, RCGM, IBSC, GEAC
   - Rules for handling GMOs (1989 Rules under EPA 1986)

2. **International Biosafety Guidelines**
   - Cartagena Protocol on Biosafety
   - WHO, NIH, OECD guidelines
3. **Biosecurity**
   - Concepts of dual-use research (DURC)
   - Biological warfare and bioterrorism
   - Laboratory biosecurity measures
4. **Transportation of Dangerous Biological Materials**
   - Packaging, labeling, emergency response
   - IATA regulations
5. **Case Studies**
   - Ebola labs, SARS research regulations
   - Gene-editing (CRISPR-Cas9) and biosecurity implications

UNIT III: Bioethics(15 Hours)

1. **Foundations of Bioethics**
   - Ethical principles: autonomy, beneficence, justice, non-maleficence
   - Ethical theories: deontology, utilitarianism
2. **Ethics in Biological Research**
   - Human clinical trials, informed consent
   - Animal experimentation ethics (CPCSEA guidelines)
   - Replacement, Reduction, Refinement (3Rs)
3. **Ethical Issues in Modern Biotechnology**
   - GMOs, transgenic animals, cloning
   - Stem cells and regenerative medicine
   - Gene therapy, gene editing (CRISPR)
4. **Environmental Ethics**
   - Conservation ethics, wildlife protection
   - Biodiversity and ecosystem rights
5. **Intellectual Property Rights (IPR)**
   - Patents, copyrights, trademarks
   - Patenting of life forms
   - Traditional knowledge and benefit-sharing (Nagoya Protocol)

UNIT IV: Ethical, Legal & Social Implications (ELSI) and Case Studies(15 Hours)

1. **ELSI of Emerging Technologies**
   - Synthetic biology
   - Artificial intelligence in biology
   - Personalized genomics
2. **Ethics of Vaccines & Public Health Interventions**
   - Vaccine approval & regulations
   - Ethical issues during pandemics (COVID-19 case study)
3. **Data Ethics & Privacy**
   - Genetic databases (e.g., genomic surveillance)
   - Confidentiality and ethical data handling
4. **Biosafety in Industry & Agriculture**
   - GM crops, Bt cotton, biofertilizers, biopesticides
   - Impact assessment and regulation
5. **Controversial Case Studies**
   - He Jiankui "CRISPR babies" case
   - Dolly the sheep cloning
   - Bhopal disaster & global relevance to chemical safety
   - Ethical debates in xenotransplantation

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. **Identification of Biosafety Symbols and Hazard Labels**
   - Study and interpretation of **biohazard, chemical hazard, radioactive, GMO, BSL** symbols.
   - Preparation of a chart on laboratory signage.
2. **PPE (Personal Protective Equipment) Demonstration & Proper Donning–Doffing**
   - Handling and correct sequence of wearing/removal of gloves, masks, lab coats, goggles, face shields.
   - Fit testing of N95 mask (demo).
3. **Study of Biosafety Cabinets (Class I, II, III) – Demonstration/Model**
   - Working principle, airflow patterns, use of UV light.
   - Hands-on demonstration with laminar airflow cabinet.
4. **Sterilization & Disinfection Techniques**
   - Autoclave operation demonstration.
   - Preparation of 70% ethanol, bleach solution and comparison of disinfectant efficacy (spot test method).
5. **Biomedical Waste Segregation and Disposal**
   - Identification of coloured bins (red, yellow, blue, white).
   - Sorting different waste materials into correct categories.
   - Case scenarios on BMW Rules (2016 + amendments).
6. **Risk Assessment Exercise Using Real/Mock Lab Setups**
   - Identification of biosafety hazards in a given model lab.
   - Preparation of *Risk Assessment Sheet*: hazard, exposure, mitigation.
7. **Study of National Biosafety Regulatory Bodies (IBSC, RCGM, GEAC)**
   - Preparation of a workflow chart for GMO approval under **EPA Rules, 1989 (India)**.
   - Review of a real application form (DBT formats).
8. **Case Study Analysis on Bioethics**
   - Students analyze any one:
     - **CRISPR babies,**
     - **Stem cell ethics,**
     - **GM crops,**
     - **Human cloning,**
     - **COVID-19 vaccine ethics.**
   - Presentation on ethical issues, regulatory responses and societal impact.
9. **Animal Ethics & CPCSEA Guidelines – Practical Exercise**
   - Study of CPCSEA forms for animal house registration.
   - Designing an ethically acceptable animal experiment using 3Rs (Replace–Reduce–Refine).
10. **Emergency Response Drill for Biological Spills**
    - Simulation of small biological spill with mock materials.
    - Steps: contain → disinfect → dispose → report.
    - Preparation of a spill management SOP.

SUGGESTED READINGS:

Books:

1. **Biosafety in Microbiological and Biomedical Laboratories (BMBL), 6th Edition** – CDC & NIH
2. **Bioethics: Principles, Issues and Cases** – Lewis Vaughn
3. **Pandora's Picnic Basket: The Potential and Hazards of Genetically Modified Foods** – Alan McHughen
4. **Fundamentals of Bioethics** – D.C. Raghunandan (Indian context)
5. **Environmental Biotechnology and Safety** – P. K. Gupta

National/International Manuals & Documents

6. **Guidelines for Establishment and Certification of BSL Labs** – DBT, Govt. of India
7. **Cartagena Protocol on Biosafety** – CBD Secretariat
8. **NIH Guidelines for Research Involving Recombinant DNA Molecules**
9. **CPCSEA Guidelines for Laboratory Animal Facility**
10. **Biomedical Waste Management Rules (2016 & amendments)** – MoEFCC (India)

M.Sc. Zoology (Semester–II)
Elective Course 12
ZOO-20209-T Epigenetics and Gene Regulation

Credits: 04 **Total Hours:** 60 (Theory)

Course Objectives (COs):

The course aims to:

- Provide an advanced understanding of epigenetic mechanisms and their molecular basis.
- Explain how chromatin structure and modifications regulate gene expression.
- Familiarize students with RNA-based regulation and non-coding RNA biology.
- Introduce epigenetic techniques, tools and experimental approaches.
- Explore the role of epigenetics in development, disease, adaptation and evolution.

Learning Outcomes (LOs):

After completing this course, students will be able to:

- Explain the molecular mechanisms of DNA methylation, histone modification and chromatin remodeling.
- Analyze the role of non-coding RNAs in post-transcriptional and epigenetic regulation.
- Evaluate epigenetic changes in development, differentiation and diseases.
- Interpret experimental data generated from major epigenetic techniques.
- Describe recent advances and future applications in epigenetic therapy and diagnostics.

DETAILED SYLLABUS

UNIT I: Fundamentals of Epigenetics & Chromatin Biology (15 Hours)

- **Introduction to Epigenetics:** concept, history, epigenomevs genome
- **Chromatin organization:**
  - Nucleosome structure
  - Euchromatinvs heterochromatin
  - Higher-order chromatin folding
- **DNA Methylation:**
  - Mechanisms of methylation (DNMTs)
  - CpG islands & methylation patterns
  - Demethylation pathways (TET enzymes)
  - Maintenance vs de novo methylation
- **Histone Code & Modifications:**
  - Acetylation, methylation, phosphorylation, ubiquitination, sumoylation
  - Histone acetyltransferases (HATs), HDACs, HMTs, demethylases
  - Functional significance of PTMs in gene regulation
- **Chromatin Remodeling Complexes:**
  - SWI/SNF, ISWI, INO80, CHD families
  - Role in transcription activation/repression

UNIT II: Non-coding RNAs & RNA-mediated Gene Regulation (15 Hours)

- **Types of Non-coding RNAs:**
  - microRNAs, siRNAs, piRNAs
  - Long non-coding RNAs (lncRNAs)
  - Circular RNAs

- **Biogenesis & Mechanism of Action:**
  - Dicer, Drosha, RISC complex
  - miRNA-mediated post-transcriptional control
  - RNA interference (RNAi)
- **RNA in Epigenetic Regulation:**
  - lncRNA-guided chromatin modification
  - RNA-directed DNA methylation
  - X-chromosome inactivation (Xist)
  - Genomic imprinting mechanisms and examples
- **RNA Modifications (Epitranscriptomics):**
  - m6A modification, writers, erasers, readers
  - Functional significance

UNIT III: Epigenetics in Development, Environment & Disease (15 Hours)

- **Epigenetics of Development:**
  - Germline epigenetics
  - Early embryogenesis
  - Stem cell epigenetics & cell-fate decisions
- **Environmental Epigenetics:**
  - Nutrition, stress, toxins, climate
  - Transgenerational epigenetic inheritance
- **Epigenetics of Sex Determination &Behavioral Epigenetics**
- **Epigenetics in Diseases:**
  - Cancer epigenetics (hypermethylation, histone changes)
  - Neurodegenerative disorders
  - Autoimmune diseases
  - Metabolic disorders
- **Epigenetic Therapeutics:**
  - DNMT inhibitors
  - HDAC inhibitors
  - CRISPR-based epigenome editing (dCas9-DNMT/TET/HDAC systems)

UNIT IV: Techniques & Applications in Epigenetics Research (15 Hours)

- **DNA Methylation Analysis:**
  - Bisulfite sequencing
  - MeDIP-seq
  - Whole genome bisulfite sequencing (WGBS)
- **Chromatin Studies:**
  - ChIP, ChIP-seq
  - ATAC-seq
  - MNase digestion assays
- **RNA-level Epigenetics:**
  - RNA-seq for ncRNAs
  - RIP-seq
- **Chromatin Imaging:**
  - FISH, IF, super-resolution microscopy
- **Genomic &Epigenomic Databases:**
  - ENCODE, Roadmap Epigenome
- **Applications:**
  - Biomarkers, precision medicine
  - Epigenetic reprogramming
  - Biological aging clocks

PRACTICAL SYLLABUS (1 Credit) **(30hrs)**

1. DNA Extraction & Qualitative Analysis (Plant/Animal Tissue)

- Extraction from onion/banana/animal tissue using simple buffers or kit.
- Visual observation + gel check (if available).

Concept covered: Chromatin accessibility, DNA purity for epigenetics work.

2. Demonstration of DNA Methylation Detection Using Methylation-Sensitive Restriction Enzymes

- Use two enzymes: one methylation-sensitive, one methylation-insensitive.
- Compare digestion patterns on agarose gel.

Concept covered: CpG methylation and gene repression.

3. Simulation of Bisulfite Conversion & Methylation Analysis (Bioinformatics-based)

- Use online tools: **BISMA, MethPrimer, Galaxy**.
- Students perform virtual bisulfite sequencing analysis.

Concept covered: Bisulfite sequencing, methylation pattern interpretation.

4. Isolation of Total RNA (Plant/Yeast/Animal Cells)

- Using TRIzol or simple phenol-chloroform method.

Concept covered: RNA as substrate for ncRNA studies.

5. Demonstration of miRNA/siRNA Design Using Online Tools

- Use **miRBase, RNAfold, siRNA Wizard.**

Concept covered: Non-coding RNA function, RNA interference.

6. Chromatin Staining and Visualization (Feulgen or Acetocarmine)

- Simple nuclear staining to differentiate euchromatinvs heterochromatin.

Concept covered: Chromatin condensation and gene activity.

7. Protein Extraction and Histone-like Protein Observation

- Acid extraction of histone-like proteins from chicken liver or yeast.
- Run on SDS-PAGE (if available).

Concept covered: Histone biology and post-translational modifications (PTMs).

8. Demonstration of RNA Interference (RNAi) in Plants (Safe & Low-Cost)

- Use **leaf disc infiltration** or observe **virus-induced gene silencing (VIGS)** demonstration video.

Concept covered: Gene silencing by RNAi.

9. ATAC-seq / ChIP-seq*Data Analysis Exercise* (Bioinformatics)

- Students download sample datasets from **ENCODE**.
- Use simple tools to visualize peaks (IGV).

Concept covered: Chromatin accessibility, transcription factor binding.

10. Epigenetic Effect of Environment (Case-study & Simulation-based Practical)

- Students analyze a dataset showing methylation change due to:
  - Nutrition
  - Stress
  - Toxins
- Use R-free packages or Excel for plotting.

Concept covered: Environmental epigenetics & plasticity.

Suggested Readings:

1. Allis, C.D., Jenuwein, T., Reinberg, D. (Eds.). **Epigenetics**. Cold Spring Harbor Laboratory Press, 2015.
2. Berger, S.L., Kouzarides, T., Shiekhattar, R., Shilatifard, A. **The Regulation of Chromatin Structure and Gene Expression**. Annual Review of Biochemistry, 2009.
3. Armstrong, L. **Epigenetics**. Garland Science, 2014.
4. Henikoff, S., Greally, J.M. **Epigenetics: A Landscape Takes Shape**. Cell, 2016.

5. Jirtle, R.L., Tyson, F.L. **Environmental Epigenomics in Health and Disease**. Springer, 2013.
6. Luger, K. et al. **Structure of the Nucleosome Core Particle**. Nature, 1997.
7. Ptashne, M. **Genes & Signals**. Cold Spring Harbor Laboratory Press, 2002.
8. Jaenisch, R., Bird, A. **Epigenetic Regulation of Gene Expression**. Nature Genetics, 2003.
9. Reik, W. **Epigenetic Reprogramming in Mammalian Development**. Science, 2007.
10. Tollefsbol, T. (Ed.). **Handbook of Epigenetics: The New Molecular and Medical Genetics**. Academic Press, 2023.

Inter Disciplinary Courses (IDC)

IEC-2021S-T

M.Sc. ZOOLOGY

SEMESTERII

1.Computer and Bioinformatics

Credits: 04(Total Hours: 60)

Course Objectives (COs):

- To provide foundational knowledge of computers, operating systems and digital data handling relevant to biological sciences.
- To familiarize students with major biological databases and sequence formats.
- To train students in retrieving, analyzing and interpreting nucleotide and protein sequence data.
- To introduce computational tools for alignment, phylogenetic analysis and molecular modelling.
- To build interdisciplinary skills for applying bioinformatics in zoology, genomics and molecular biology research.

Learning Outcomes (LOs):

Upon completion of this IDC, students will be able to:

- Operate computers and manage scientific data efficiently.
- Retrieve, store and analyze biological sequences using online databases.
- Perform basic sequence alignment and phylogenetic analysis.
- Understand essential concepts of genomics, proteomics and molecular markers.
- Apply computational tools to zoological and molecular research problems.

Detailed Course Content

UNIT I: Fundamentals of Computers and Data Handling (15 Hours)

- Introduction to computers: hardware, software, OS (Windows & Linux basics)
- File systems, data storage, file formats (.txt, .fasta, .csv, .gb)
- Internet tools, online search strategies, research databases
- Introduction to MS Word, Excel & PowerPoint
- Data entry, graph plotting, basic statistics in Excel
- Introduction to algorithms & flowcharts

UNIT II: Introduction to Bioinformatics(15 Hours)

- History, scope and applications of bioinformatics
- Biological databases:
  - Nucleotide: **NCBI, DDBJ, EMBL**
  - Protein: **UniProt, PDB, SwissProt**
  - Specialized: **Pfam, KEGG, Ensembl**

- Sequence file formats: FASTA, GenBank, PDB
- Sequence retrieval, accession numbers, database searching

UNIT III: Sequence Alignment and Phylogenetics(15 Hours)

- Basic concepts: similarity, identity, homology
- **BLAST**: types, tools, interpretation of output
- Pairwise alignment: global vs. local
- Scoring matrices: PAM, BLOSUM (intro level)
- Multiple sequence alignment: Clustal Omega, MUSCLE
- Phylogenetic analysis: UPGMA, NJ (basics)
- Tree visualization tools: MEGA, iTOL

UNIT IV: Genomics, Proteomics and Applied Bioinformatics(15 Hours)

- Genome organization in animals
- Introduction to genomics, transcriptomics and proteomics
- Protein structure prediction: SWISS-MODEL (overview)
- DNA barcoding and species identification
- Molecular markers: RFLP, RAPD, AFLP, microsatellites
- Basics of molecular docking and drug–target interactions
- Applications in wildlife forensics, taxonomy and evolutionary biology

Suggested Readings:

1. Lesk, A. M. **Introduction to Bioinformatics**. Oxford University Press.
2. Mount, D. W. **Bioinformatics: Sequence and Genome Analysis**. CSHL Press.
3. Baxevanis, A. & Ouellette, B. **Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins**. Wiley.
4. Krane, D. E., &Raymer, M. L. **Fundamental Concepts of Bioinformatics**. Pearson.
5. Singh, R. P. **Introduction to Computers for Biological Sciences**.
6. Jin, X. (2020). **Bioinformatics for Beginners**. Springer.

2. Wildlife tourism

Credits: 04 **(Total Hours: 60)**

Course Objectives (COs):

1. To develop understanding of the principles, scope and significance of wildlife tourism.
2. To study wildlife resources of India, including national parks, sanctuaries, biosphere reserves and ecotourism sites.
3. To build knowledge of biodiversity conservation, wildlife laws and responsible tourism practices.
4. To examine ecological, sociocultural and economic impacts of wildlife tourism.
5. To enhance practical skills for wildlife interpretation, nature guiding and sustainable tourism planning.

Learning Outcomes (LOs):

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

1. Explain the scope and principles of wildlife tourism.
2. Identify major protected areas and their conservation significance.
3. Understand wildlife management strategies and legal frameworks.
4. Apply ecotourism principles for sustainable wildlife tourism planning.
5. Demonstrate basic field skills related to nature guiding and wildlife interpretation.

Detailed Course Content

UNIT I: Introduction to Wildlife Tourism **(Hours: 15)**

A. Concept and Scope

- Definition, history and evolution of wildlife tourism
- Types of wildlife tourism: adventure, photographic, birdwatching, marine, safari-based
- Role of wildlife tourism in conservation and livelihood generation

B. Principles of Wildlife Tourism

- Carrying capacity
- Responsible and ethical tourism
- Interpretation and visitor management

C. Indian Wildlife Resources

- Biogeographic zones of India
- Flagship species and major habitats
- Overview of ecotourism vs. mass tourism

UNIT II: Protected Areas and Wildlife Management **(Hours: 15)**

A. Protected Area Network in India

- National Parks, Wildlife Sanctuaries, Tiger Reserves
- Biosphere Reserves, Community Reserves, Conservation Reserves
- UNESCO World Heritage Sites (Natural)

B. Wildlife Management Practices

- Habitat management: water holes, fire lines, grassland management
- Anti-poaching methods
- Human–wildlife conflict overview

C. Laws and Policies

- Wildlife (Protection) Act, 1972
- Forest Conservation Act, 1980
- National Wildlife Action Plan
- Roles of WII, NTCA, NGT and State Forest Departments

UNIT III: Tourism Planning and Ecotourism **(Hours: 15)**

A. Tourism Planning

- Site selection and zoning
- Interpretation centres, nature education and signage
- Pollution management, waste disposal & eco-friendly infrastructure

B. Ecotourism Principles

- Minimal impact travel
- Community-based ecotourism
- Homestays, tribal tourism, local enterprise development

C. Environmental Impact Assessment (EIA)

- Need and importance
- Visitor impact monitoring
- Case studies of ecotourism success and failure

UNIT IV: Practical Aspects of Wildlife Tourism **(Hours: 15)**

A. Wildlife Interpretation Skills

- Nature guiding: behaviour, ethics, communication skills
- Identification of birds, mammals, reptiles, plants – basics
- Use of field guides and digital apps (eBird, iNaturalist, INature)

B. Tools & Techniques for Wildlife Tourism

- Binoculars, field scopes, trail cameras
- GPS, maps, wildlife photography basics
- Safari procedures, safety protocols, field etiquette

C. Case Studies (India & Global)

- Keoladeo National Park, Jim Corbett, Kaziranga, Ranthambhore, Gir, Sundarbans
- Periyar community-based ecotourism
- African savannah safaris (overview)
- Issues of overtourism and mitigation measures

Suggested Readings:

1. Karanth, K. K. **Wildlife Tourism in India.**
2. Singh, S. **Wildlife Tourism: Impacts, Management and Planning.**
3. Krishnan, M. **Indian Wildlife.**
4. Balachandran, S. **Birds of India: A Field Guide.**
5. Weaver, D. **Ecotourism.**
6. Indira Gandhi National Forest Academy (IGNFA) & WII publications on wildlife management.

3. Holistic Approach to health

Credits: 04 **(Total Hours: 60)**

Course Objectives (COs):

1. To develop a multidimensional understanding of health by integrating physical, mental, emotional, social and spiritual perspectives.
2. To introduce students to the foundations of **Ayurveda** and its role in promoting holistic well-being.
3. To apply principles of yoga, meditation, balanced nutrition and lifestyle management for preventive health.
4. To understand how traditional knowledge systems and modern medicine can complement each other in disease prevention and health promotion.
5. To empower students with practical tools for stress management, emotional regulation and sustainable healthy living.

LEARNING OUTCOMES (LOs):

Students completing this course will be able to:

1. Explain holistic health concepts integrating Ayurveda, Yoga and modern science.
2. Identify their own body constitution (Prakriti) and design healthy routines.
3. Demonstrate basic yogic, breathing and relaxation techniques for stress management.
4. Understand diet principles and preventive strategies for major lifestyle diseases.
5. Evaluate the role of complementary systems (Ayurveda, Naturopathy, TCM) in wellness promotion.
6. Develop a personalized lifestyle plan based on holistic principles.

Detailed Course Content

UNIT I: Foundations of Holistic Health and Ayurveda **(Hours: 15)**

A. Concept of Holistic Health

- Meaning and dimensions: physical, mental, emotional, social, spiritual
- Determinants of health: environment, lifestyle, heredity, socio-cultural factors
- Limitations of the biomedical model and the rise of integrative health

B. Introduction to Ayurveda

- Historical development and philosophy of Ayurveda
- PanchaMahabhutas&Tridosha theory (Vata, Pitta, Kapha)
- Concept of Dhatus, Malas, Agni andOjas
- Prakriti assessment (body constitution) and its health implications

C. Daily and Seasonal Routines (Dinacharya&Ritucharya)

- Waking, sleeping, exercise, diet, breathing routines
- Seasonal adaptions and disease prevention

UNIT II: Yoga, Meditation & Mind–Body Medicine **(Hours: 15)**

A. Yogic Science for Health

- Eight limbs of Yoga (Ashtanga)
- Types of Yoga: Hatha, Ashtanga, Kundalini, Restorative
- Physiological benefits: Musculoskeletal, cardiovascular, endocrine and neural

B. Meditation & Stress Management

- Mindfulness meditation
- Pranayama (NadiShodhana, Bhastrika, Kapalbhati – introductory)
- Guided relaxation, Yoga Nidra, visualization techniques
- Stress physiology and psychoneuroimmunology

C. Ayurveda & Mental Health

- Sattva, Rajas, Tamas – mental gunas
- Ayurvedic lifestyle for emotional balance
- Herbs for mental wellness (Brahmi, Ashwagandha, Jatamansi – overview)

UNIT III: Nutrition, Preventive Health and Lifestyle Diseases **(Hours: 15)**

A. Science of Nutrition

- Modern nutrition: macro- & micronutrients
- Ayurvedic nutrition principles:
  - Six tastes (Shad Rasa)
  - Concept of ViruddhaAahara (incompatible food combinations)
  - Balanced diet according to Dosha

B. Lifestyle Disorders

- Obesity, diabetes, hypertension, metabolic syndrome
- Relationship between diet, inactivity, sleep and stress
- Ayurvedic preventive measures:
  - Panchakarma overview: Vamana, Virechana, Basti, Nasya, Raktamokshana
  - Detoxification &Rasayana therapy (rejuvenation)

C. Preventive Healthcare

- Immunity enhancement: role of Rasayana herbs
- Vaccination, hygiene, sanitation (modern concepts)
- Healthy aging, women's wellness, reproductive health

UNIT IV: Complementary Therapies and Community Wellness **(Hours: 15)**

A. Traditional & Complementary Health Systems

- Ayurveda, Siddha, Unani, Homeopathy – brief comparison
- Traditional Chinese Medicine (TCM): meridians & Qi (intro)
- Naturopathy and herbal home remedies

B. Holistic Therapies

- Aromatherapy, acupressure, hydrotherapy
- Music therapy, art therapy, nature therapy (forest bathing)
- Ayurvedic therapies for wellness (Abhyanga, Shirodhara, Swedana)

C. Health Promotion & Community Wellness

- Workplace ergonomics and wellness
- Yoga and Ayurveda in schools & communities
- Government schemes: AYUSH, Fit India, National Yoga Day
- Digital tools for health: mobile apps, fitness trackers, meditation apps

SUGGESTED READINGS:

1. Saraswati, Swami Satyananda.***Asana Pranayama Mudra Bandha***.Munger, Bihar: Bihar School of Yoga.
2. Iyengar, B. K. S.***Light on Yoga: The Bible of Modern Yoga***. New York: Schocken Books.
3. Lad, Vasant.***Textbook of Ayurveda: Fundamental Principles* (Vol. 1–3)**. Albuquerque, NM: The Ayurvedic Press.
4. Tiwari, B. N.***Elements of Ayurveda***. New Delhi: ChaukhambaOrientalia.
5. Ministry of AYUSH.***Standard Yoga Protocol* and *Ayurveda Guidelines for Preventive Health***. Government of India.
6. Chopra, Deepak.***Perfect Health: The Complete Mind–Body Guide***. New York: Harmony Books.

4.Integrated Pest Management

Credits: 04 **(Total Hours: 60)**

Course Objectives (COs):

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

- Understand advanced ecological, molecular and behavioural principles underlying pest dynamics and outbreaks.
- Analyse and evaluate modern IPM technologies including biocontrol, semiochemicals, genetic tools and precision pest surveillance.
- Apply modelling, decision-support systems and risk assessment frameworks for effective pest management planning.
- Integrate ecological, technological and regulatory knowledge to design sustainable, research-oriented IPM modules.

Learning Outcomes (LOs)

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

- Interpret complex pest ecology and population dynamics using advanced scientific tools

and models.

- Critically assess and select appropriate modern IPM strategies for agricultural, forestry, storage or urban ecosystems.
- Use data-driven tools (GIS, remote sensing, sensors, forecasting models) to support decision-making in IPM.
- Develop and present scientifically sound, sustainable IPM modules addressing real-world pest management problems.

UNIT I: Advanced Concepts in Pest Biology, Ecology & Modelling (15 Hours)

A. Advanced Pest Ecology

- Landscape ecology and spatial heterogeneity
- Metapopulations and source–sink dynamics
- Pest invasion biology and climate change impacts
- Sampling theory, Bayesian approaches in pest estimation

B. Pest Population Modelling

- Mathematical models: logistic, Lotka–Volterra, matrix models
- Population dynamics under IPM interventions
- Modelling outbreak cycles and forecasting epidemics
- Decision thresholds: dynamic ETLs and probabilistic risk models

C. Molecular & Genomic Basis of Pest Adaptation

- Resistance genes, detoxification enzymes and genetic polymorphism
- CRISPR-based gene editing in pests (sterile/incompatible insect technique)
- Molecular diagnostics and barcoding for pest identification

UNIT II: Advanced IPM Strategies & Technologies (15 Hours)

A. Semiochemical and Behavioural Approaches

- Pheromone-based mass trapping, attract-and-kill, mating disruption
- Kairomones, allomones and push–pull technology
- Smart pheromone dispensers and automated lure-release systems

B. Biocontrol – Next Generation Tools

- Genetically improved predators/parasitoids
- Microbial consortia, entomopathogenic nematodes, fungal toxins
- RNAi-based biopesticides, dsRNA delivery systems
- Microbiome manipulation for pest suppression

C. Nanotechnology & Advanced Chemical Control

- Nanoformulated pesticides, controlled-release systems
- Biosensors for pesticide detection
- Innovative application tools: drones, UAV spraying, precision nozzles
- Resistance management using rotation, mosaic and refuge strategies

UNIT III: Data-Driven IPM: Surveillance, Forecasting & Decision Tools (15 Hours)

A. Precision Pest Surveillance

- Remote sensing, GIS & GPS-based mapping
- IoT sensors, camera traps, automated insect recognition (AI/ML)
- Sentinel plots, e-traps and climate-driven pest forecasting models

B. Decision-Support Systems (DSS) in IPM

- Expert systems, cloud-based agricultural advisory tools
- Simulation models and predictive analytics
- Risk assessment, uncertainty analysis, cost-benefit models

C. Biosafety, Regulatory Framework & Environmental Risk

- Biosecurity measures & invasive species management
- National and international pesticide regulation frameworks
- Environmental risk assessment for GM biocontrol agents
- Ethical considerations in gene drive and genetic suppression

UNIT IV: Applied IPM: Sector-Specific Advanced Modules & Case Studies (15 Hours)

A. Advanced IPM Modules

- Precision IPM for major crops: cotton, soybean, sugarcane, rice, horticulture
- Forestry IPM: bark beetles, termites, defoliators
- Urban IPM: termites, mosquitoes, vector control optimization
- Storage IPM: hermetic storage, modified atmospheres, CO2 fumigation

B. International IPM Case Studies

- FAO–IPM Farmer Field Schools (FFS)
- US-EPA and EU IPM frameworks
- Biological suppression of fall armyworm, bollworms, locust upsurges

C. Research Applications

- Designing research problems in IPM
- Lab-to-field validation strategies
- Integration of socio-economic factors in adoption of IPM

Suggested Readings:

1. **Pedigo, L. P., & Rice, M. E.** *Entomology and Pest Management.* Pearson.
2. **Dent, D., &Binks, R.** *Insect Pest Management.* CABI.
3. **Kogan, M., & Jepson, P.C.** *Perspectives in Ecological Theory and Integrated Pest Management.* Cambridge University Press.
4. **Horowitz, A. R., &Ishaaya, I.** *Insect Pest Management: Field and Protected Crops.* Springer.
5. **Naranjo, S., & Ellsworth, P.** *Integrated Pest Management Advances in Sustainable Agriculture.* Academic Press.

6. **FAO &IPPC.** *International Standards for Phytosanitary Measures.*

प्रभारी अकादामक प्रभाग