2-YEAR NEP PG CURRICULUM

M.Sc. ZOOLOGY PROGRAMME

SUBJECT CODE = ZOO

FOR POSTGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2025-26 Onwards

Members of the Board of Studies of NEP PG Syllabus of Zoology
As per Guidelines of the Ranchi University, Ranchi

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COURSE STRUCTURE FOR PG **'PG DIPLOMA/ COURSEWORK ONLY/ COURSEWORK WITH RESEARCH/ RESEARCH ONLY'**

Table 1: Credit Framework for Two-Year Postgraduate Programme [Total Credits = 80]

Academic Level	Level of Courses	Semester	Coursework Level 400	Coursework Level 500	Research Preparedness	Research thesis/ Project/ Patent	Total Credits
YEAR 1							
Level 6	**Coursework**	**I**	**4+4+4**	**4+4**	**---**	**---**	**20**
		II	**4+4+4**	**4+4**	**---**	**---**	**20**
YEAR 2:	**Exit Point: Having an Internship of 4 credits Exit allowed with PG Diploma Certificate**						
Level 6.5	**Coursework**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**4+4+4+4+4**	**---**	**---**	**20**
OR							
Level 6.5	**Coursework + Research**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**---**	**20**		**20**
OR							
Level 6.5	**Research**	**III**	**---**	**---**	**20**	**---**	**20**
		IV	**---**	**---**	**---**	**20**	**20**
Total credits of P.G. Programme = **80**							

Note: **Every student has to take any one Value-added course of 2-credits compulsorily in the 1st Semester of the PG programme**.

HIGHLIGHTS OF NEP PG CURRICULUM

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.
One credit for Theory = 15 Hours of Teaching
One credit for Practicum = 30 Hours of Practical work
One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
Hours (L) – Classroom Hours of one hour duration.
Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.

Internship – For the Exit option after 1st year of the 2-year P.G. Programme for the award of P.G. Diploma, Level 6.5, Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

PG CURRICULUM

1. The PG Curriculum will be either of 1-year duration for students who studied the four-year UG Programme (FYUGP) or a 2-year duration for students who studied a three-year UG programme from a CBCS/LOCF/FYUGP Curriculum.
2. There is a flexible mode in the PG programme offered to the students of Ranchi University, Ranchi. The total credit for any semester will be 20 credits.
3. **Two-year PG curriculum:** The First year of the PG curriculum offers coursework only. There will be 3 courses at level 400 and 2 courses at level 500 in the first and the second semesters of any 2-year PG programme.
4. **One-year PG curriculum:** The Courses in the 1-year PG programme and the second year of the 2-year PG programme are the same.
   a. **Course work only**: There will be 5 courses at level 500 of 4 credits each in every semester for the coursework offered in the programme.
   b. **Course work and Research**: There will be 5 courses at the level 500 bearing 4 credits each in the first semester of a 1-year PG or in the third semester of a 2-year PG. There will be Research work offered in the next semester for this mode offered in the programme. The eligibility for this mode is available in the NEP PG curriculum of Ranchi University, Ranchi.
   c. **Research work only**: The eligible student will be offered this mode to conduct extensive research under the supervision of a guide. Each semester will be equivalent to 20 credits. The selection of a candidate for the research mode will depend upon the eligibility of the student, availability of the guide and seat in the department/institution of Ranchi University, Ranchi.

PROMOTION CRITERIA

Two Years Post-graduation programme having coursework only:

i. Each course shall be of **100 marks** having two components: **30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College and 70 marks for the End Semester University Examination (ESUE), conducted by the University**.
ii. The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Assignment/ Project/Seminar presentation and 05 for attendance in the classroom lectures and other activities of the Department/College.

iii. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.
iv. There shall be two written internal examinations, each of 1 hour duration and each of 20 marks, in a semester out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.
v. It is compulsory to pass the Mid-Semester examination. If someone fails in the Mid-Semester exam of a particular course, he/she has to retake both the Mid-Semester and End-Semester exams next year, regardless of how many marks he/she obtained in the End-Semester Examination.
vi. In case a student fails to secure pass marks in End Semester Examination, then he/she has to appear only in End Semester Examination of the following Sessions within the period of Upper Limit of Four Years and the Marks of Mid Semester will be carried for the preparation of result.
vii. Students' final marks and the result will be based on the marks obtained in Mid Semester and End Semester Examination taken together.
viii. The pass marks in the programme will be 45% of the total marks obtained in each Core/ Elective/ Other Courses offered.
ix. In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE** and **a minimum of 17 marks is to be secured in the SIA** to clear the course. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.
x. Every candidate seeking to appear in the ESUE shall be issued an Admit Card by the University. **No candidate will be permitted to appear in the examination without a valid admit card.**
xi. A candidate shall be permitted to proceed in next Semester (2^{nd}, 3^{rd} and 4^{th}) **provided he/she has passed at least in 3 courses out of 5 courses** in the respective semester in theory and practical/ project courses taken together.
xii. A student will have to clear all his papers within a maximum of Four Years of duration to qualify for the degree.

However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

VALUE-ADDED COURSES

1. The Value-added course will be of **2 credits** to be covered during the first semester.
2. There will be objective-type questions asked in the End Semester University Examination (ESUE).
3. There will be an OMR-based examination and the correct answer is to be marked by a black ballpoint pen only on the OMR sheet provided by the University.
4. For the **50 Marks Examination,** the student will be provided **two hours** to mark their responses.
5. Students are not allowed to choose or repeat courses already undergone at the undergraduate level in the proposed major and minor streams.
6. The performance in this course will not influence the SGPA or CGPA of the PG Programme where the student is registered to obtain the Master's Degree. However, it will be mandatory to secure minimum pass marks in the course before exit from the PG Programme.
7. If the student fails to secure the minimum pass marks in the Value-added course in the first semester, he may appear in the examination of the said course with the following batch of the next session.
8. The student may appear in the examination of the said course further if could not clear the course in the following attempt, subject to the date of validation of the Registration.

The existing Regulations of the PG Curriculum of Ranchi University, Ranchi, shall govern any matters not mentioned above.

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AIMS OF MASTER'S DEGREE PROGRAMME IN ZOOLOGY

The aim of the Master's degree programme in Zoology is to provide:

The aim of the Master's degree programme in Zoology is to provide advanced and comprehensive knowledge of animal biology, integrating structural, functional, developmental, ecological, and evolutionary perspectives. The programme is designed to develop a deep understanding of biodiversity, the interrelationships among organisms, and their adaptations to diverse environments. It seeks to equip students with both theoretical insights and practical skills in taxonomy, anatomy, physiology, genetics, molecular biology, ecology, conservation, and applied zoology. Through laboratory work, field studies, and research projects, the programme fosters scientific inquiry, critical thinking, and analytical skills. A key objective is to prepare students for careers in research, education, environmental management, aquaculture, wildlife conservation, and related applied sectors, while also enabling them to pursue higher studies and contribute to addressing contemporary biological and environmental challenges. Ultimately, the programme aims to nurture professionals with scientific competence, ethical responsibility, and a commitment to the sustainable management of animal resources.

PROGRAMME LEARNING OUTCOMES

The broad Learning Outcomes of Master's degree programme in Statistics are:

1. Knowledge Domain: Demonstrate comprehension of the theoretical and computational underpinnings of probability theory, inference, sample surveys, multivariate techniques, regression analysis, and stochastic processes, emphasizing their significance in data analytics.
2. Problem Analysis: Apply principles of scientific inquiry and critical thinking to solve problems and make informed decisions, systematically finding, analysing, evaluating, and applying information.
3. Presentation and Interpretation of Data: Exhibit proficiency in manipulating, visualizing, and computing standard statistical summaries from data sets.
4. Modern tool usage: Acquire proficiency in selecting and employing appropriate methods, procedures, resources, and computing tools such as Excel, MATLAB, SPSS, and R, while understanding their limitations.
5. Technical Skills: Utilize modelling, simulation, and data analysis tools to address real-world problems, generating solutions capable of predicting and explaining complex phenomena.
6. Analyse ethical issues relevant to academia, profession, and research, adhering to ethical norms in data analysis and research practices.
7. Communication: Effectively communicate statistical concepts and activities to peers and society, including comprehension of writing effective reports, designing documentation, and delivering presentations.
8. Project Management: Apply statistical principles effectively in managing projects both individually and within diverse teams, fostering multidisciplinary collaboration.
9. Lifelong Learning: Demonstrate the ability to independently explore and learn statistical tools, adapting to technological advancements and continuing professional development.

The Courses in One Year P.G. Programme and in the Second year of Two years P.G. Programme are Common.

Table 2: Semester-wise Course Code and Credit Points

Sem	Core, AE/ GE/ DC/ EC & Compulsory FC Courses				Examination Structure		
	Paper	Paper Code	Credit	Name of Paper	Mid Semester Evaluation (F.M.)	End Semester Evaluation (F.M.)	End Semester Practical/ Viva (F.M.)
I	Foundation Course	FCZOO121	4	Advanced Biochemistry and Biotechnology	30	70	----
	Core Course	CCZOO122	4	Advanced Immunology and Methods in Biology	30	70	----
	Core Course	CCZOO123	4	Research Methodology	30	70	----
	Core Course	CCZOO124	4	Genetics and Evolution	30	70	----
	Practicals on Core	CPZOO125	4	Practical	----	----	100
II	Core Course	CCZOO221	4	Toxicology, Histology and Histochemistry	30	70	----
	Core Course	CCZOO222	4	Advanced Cell Biology & Molecular Genetics	30	70	----
	Core Course	CCZOO223	4	Neuro-Endocrinology & Basic Bioinformatics	30	70	----
	Core Course	CCZOO224	4	Biostatistics & Biophysics	30	70	----
	Practicals on Core	CPZOO225	4	Practical	----	----	100
III	Core Course	ECZOO321	4	IKS & Human Physiology	30	70	----
	Skill Enhancement Course	CCZOO322	4	A. Fisheries B. Sericulture	30	70	----
	Core Course	CCZOO323	4	Reproductive Physiology and Developmental Biology	30	70	----
	Core Course	CCZOO324	4	Non-Chordates and Parasitology	30	70	----
	Practicals on Core	CPZOO325	4	Practical	----	----	100
IV	Elective	ECZOO421	4	A. Fish and Fisheries-I B. Entomology-I C. Ecology-I	30	70	----
	Elective	ECZOO422	4	A. Fish and Fisheries-II B. Entomology-II C. Ecology-II	30	70	----
	Core Course	CCZOO423	4	Chordates	30	70	----
	Practicals on Elective	EPZOO424	4	A. Practical-A B. Practical-B C. Practical-C	----	----	100
	PROJECT	PRZOO425	4	Dissertation/ Project/ Teaching Aptitude	----	----	100

Note:

1. **Every student has to take any one Value-added course of 2 credits compulsorily in the 1st Semester of the PG programme.**
2. **Either One Internship of 4 credits or Two Internships of 2 credits each is required before opting for the 'Exit' option after the first year of the P.G. Programme.**

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

Marks Weightage of a Course: Each non-practical/non-project course shall be of **100 marks** having two components: **70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University, and, 30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College**.

The marks of SIA shall further be divided into 20 for Internal Written Examinations, 05 for Assignment/Project/Seminar presentation, and 05 for attendance at classroom lectures and other activities of the Department/College. There shall be two written internal examinations, each of 1-hour duration and each of 20 marks, in a semester, out of which the **'Better One out of Two'** shall be taken for computation of marks under SIA.

In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE and a minimum of 17 marks is to be secured in the SIA to clear the course**. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

A. (SIE 20+5+5=30 marks):

There will be a uniform pattern of questions for mid-semester examinations in all the courses and across all the programmes. There will be **two** groups of questions in 20-mark written examinations. **Group A is compulsory** and will contain five questions of **very short answer type** consisting of 1 mark each. **Group B will contain descriptive type five** questions of five marks each, out of which any three are to be answered. Department may conduct Sessional Internal Examinations in other format as per needs of the course.

The Semester Internal Examination shall have three components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Assignment/Project/ Seminar Presentation of 5 marks (c) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESUE):

A. (ESUE 70 marks):

There will be a uniform pattern of questions for all the courses and all the programmes. There will be **two** groups of questions. **Group A is compulsory** and will contain two questions. **Question No.1 will be very short-answer type** consisting of five questions of 1 mark each. **Question No.2 will be a short-answer type** of 5 marks. **Group B will contain descriptive type six** questions of fifteen marks each, out of which any four are to be answered. The questions will be so framed that examinee could answer them within the stipulated time.

[**Note:** There may be subdivisions in each question asked in Theory Examinations]

B. (ESUE 100 marks):

Practical/ Project courses would also be of 100 marks but there **shall be no internal written examinations** of the type specified above. The total 100 marks will have two components: **70 marks for the practical ESUE and 20 marks for the Viva-voce examination** conducted during the ESUE to assess the applied and practical understanding of the student.

The written component of the project (**Project Report**) shall be of **70 marks and 20 marks will be for the Viva-voce examination** jointly conducted by an external examiner, appointed by the University, and the internal supervisor/ guide.

10 marks will be assigned on the cumulative assessment of the examinee during the semester and will be awarded by the department/faculty concerned.

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FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [10]
4. ..... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **70 Marks**:

Subject/ Code

F.M. =70 **Time**=3HrS. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. .....
   ii. .....
   iii. .....
   iv. .....
   v. .....
2. ..... [5]

Group B

3. ..... [15]
4. ..... [15]
5. ..... [15]
6. ..... [15]
7. ..... [15]
8. ..... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. FOUNDATION COURSE [FCZOO121]
ADVANCED BIOCHEMISTRY & BIOTECHNOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective

1. To understand the molecular basis of life processes in animals and to develop analytical and critical thinking skills in biochemical research.
2. To familiarize the students with the fundamental principles of biotechnology, various potential applications of biotechnology in Zoology.

Course Learning Outcomes

1. Application of Genetic Engineering Tools: Students will be able to apply molecular biology techniques such as PCR, gene cloning, and CRISPR to study and manipulate genes in animal systems for research or therapeutic purposes.
2. Understanding of Biotechnological Advances in Zoology: Students will critically evaluate and apply biotechnological approaches (e.g., stem cell technology, transgenesis, and animal tissue culture) to solve problems in animal health, reproduction, and conservation.
3. Metabolic and Enzymatic Processes: Students will have a thorough understanding of animal metabolism, enzyme kinetics, and regulation, and their integration in physiological systems.
4. Experimental and Analytical Proficiency: Students will acquire hands-on experience in biochemical techniques (e.g., spectrophotometry, chromatography, electrophoresis) and use them to analyze biological samples to interpret results in the context of animal biochemistry.

Course Content:

UNIT-1: ADVANCED BIOCHEMISTRY

1. **Water as the Basic Molecule of Life** **(04 Lectures)**
   a. Molecular structure and solvent properties of water, tetrahedral geometry, hydrogen bond, thermal properties of water and their biological significance.
   b. Ionization of water, Ion product of water (Kw), Concept of pH, Dissociation of weak acids and weak bases, Henderson-Hasselbalch Equation, Titration curves of strong and weak acids, concept of buffer, buffers in biological systems.
2. **Biological Macromolecules** **(09 Lectures)**
   a. Central role of carbon, Common ring structure, Chirality, and Isomerization in biomolecules.
   b. Composition, structure and functions of monomers and polymers, carbohydrates, lipids, proteins, nucleic acids
   c. Vitamins
3. **Interactions of Macromolecules** **(04 Lectures)**
   a. Stability of Proteins and Nucleic Acids; Stabilizing Interactions such as Vander Waals, Electrostatic, Hydrogen Bonding, Hydrophobic Interactions
   b. Confirmation of proteins: Ramachandran plot, secondary structure, domains, motif and folds, Hydropathy index (HI) of amino acids, isoelectric point (pI) of proteins
4. **Complex biomolecules** **(03 Lectures)**
   a. Glycoproteins: ABO blood group determinants
   b. Lipoproteins: classification and functions of chylomicrons, VLDL, LDL, HDL, and free fatty acid-albumin complex, Cholesterol ratio (CR)
5. **Carbohydrate and Lipid Metabolism** **(15 Lectures)**
   a. Glycolysis, Krebs cycle, ETC, and their energetics & regulation.
   b. Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, and lactate.
   c. Glycogen metabolism: Glycogenesis, Glycogenolysis, and their regulation.
   d. Significance of the pathways: Hexose Monophosphate (HMP) Shunt as a multifunctional pathway
   e. Fatty acid metabolism: Beta-oxidation of saturated even and odd carbon atoms, and unsaturated fatty acids, metabolism of cholesterol

UNIT-2: BIOTECHNOLOGY

1. **Genome Organization** **(06 Lectures)**
    a. Organization of genomes in prokaryotes and eukaryotes, the C-value paradox, and genome size.
    b. Complexity of viral, bacterial, and eukaryotic genomes, Cot curves, repetitive and non-repetitive DNA sequences.
2. **Methods in Biotechnology** **(09 Lectures)**
    a. Cloning using plasmid pBR322, pUC19, pJM, pBluescript, detection of recombinants by blue-white screening, cloning in bacteriophage, cosmid, BAC, MAC, and YAC vectors.
    b. Chromosome walking, RAPD Microarrays. Strategies of genome separation – Sanger methods and Next Generation Sequencing (NGS).
3. **Microbial biotechnology** **(10 Lectures)**
    a. Microbial fermentation, Microbial growth kinetics, Design of a fermenter, Organisms used in large scale fermentation.
    b. Monoclonal antibodies (MABs) and their therapeutic applications.
    c. HIV therapeutic agents.
    d. Production of biopharmaceuticals from transgenic animals – Human Tissue Plasminogen Activator (hTPA) and α-1Antitrypsin (AAT).
    e. Environmental biotechnology: Effluent treatment, Bioremediation, Phytoremediation, Biosensors, Biofuels.

Suggested Readings:

Text Books:

1. Lehninger, L. Albert, David, L. Nelson, Michael, M. Cox (Latest edition). Principles of Biochemistry, CBS Publishers and Distributors, Delhi.
2. Medical Biotechnology – S. N. Jogdand – Himalaya Publishing House.

Reference Books:

1. Puri, Dinesh (Latest edition). Textbook of Medical Biochemistry (3rd Edition).
2. Bhagavan N. V. and Chung-Eun Ha (Latest edition). Essentials of Medical Biochemistry (2nd Edition).
3. Harper's Illustrated Biochemistry.
4. Satyanarayana U. and Chakrapani (Latest edition). Biochemistry.
5. Stryer, L (Latest edition), Biochemistry, W.H. Freeman and Company, New York.
6. Smith (Latest edition), Principles of Biochemistry, (7th Edition), McGraw Hill (Mammalian Biochemistry), New York.
7. Voet, D. & Voet, J (Latest edition), Biochemistry, John Wiley and Sons, New York.
8. Fundamentals of Biochemistry – J L Jain, Sunjay Jain, Nitin Jain – S. Chand.
9. Biotechnology- Expanding Horizon by P.D. Singh, Kalyani Publication
10. Cell & Molecular Biology: Concepts & Experiments (6th Edition) – Gerald Karp.
11. iGenetics – A molecular approach (3rdEdition) – Peter J Russell – Pearson Education Inc.
12. Molecular Biology and Biotechnology– KG Ramawat & Shaily Goyal – S. Chand.

II. CORE COURSE [CCZOO122]
ADVANCED IMMUNOLOGY AND METHODS IN BIOLOGY

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. In immunology, learners will explore the structure and function of immune cells, organs, and molecules, along with the mechanisms of innate and adaptive immunity, antigen-antibody interactions, immunological memory, and hypersensitivity reactions.
2. Emphasis is placed on understanding the roles of B and T lymphocytes, cytokines, MHC molecules, and the principles of immunological disorders, vaccination, and host-pathogen interactions.
3. The Methods in Biology component equips students with the theoretical and practical knowledge of core experimental techniques used in modern biology. These include microscopy (light, fluorescence, electron), centrifugation, chromatography, electrophoresis, blotting techniques (Southern, Northern, Western), ELISA, flow cytometry, and molecular biology techniques like PCR, cloning, and gene expression analysis.
4. By integrating these two areas, the course develops the ability to design, conduct, and interpret experiments related to immune functions and biological processes, fostering scientific thinking and preparing students for research and clinical applications.

Course Learning Outcomes:

After completing this course, students will be able to:

1. Understand the immune system – Describe the components and functions of the innate and adaptive immune responses, including key immune cells, organs, antibodies, antigens, and signaling pathways.
2. Explain immunological mechanisms – Demonstrate knowledge of immune processes such as antigen processing and presentation, immune memory, tolerance, vaccination, autoimmunity, and hypersensitivity.
3. Apply experimental techniques – Understand the principles, procedures, and applications of key biological methods such as microscopy, centrifugation, chromatography, gel electrophoresis, blotting, ELISA, flow cytometry, and molecular cloning.
4. Interpret immunological and molecular data – Analyze and interpret results from laboratory experiments involving immunological assays and molecular biology techniques.
5. Design experiments – Develop the ability to plan and execute basic experiments in immunology and cell/molecular biology, with attention to accuracy, controls, and reproducibility.

Course Contents:

UNIT-I: ADVANCED IMMUNOLOGY

1. Immune System Architecture and Cell Signaling: (09 Lectures)

a. Advanced overview of innate and adaptive immunity.
b. Antigen recognition: MHC complex, antigen processing and presentation.
c. Immune cell receptors: T-cell receptor, B-cell receptor, co-stimulatory molecules.
d. Signal transduction pathways in immune responses.

2. Immunogenetics and Immune Regulation: (08 Lectures)

a. Organization and genetics of immunoglobulin and T-cell receptor genes.
b. Somatic recombination, hypermutation, and class switching.
c. Mechanisms of immune tolerance, central and peripheral.
d. Cytokine networks, immune checkpoints, and regulation.

3. Immunopathology and Disease: (08 Lectures)

a. Hypersensitivity reactions (Types I–IV).
b. Autoimmunity: mechanisms and major autoimmune diseases.
c. Immunodeficiencies: primary and acquired (e.g., HIV/AIDS).
d. Tumor immunology: cancer immunosurveillance, immunoediting.

4. Applied and Emerging Immunology: (05 Lectures)

a. Vaccinology: traditional and modern vaccine design, mRNA vaccines.
b. Immunodiagnostics: ELISA, flow cytometry, immunofluorescence.
c. Introduction to immunoinformatics and systems immunology.

UNIT-II: METHODS IN BIOLOGY

1. Molecular biology and recombinant DNA methods: (14 Lectures)

a. Isolation and purification of RNA, DNA (genomic and plasmid) and proteins, different separation methods; analysis of RNA, DNA, and proteins by one and two-dimensional gel electrophoresis, isoelectric focusing gels. Molecular cloning of DNA or RNA fragments in bacterial and eukaryotic systems.
b. Isolation of specific nucleic acid sequences; generation of genomic and cDNA libraries in plasmid, phage, cosmid, BAC, and YAC vectors.
c. *In vitro* mutagenesis and deletion techniques.
d. Gene knock-out in bacterial and eukaryotic organisms.

e. Protein sequencing methods, detection of post-translational modification of proteins.
f. DNA sequencing methods, strategies for genome sequencing.
g. Methods for analysis of gene expression at RNA and protein levels. RAPD and AFLP techniques.

2. Immunotechniques: (06 Lectures)

a. Antibody generation, detection of molecules using ELISA, RIA, western blot, immunoprecipitation, flow cytometry and immunofluorescence microscopy, detection of molecules in living cells, *in situ* localization by techniques such as FISH and GISH.

3. Radiolabeling techniques: (04 Lectures)

a. Properties of different types of radioisotopes normally used in biology, and their detection
b. Measurement, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material and safety guidelines.

4. Microscopic techniques: (06 Lectures)

a. Visualization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes
b. Different fixation and staining techniques for EM, freeze-etch

Suggested Readings:

Text Books:

1. Kuby Immunology, Jenni Punt, Sharon Stranford, Patricia Jones, Judy Owen, W.H. Freeman and Company, Address**:** 41 Madison Avenue, New York, NY 10010, USA
2. Principles and Techniques of Biochemistry and Molecular Biology, Editors**:** Keith Wilson, John Walker, Publisher**:** Cambridge University Press, **Address**: University Printing House, Shaftesbury Road, Cambridge CB2 8BS, UK

Reference Books:

1. Janeway's Immunobiology, Kenneth Murphy, Casey Weaver, Publisher**:** Garland Science, Taylor & Francis Group, Address**:** 711 Third Avenue, New York, NY 10017, USA
2. Essential Immunology, Author**:** Peter L. Roitt, Publisher**:** Wiley-Blackwell, Address**:** 111 River Street, Hoboken, NJ 07030, USA
3. Cellular and Molecular Immunology, Authors**:** Abul K. Abbas, Andrew H. Lichtman, Shiv Pillai, Publisher**:** Elsevier (Saunders), Address**:** 3251 Riverport Lane, Maryland Heights, MO 63043, USA
4. Immunology: A Short Course, Authors: Richard Coico, Geoffrey Sunshine**,** Publisher**:** Wiley-Blackwell**,** Address**:** 111 River Street, Hoboken, NJ 07030, USA
5. Molecular Cloning: A Laboratory Manual, Authors**:** Michael R. Green, Joseph Sambrook**,** Publisher**:** Cold Spring Harbor Laboratory Press**,** Address: 500 Sunnyside Blvd, Woodbury, NY 11797, USA
6. Molecular Biology Techniques: A Classroom Laboratory Manual, Authors**:** Heather Miller, D. Scott Witherow, Sue Carson, Publisher**:** Elsevier/Academic Press, Address**:** 125 London Wall, London EC2Y 5AS, UK
7. Experimental Techniques in Biochemistry and Molecular Biology, Author**:** S.K. Sawhney, Randhir Singh**,** Publisher: Narosa Publishing House**,** Address**:** 4746/23 Ansari Road, Daryaganj, New Delhi – 110002, India

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III. CORE COURSE [CCZOO123]
RESEARCH METHODOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner will be able to understand:

1. The basics of research
2. Research problems, various research methods, tools, and ethical practices
3. Basic skills in data collection, analysis, and reporting

Course Learning Outcomes:

Students would be able to understand:

1. Characteristics of good research viz; a comprehensive study of research reviews, gaps, objective, methodology, results, discussion and conclusion with future scope.
2. How to keep ethical considerations and stay away from plagiarism.

Course Content:

UNIT 1: Introduction to Research **(09 Lectures)**

Definition and objectives of research, Types of research: basic, applied, qualitative, quantitative
Steps in the research process, Research questions and hypothesis formulation, Characteristics of good research

UNIT 2: Research Design and Sampling **(09 Lectures)**

Research design: exploratory, descriptive, experimental, Variables and control groups, Sampling methods: probability and non-probability, Sample size determination, Limitations and delimitations

UNIT 3: Data Collection Methods **(09 Lectures)**

Primary and secondary data, Techniques: questionnaires, interviews, observation, case studies
Survey tools and fieldwork, online and offline data collection, Validity and reliability of data

UNIT 4: Data Analysis and Interpretation **(09 Lectures)**

Basics of data organization, Introduction to descriptive statistics: mean, median, mode, standard deviation
Graphical representation: tables, charts, graphs, Introduction to inferential statistics
Use of software tools (e.g., MS Excel, SPSS/R/PAST – demo-based)

UNIT 5: Report Writing and Research Ethics **(09 Lectures)**

Structure of a research report/thesis, Referencing and citation styles (APA/MLA)
Plagiarism and how to avoid it, Intellectual property rights and copyright
Ethical issues in research (including human and animal ethics)

Practical / Project Work **(15 Lectures)**

Framing a research question and writing a short proposal
Designing a sample questionnaire or data collection tool
Collecting mock data and presenting it using graphs or basic statistics
Referencing using software like Zotero, Mendeley
Writing a mini-report based on collected data

Suggested Readings:

Text Book:

1. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New Age International.

Reference Books:

1. Research methodology tailored to Biological Sciences by N. Gurumani, Edi-2021, MJP Publisher, Chennai
2. Online resources: SWAYAM, NPTEL, and Google Scholar.
3. Breakwell, Glynis M. Hammond, S. Fifeschaw, C., Smith, J.A. Research Methods in Zoology, Sage Publication.
4. Kerlinger, Fred N., Foundation of Behavioral Research, Hort, Rinehart and Winston publishing.
5. Ahuja, Ram., Research Methods, Rawat Publications.

IV. CORE COURSE [CCZOO124]
GENETICS AND EVOLUTION

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To get acquainted with applications of genes in modern science and population genetics
2. To give in-depth knowledge of biological processes through molecular mechanisms
3. To develop the understanding of genes, genomes in evolution. To comprehend the pattern of genetic relatedness between all species. To understand the contribution of genetic variation in phenotypic expression

Course Learning Outcomes:

After completing this course, students will be able to:

1. The learner will understand the molecular processes that occur in and between the cells.
2. The learner will gain insight into the most significant molecular and cell-based methods used to expand the understanding of modern Biology. The learners will understand the genetic analysis at the gene, genome, and population level.
3. The learner would realize the flow of genetic information and complex networking of genes in biological system leading to major phenotypic changes.

Course Contents:

PART-A: GENETICS

UNIT I: Gene Library: (04 Lectures)

1. Molecular analysis of genes and gene products
2. Types – Genomic Library, cDNA Library, Construction of a genomic library – human antibody gene library
3. Applications of gene library

UNIT II: Types of Genes: (04 Lectures)

1. Definition and examples – Multigene, Repeated genes, Single copy gene, House-keeping gene (constitutive gene), Luxury gene (non-constitutive gene), Pseudogene, Jumping gene (Transposons), Overlapping gene, Structural gene, Processed gene, Split gene, Regulatory gene.

UNIT III: Multi-gene Families and Types: (04 Lectures)

1. Split Genes or Interrupted genes- Introduction, Structure of split genes, Discovery and theory of split genes,
2. Evolution of split genes and Pseudogenes

UNIT IV: Mapping units: (05 Lectures)

1. Types –genetic mapping and physical mapping, Detection of linkage,
2. Construction of linkage maps in diploids and their characteristics, Coefficient of coincidence, Outline of other types of gene mapping

UNIT V: Gene cloning: (05 Lectures)

1. Definition and strategies of gene cloning
2. Techniques in gene cloning, and Applications of gene cloning in DNA analysis in research.

UNIT VI: Population genetics: (03 Lectures)

1. Population genetics in DNA typing.
2. Mutation – Selection balance.

UNIT VII: Non-allelic gene interactions: (10 Lectures)

1. Epistasis, Complementary genes, Inhibitory genes, Duplicate genes, Collaborative genes, Additive genes, Pleiotropy.

PART-B: EVOLUTION (25 Lectures)

1. Concept of Evolution**,** Concept of neutral evolution, Theories of organic evolution: Neo Darwinism & Synthetic Theory of Evolution. Evolution of man
2. Population, Gene frequency, Hardy-Weinberg's law in genetic stability
3. Genome evolution: Evolution of Multigene families, Genetic Drift
4. Isolation and its mechanism for speciation
5. Evolution of Cytochrome c, Cox gene and Haemoglobin gene structures.
6. Fossil dating, Geological time scale – Eras, Periods, and Epochs, Major events in evolutionary time scales. Fossil dating – Absolute and Relative dating. Process of C-14 dating.
7. Frozen zoo – concept of frozen zoo to save endangered species, Current status of frozen zoo.
8. Selfish Gene - Introduction and definition, Individual altruism and genetic egoism

Suggested Readings:

Text Books:

1. Principles of Genetics by Robert H. Tamarin, 7th edition, revised version published in 2004 by McGraw-Hill Education, India
2. Evolution (5th Edition) – Douglas J. Futuyma & Mark Kirkpatrick, Oxford University Press, Great Clarendon Street, Oxford OX2 6DP, United Kingdom

Reference Books:

1. Introduction to genetic analysis (11th ed.). Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2015). W. H. Freeman & Company
2. Genetics (5th ed.). Russell, P. J. (1998). Benjamin/Cummings.
3. Molecular Genetic Analysis of Populations: A Practical Approach (Latest Online Edition, Oxford University Press), A. R. Hoelzel, Oxford University Press, Great Clarendon Street, Oxford OX2 6DP, UK
4. A Complete Guide to Gene Cloning: From Basic to Advanced (2022), Shalmali Bivalkar et al. Springer, Cham, Switzerland (Springer Nature)
5. Population Genetics, Molecular Evolution, and the Neutral Theory, Naoyuki Takahata (collecting works of Motoo Kimura), University of Chicago Press, 1427 E. 60th Street, Chicago, IL 60637, USA
6. Evolution (4th Edition) – Mark Ridley, Wiley-Blackwell (an imprint of John Wiley & Sons), 111 River Street, Hoboken, NJ 07030, USA
7. Vertebrate Palaeontology (5th Edition, 2024) – Michael J. Benton, Wiley-Blackwell, 111 River Street, Hoboken, NJ 07030, USA

V. CORE COURSE [CPZOO125]
PRACTICAL

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter for
Scheme of Examination **Time: 6 Hrs**

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

a. *Experiments from Unit II/III* = *20 marks*
b. *Experiment from Unit IV/V/VII* = *20 marks*
c. *Experiments from Unit I/VI* = *20 marks*
d. *Practical Records* = *20 marks*
e. *Viva-voce* = *20 marks*

List of Practical

UNIT I: Research Methodology

1. Formulation of a Research Problem & Hypothesis:
   Selection of a research topic, writing aims & objectives, framing testable hypotheses.
   Introduction to literature search using Google Scholar, PubMed, and reference managers.
2. Sampling Techniques & Data Collection Methods:
   Random, stratified, and systematic sampling (field/experimental).
   Preparation of field data sheets.
3. Data Analysis & Scientific Writing
   Introduction to basic statistics (mean, SD, SE, t-test, chi-square).
   Plotting graphs using Excel/SPSS/R.
   Formatting a short scientific report in APA/Harvard style.

UNIT II. Biochemistry

1. Estimation of Proteins by Lowry's or Biuret method.
2. Qualitative Tests for Carbohydrates, Proteins, and Lipids.
3. Effect of temperature/pH on salivary amylase activity.
4. Estimation of Enzyme Activity.

UNIT III. Immunology

1. Preparation of Blood Smear & Differential Leucocyte Count (DLC).
2. Determination of Blood Group (ABO & Rh typing) using agglutination test.
3. Enzyme-Linked Immunosorbent Assay (ELISA) – demonstration or simulation.

UNIT IV. Genetics

1. Study of Mendelian Ratios using seed traits of garden pea or online simulation data.
2. Preparation of Polytene Chromosome Squash from *Drosophila* salivary glands.
3. Chi-Square Analysis of genetic crosses (data-based problem-solving).

UNIT V. Evolution

1. Study of Homologous and Analogous Organs from museum specimens and charts.
2. Construction of a Simple Phylogenetic Tree using morphological or molecular data (UPGMA/Cladistics).
3. Demonstration of Hardy–Weinberg Equilibrium using bead/coin simulation for allele frequency.

UNIT VI. Biotechnology

1. Agarose Gel Electrophoresis of DNA (demonstration).
2. Plasmid DNA Isolation from *E. coli* (demonstration or simulation).
3. Polymerase Chain Reaction (PCR) – amplification of a target sequence (demo/simulation).

VII. Methods in Biology

1. Use and Calibration of Light Microscope – oil immersion, measurement using ocular & stage micrometer.
2. Preparation of Permanent and Temporary Mounts (e.g., insect parts, invertebrate larvae).
3. Spectrophotometry – principle, calibration curve preparation, and sample absorbance measurement.

Suggested Readings:

1. Kothari, C. R., & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th ed.). New Age International Publishers.
2. Sinha, R. K. (2004). *Research Methodology in Zoology*. Anmol Publications Pvt. Ltd.
3. Plummer, D. T. (2017). *An Introduction to Practical Biochemistry*. McGraw-Hill Education.
4. Jain, J. L., Jain, S., & Jain, N. (2020). *Fundamentals of Biochemistry*. S. Chand & Company Pvt. Ltd.
5. Plummer, D. T. (2017). *An Introduction to Practical Biochemistry*. McGraw-Hill Education.
6. Kuby, J., Kindt, T. J., Goldsby, R. A., & Osborne, B. A. (2018). *Kuby Immunology*. W. H. Freeman.
7. Talwar, G. P., & Gupta, S. K. (2017). *Textbook of Immunology*. CBS Publishers & Distributors.
8. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2011). *Principles of Genetics*. Wiley.
9. Verma, P. S., & Agarwal, V. K. (2017). *Cell Biology, Genetics, Molecular Biology, Evolution and Ecology*. S. Chand Publishing.
10. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
11. Hall, B. G., & Hallgrímsson, B. (2013). *Strickberger's Evolution*. Jones & Bartlett Learning.
12. Rastogi, V. B. (2018). *Principles of Animal Ecology and Evolution*. Kedarnath Ramnath & Co
13. Sambrook, J., & Russell, D. W. (2001). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
14. Dubey, R. C. (2014). *A Textbook of Biotechnology*. S. Chand Publishing.
15. Humason, G. L. (1979). *Animal Tissue Techniques*. W. H. Freeman.
16. Ghosh, A. K. (2015). *Methods in Biology: Laboratory Manual*. New Central Book Agency.

SEMESTER II

I. CORE COURSE [CCZOO221]
TOXICOLOGY, HISTOLOGY AND HISTOCHEMISTRY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. Theoretical and applied knowledge of the effects of chemical substances on human health.
2. The toxicological analysis and the signs and symptoms of important toxic syndromes.
3. The basic toxicokinetic principles and metabolic systems to elucidate mechanisms of toxicity induced by xenobiotic compounds.

Course Learning Outcomes:

After completing this course, the students will be able to:

1. Understand the principles and scope of toxicology.
2. Learn about different types of toxins and their effects on organisms
3. Study detoxification mechanisms and risk assessment
4. Provide hands-on experience in toxicity testing and analysis

Course Content:

UNIT I: TOXICOLOGY

1: Introduction to Toxicology **(04 Lectures)**

a. Definition, scope, and branches of toxicology
b. History and development of toxicology
c. Classification of toxicants: chemical, biological, and physical
d. Dose-response relationship, Factors affecting toxicity (age, sex, route, duration, etc.)

2: Absorption, Distribution, Metabolism and Excretion (ADME) of Toxicants **(07 Lectures)**

a. Routes of exposure: oral, dermal, inhalation
b. Toxicokinetics: absorption, distribution, biotransformation, excretion
c. Phase I and II metabolic reactions, Bioaccumulation, and biomagnification

3: Organ System Toxicity **(07 Lectures)**

a. Hepatotoxicity, nephrotoxicity, neurotoxicity
b. Hematotoxicity and reproductive toxicity

4: Environmental and Occupational Toxicology **(09 Lectures)**

a. Pesticide toxicity: organochlorines, organophosphates, carbamates
b. Heavy metals: arsenic, lead, mercury, cadmium
c. Industrial and household toxicants
d. Risk assessment and safety limits (LD_{50}, LC_{50}, NOAEL, etc.)

5: Toxicology in Public Health and Regulation **(03 Lectures)**

a. Food and drug toxicology, Forensic toxicology: poisoning and antidotes
b. Introduction to biosafety and toxicology regulations
c. National and international regulatory agencies (EPA, CPCB)

UNIT-II: HISTOLOGY AND HISTOCHEMISTRY

1. Definition, scope, and importance of histology in zoological studies **(01 Lecture)**
2. **Fixation and tissue processing:** Types of fixatives, Chemistry of fixation, and selection of fixatives. Dehydration, Clearing and embedding, Microtomy. **(08 Lectures)**
3. **Histological Staining of paraffin sections:** Types of staining, Dye chemistry, Principle and methods of staining of paraffin sections (Hematoxylin & Eosin, Trichrome stains) **(05 Lectures)**
4. **Histochemical identification and localization of the following:** **(16 Lectures)**
   A. **Carbohydrates -** Periodic Acid-Schiff (PAS) reaction (for glycogen and glycoprotein)

B. **Protein end groups -** Mercury Bromophenol Blue method (for general proteins), Ninhydrin/Schiff method (for α-amino acids), and Performic acid Alcian Blue method (for disulfide)
C. **Lipid moieties -** Sudan Black B method (for phospholipids), Performic acid-Schiff (for unsaturated fatty acids), Perchloric acid nephthaoquinone Reaction (for cholesterol).
D. **Nucleic acids –** Pyronin-Methyl green method (for nucleic acid) and Feulgen nuclear reaction (for DNA).

Suggested Readings:

1. Casarett and Doull's Toxicology – Curtis D. Klaassen
2. Principles of Toxicology – Karen Stine & Thomas M. Brown
3. Textbook of Toxicology – P.D. Sharma
4. Essentials of Toxicology – M.A. Subramanian
5. Environmental Toxicology – T.W. Clar

II. CORE COURSE [CCZOO222]
ADVANCED CELL BIOLOGY & MOLECULAR GENETICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner will be able to learn:

1. Advanced molecular mechanisms governing cellular function.
2. The details of cellular compartments, genome organization, and gene regulation.
3. The modern tools in molecular biology and cellular imaging.
4. The analytical thinking through case studies and current research.

Course Learning Outcomes:

Students would be able to understand:

1. Cell architecture, membrane dynamics, and organelle-specific processes such as protein sorting, trafficking, and cellular compartmentalization.
2. the mechanisms of DNA replication, transcription, RNA processing, translation, and post-translational modifications in both prokaryotic and eukaryotic systems.
3. how cells regulate gene activity at transcriptional and post-transcriptional levels, and how chromatin remodeling and epigenetic modifications influence cellular behaviour.
4. how the cell cycle is controlled, how apoptosis is triggered, and how disruptions in these processes can lead to diseases such as cancer.
5. Techniques such as PCR, blotting, sequencing, gene editing (e.g., CRISPR), and microscopy to analyze molecular and cellular functions.

Course Content:

GROUP- A: ADVANCED CELL BIOLOGY

UNIT I: Advanced Cell Structure and Membrane Dynamics: (06 Lectures)

1. Membrane structure and function: Lipid rafts, membrane asymmetry, Transport mechanisms (passive, active, facilitated)
2. Membrane trafficking and vesicle transport: Endocytosis, exocytosis, clathrin, COPI, COPII, SNARE hypothesis

UNIT II: Organelle Biology and Protein Targeting: (04 Lectures)

1. Nucleus and nuclear pore complex,
2. Protein sorting and signal sequences of mitochondria, nucleus, and peroxisome.
3. Lysosomal storage disorders.

UNIT III: Cell Cycle, Apoptosis, and Cancer Biology: (06 Lectures)

1. Detailed cell cycle regulation: CDKs, cyclins, checkpoints,
2. Molecular basis of apoptosis and necroptosis, Caspase cascade, Bcl-2 family, apoptosome,
3. Cancer as a cell cycle disease: oncogenes, tumor suppressors (p53, Rb) genes.

UNIT IV: Signal Transduction Pathways: (09 Lectures)

1. MAPK/ERK, JAK/STAT, PI3K-Akt pathways,
2. Wnt, Hedgehog, TGF-beta families signal transduction pathways
3. Crosstalk between signaling pathways,
4. Cell adhesion molecules and extracellular matrix

GROUP-B: MOLECULAR GENETICS

UNIT I: Genome Organization and Epigenetics: (05 Lectures)

1. Chromatin structure and remodelling, Histone code and post-translational modifications,
2. DNA methylation, imprinting, X-inactivation,
3. Non-coding RNAs in epigenetic regulation,
4. Epigenetic inheritance and diseases.

UNIT II: DNA Replication, Repair, and Recombination: (08 Lectures)

1. Prokaryotic vs. eukaryotic replication, DNA polymerases, and replication complexes,
2. DNA damage and repair methods.
3. Homologous and site-specific recombination, Transposons.

UNIT III: Gene Expression and Regulation: (08 Lectures)

1. Transcription regulation in prokaryotes and eukaryotes: Enhancers, silencers, promoters, transcription factors, RNA polymerases, and transcription initiation,
2. Post-transcriptional regulation,
3. RNA interference (RNAi), miRNA, siRNA, RNA transport, and mRNA stability.

UNIT IV: Translation and post-translational modifications (PTMs) **(04 Lectures)**

1. Chaperones, ubiquitin-proteasome system

UNIT V: Gene Regulations: **(04 Lectures)**

1. Lac operon regulations- inducible, non-inducible, and constitutive expressions of lactose, allolactose, glucose, cAMP, and artificial inducers.
2. Trp operon regulations – attenuation-based control of the operon.

UNIT VI: Molecular Techniques and Applications: **(06 Lectures)**

1. PCR, RT-PCR, qPCR
2. Blotting techniques
3. CRISPR-Cas9 and gene editing,
4. Single-cell and spatial transcriptomic

Suggested Readings

Text Books:

1. Molecular Biology of the Cell – Alberts et al. (Garland Science)
2. Lehninger Principles of Biochemistry, David L. Nelson and Michael M. Cox, 8th Edition (latest as of 2024), W. H. Freeman and Company (an imprint of Macmillan Learning), ISBN: 9781319381493, New York, USA

Reference Books:

1. Molecular Cell Biology – Lodish et al. (W.H. Freeman)
2. Lewin's Genes XII – Krebs, Goldstein & Kilpatrick (Jones and Bartlett)
3. Cell and Molecular Biology: Concepts and Experiments – Gerald Karp (Wiley)
4. Principles of Gene Manipulation and Genomics – Primrose & Twyman (Wiley-Blackwell)
5. Introduction to Genetic Analysis – Griffiths et al. (W.H. Freeman)
6. Molecular Biology of the Gene (Watson), James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick, 7th Edition, Pearson Education, ISBN: 9780321762436, San Francisco, USA

III. CORE COURSE [CCZOO223]
NEURO-ENDOCRINOLOGY & BASIC BIOINFORMATICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Learning Objective:

1. To understand the integration of the nervous and endocrine systems – Explain how the brain and endocrine glands communicate to regulate physiological processes like growth, metabolism, reproduction, and stress.
2. To describe neuroendocrine structures and pathways – Identify key neuroendocrine organs (e.g., hypothalamus, pituitary, pineal gland) and understand their roles in hormone synthesis and secretion.
3. To explain hormone-receptor interactions – Understand the molecular mechanisms by which hormones act on target tissues through specific receptors and signal transduction pathways.
4. To analyze feedback loops – Interpret positive and negative feedback mechanisms in neuroendocrine regulation, such as the hypothalamic-pituitary-adrenal (HPA) axis.
5. To apply knowledge to experimental design – Design and analyze basic experiments to study hormone levels, receptor activity, or neuroendocrine interactions using laboratory or model system approaches.

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Understand the integration of nervous and endocrine systems-Explain how the nervous system and endocrine system coordinate to regulate physiological processes such as stress, reproduction, and metabolism.
2. Identify neuroendocrine organs and pathways- Describe the structure and function of key neuroendocrine organs such as the hypothalamus, pituitary gland, and pineal gland.
3. Analyze hormone synthesis and release mechanisms- Understand the synthesis, secretion, and feedback regulation of neurohormones like oxytocin, vasopressin, and releasing hormones.
4. Interpret neuroendocrine dysfunctions- Identify and discuss diseases and disorders related to neuroendocrine malfunction, such as diabetes insipidus, hypothyroidism, or Cushing's syndrome.

Course Content:

PART-A: NEURO-ENDOCRINOLOGY

UNIT I: Nervous system: **(7 Lectures)**

1. Neurons, action potential, gross neuroanatomy of the brain and spinal cord,
2. Central and peripheral nervous system,
3. Neural control of muscle tone and posture.

UNIT II: Sense organs: **(9 Lectures)**

1. Vision – Anatomy and physiology
2. Hearing – Anatomy and physiology
3. Tactile response – Anatomy and physiology

UNIT III: Endocrinology: **(10 Lectures)**

1. Endocrine glands, basic mechanism of hormone action, hormones and diseases,
2. Neuroendocrine regulation.
3. Endocrine as chemical messengers, hormones, and mechanisms of their action.
4. Cellular Receptor types of hormones and their structure, second messenger system, cytosolic receptors, and their action via gene expression.

UNIT IV: Physiological Endocrinology: **(4 Lectures)**

1. Endocrinology of calcium regulation
2. Endocrinology of osmoregulation

PART-B: BASIC BIOINFORMATICS

UNIT I: Introduction to Bioinformatics: **(4 Lectures)**

1. Definition, scope, and history of bioinformatics
2. Applications in zoology, medicine, and evolutionary biology

UNIT II: Biological Databases and Data Retrieval: **(6 Lectures)**

1. Biological databases: primary, secondary, and specialized databases. (GenBank, EMBL, DDBJ, Swiss-Prot, PDB)
2. NCBI tools (PubMed, Gene, BLAST)
3. Data formats: FASTA
4. Database searching: Entrez system, sequence submission

UNIT III: Sequence Alignment and Phylogenetics: **(8 Lectures)**

1. Pairwise sequence alignment: global vs local
2. Multiple sequence alignment: Clustal Omega, MUSCLE
3. Phylogenetic tree construction: UPGMA, Neighbor-Joining

UNIT IV: Gene and Protein Analysis: **(5 Lectures)**

1. Basic ideas of Gene prediction tools: ORF Finder, GenScan
2. Protein structure databases: PDB, InterPro
3. Functional annotation tools: Pfam, Prosite

UNIT V: Genomics and Proteomics: **(4 Lectures)**

1. Introduction to genome annotation and mapping
2. Basics of transcriptomics and microarray data
3. Proteomics: protein identification and expression analysis

UNIT VI: Applications in Zoology and Biodiversity: **(3 Lectures)**

1. Comparative genomics in vertebrates and invertebrates
2. DNA barcoding and molecular taxonomy
3. Evolutionary bioinformatics and conservation genetics

Suggested Readings:

Text Book:

1. Introduction to Bioinformatics" – Arthur Lesk, Oxford University Press
2. Neuroendocrinology: An Integrated Approach, Author: David A. Lovejoy & Antony W. Norman, Publisher: Wiley-Blackwell
3. Textbook of Endocrinology, Hadley, Mac E. & Jon E. Levine, Publisher: Pearson Education

Reference Books:

1. Principles of Neural Science. Eric R. Kandel, James H. Schwartz, Thomas M. Jessell, Publisher: McGraw-Hill Education
2. Fundamentals of Neurobiology, Duane E. Haines, Publisher: Lippincott Williams & Wilkins,
3. General and Comparative Endocrinology, Author: E. N. Hadley (Mac E. Hadley), Publisher: Pearson
4. Endocrinology, Author: William H. Freeman and Anthony W. Norman, Publisher: Oxford University Press
5. Bioinformatics: Principles and Applications" – D. D. Rawat, CBS Publishers
6. "Fundamentals of Bioinformatics" – Krane & Raymer, Pearson Education
7. "Bioinformatics: Sequence and Genome Analysis" – David W. Mount, Cold Spring Harbour Laboratory Press
8. NCBI Tutorials & Open Access Bioinformatics Tools Documentation (Online)

IV. CORE COURSE [CCZOO224]
BIOSTATISTICS & BIOPHYSICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Learning Objectives

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

1. Understand the scope and role of biostatistics in zoological research, including its applications in biodiversity, ecology, and genetics.
2. Differentiate between various data types, measurement scales, and appropriate data summarization techniques using manual and software-based tools.
3. Apply statistical methods—including descriptive, inferential, and multivariate techniques—to biological datasets for meaningful interpretation and hypothesis testing.

Learning Outcomes

After successful completion of this unit, students will be able to:

1. Organize and summarize biological data using frequency tables, charts, and graphical tools in Excel, R, and SPSS.
2. Select and apply suitable statistical tests (e.g., t-test, ANOVA, χ^2, correlation, regression) to analyze ecological and zoological data, interpreting the biological significance of results.
3. Perform multivariate analyses such as PCA, cluster analysis, and biodiversity indices to classify, compare, and interpret patterns in morphometric, genetic, and ecological datasets.

Course Content:

PART-A: BIOSTATISTICS

UNIT I: Basics of Biostatistics: (7 Lectures)

1. Scope and importance of biostatistics in zoological research.
2. Types of data: qualitative, quantitative, discrete, and continuous.
3. Scales of measurement: nominal, ordinal, interval, ratio.
4. Data summarization: tabulation, frequency distribution, bar chart, histogram, box plot.
5. Use of software tools (Excel, R, SPSS)

UNIT II: Statistical Methods: (15 Lectures)

1. Measures of central tendency and dispersal; probability distributions (Binomial, Poisson and normal)
2. Sampling distribution
3. The difference between parametric and non-parametric statistics, confidence interval, and errors
4. Levels of significance
5. Pearson's and Spearman's correlation; biological significance.
6. Linear regression and prediction models.
7. Multiple regression in ecological datasets.
8. Basics of experimental design: CRD, RBD, factorial designs.
9. T-test, F-test, analysis of variance; χ^2 test, ANOVA

UNIT III: Multivariate & Advanced Analysis (10 Lectures)

1. Basic introduction to Multivariate statistics
2. Principal Component Analysis (PCA) for morphometric data.
3. Cluster analysis in taxonomic classification.
4. Introduction to logistic regression for binary biological outcomes.

PART-B: BIOPHYSICS

UNIT I: Introduction to Biophysics (05 Lectures)

1. Scope and importance of Biophysics in Zoology
2. Forces stabilizing biological macromolecules (hydrogen bonding, hydrophobic interactions, van der Waals forces, ionic bonds)
3. Concept of energy in biological systems – free energy, entropy, and enthalpy

UNIT II: Techniques in Biophysics (15 Lectures)

1. Spectroscopy: Principles and applications (UV, visible, fluorescence)
2. Centrifugation – principle and biological applications
3. Electrophoresis – principle and types
4. Chromatography – basic concepts and biological use

UNIT III: Radiation and Biophysical Effects: **(08 Lectures)**

1. Types of radiations and their biological effects
2. Radiation dosimetry and safety
3. Isotopes in biology – tracer techniques
4. Applications of radiation in medicine and research
5. Nanobiophysics and its applications in biology

Suggested Readings:

Text Books:

1. Fundamentals of Biostatistics by Khan and Khanam, Ukaaz Publication, Hyderabad, India
2. Narayanan, P. (2000). Essentials of Biophysics. New Age International Publishers.

Reference Books:

1. Biostatistics: A Foundation for Analysis in the Health Sciences, Wayne W. Daniel, Chad L. Cross, Wiley, 11th Edition (Latest), ISBN: 9781119496571
2. Fundamentals of Biostatistics, Bernard Rosner, Cengage Learning, 8th Edition, ISBN: 9781305268920
3. Principles of Biostatistics, Marcello Pagano, Kimberlee Gauvreau, CRC Press (Taylor & Francis), 2nd Edition, ISBN: 9780534229023
4. Introductory Biostatistics, Chap T. Le. Wiley-Interscience, 2nd Edition, ISBN: 9780470112290
5. Methods in Biostatistics for Medical Students and Research Workers, B. K. Mahajan, Jaypee Brothers Medical Publishers, New Delhi, India, 9th Edition, ISBN: 9789354655311
6. Elements of Biostatistics by Sataguru Prasad, Rastogi Publicaiton, India
7. Pattabhi, V., & Gautham, N. (2017). Biophysics. Springer.
8. Glaser, R. (2012). Biophysics: An Introduction. Springer.
9. Van Holde, K. E., Johnson, W. C., & Ho, P. S. (2006). Principles of Physical Biochemistry (2nd ed.). Pearson Education.

VI. CORE COURSE PRACTICAL [CPZOO225]

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instructions to Question Setter for
Scheme of Examination **Time: 6 Hrs.**

End Semester Examination (ESE):

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

a. *Experiments from Unit I/II* = *20 marks*
b. *Experiment from Unit IV* = *20 marks*
c. *Experiments from Unit III/V* = *20 marks*
d. *Practical Records* = *20 marks*
e. *Viva-voce* = *20 marks*

List of Practical:

UNIT I. Toxicology, Histology & Histochemistry:

1. Determination of LC_{50} or EC_{50} of a toxicant on an aquatic model (e.g., *Daphnia*, fish larvae) – demonstration/experiment.
2. Effect of Heavy Metals or Pesticides on enzyme activity (e.g., catalase or cholinesterase assay).
3. Preparation of Permanent Slides from animal tissues – paraffin embedding, sectioning, and H&E staining.
4. Localization of Enzymes or Macromolecules – e.g., detection of glycogen using PAS reaction

UNIT II. Neuro-Endocrinology:

Effect of Hormones on Physiological Parameters – demonstration (e.g., thyroxine effect on amphibian metamorphosis or hormone assay via ELISA).

UNIT III. Biostatistics & Biophysics:

1. Descriptive Statistics – calculation of mean, standard deviation, correlation, regression and coefficient of variation from biological datasets.
2. Hypothesis Testing – chi-square test or t-test applied to real zoological data.
3. Spectrophotometric Analysis

UNIT IV. Cell Biology & Molecular Genetics:

1. Study of Mitosis & Meiosis using onion root tip and grasshopper testis squash preparations.
2. Agarose Gel Electrophoresis of DNA – separation and visualization.
3. PCR Amplification.

UNIT V. Classical Genetics:

1. Mendelian Ratio Analysis – using simulated genetic cross data and chi-square testing.
2. Linkage Mapping using *Drosophila* mutant data – calculation of map units.
3. Karyotyping from Human Chromosome Slides – identification of normal and abnormal karyotypes.

Suggested Readings:

Text Books:

1. Gupta, R. C. (2014). *Veterinary Toxicology: Basic and Clinical Principles* (2nd ed.). Academic Press.
2. Zar, J. H. (2010). *Biostatistical Analysis* (5th ed.). Pearson Education.
3. Rastogi, S. C. (2018). *Endocrinology: Essentials and Fundamentals*. New Age International.
4. Pandey, K., & Shukla, J. P. (2015). *Environmental and Toxicological Zoology*. APH Publishing.
5. Klaassen, C. D. (2019). *Casarett and Doull's Toxicology: The Basic Science of Poisons* (9th ed.). McGraw-Hill.
6. Junqueira, L. C., & Carneiro, J. (2013). *Basic Histology: Text and Atlas* (13th ed.). McGraw-Hill.
7. Verma, P. S., & Sarabhai, V. (2018). *A Textbook of Histology*. S. Chand Publishing.
8. Pearse, A. G. E. (1985). *Histochemistry: Theoretical and Applied* (Vols. 1–2). Churchill Livingstone.
9. Bancroft, J. D., & Gamble, M. (2019). *Theory and Practice of Histological Techniques* (8th ed.). Elsevier.
10. Khan, I. A., & Khanum, A. (2012). *Fundamentals of Biostatistics*. Ukaaz Publications.
11. Narayanan, P. (2000). *Essentials of Biophysics*. New Age International.
12. Pattabhi, V., & Gautham, N. (2017). *Biophysics*. Springer.
13. Lodish, H., Berk, A., Kaiser, C., et al. (2021). *Molecular Cell Biology* (9th ed.). W. H. Freeman.
14. De Robertis, E. D. P., & De Robertis, E. M. F. (2006). *Cell and Molecular Biology*. Wolters Kluwer.
15. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (2011). *Principles of Genetics* (8th ed.). Wiley.
16. Verma, P. S., & Agarwal, V. K. (2017). *Genetics*. S. Chand Publishing.
17. Thompson, M. W., Thompson, J. S., & Thompson, M. W. (2015). *Genetics in Medicine* (8th ed.). Elsevier.
18. Turnpenny, P. D., & Ellard, S. (2017). *Emery's Elements of Medical Genetics* (15th ed.). Elsevier.
19. Guyton, A. C., & Hall, J. E. (2021). Textbook of Medical Physiology (14th ed.). Elsevier.
20. Rastogi, S. C. (2018). Endocrinology: Essentials and Fundamentals. New Age International.

SEMESTER III

I. CORE COURSE [CCZOO321]
IKS & HUMAN PHYSIOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective:

1. To explore classical and indigenous knowledge of plants in Indian traditions.
2. To apply IKS concepts in agriculture, herbal medicine, environmental conservation, and sustainable living.
3. To understand the structure and function of the human body systems at molecular, cellular, tissue, organ, and systemic levels, and to explain how these systems interact to maintain homeostasis under normal and altered physiological conditions.
4. To develop the ability to analyze physiological data, interpret experimental results, and apply core physiological principles to assess the effects of disease, exercise, and environmental changes on human body function.

Course Learning Outcomes:

After completing this course, students will be able to:

1. Identify and interpret key IKS-based Zoological knowledge. Translate IKS concepts into real-world solutions in agriculture, health, and conservation. Students will be able to describe and explain the physiological functions of major human organ systems (e.g., nervous, circulatory, respiratory, digestive) and their roles in maintaining homeostasis.
2. Students will be able to analyze and interpret physiological data, demonstrating the ability to connect theoretical knowledge with experimental observations in laboratory or clinical settings.

Course Content:

PART-A: IKS

UNIT I: Introduction to Indian Knowledge Systems (5 Lectures)

1. Concept, definition, and scope of IKS; importance in the global context
2. Overview of IKS related to natural sciences (botany, zoology, ecology)
3. Historical sources of zoological knowledge: oral traditions, manuscripts, inscriptions
4. Role of local knowledge holders (tribal elders, farmers, traditional healers)

UNIT II: Zoological Knowledge in Ancient Indian Texts (5 Lectures)

1. Animal references in the Vedas and Upanishads (symbolism, rituals, ecological insights)
2. Arthashastra's contributions: wildlife management, elephant capture, fisheries, animal laws
3. Ayurvedic texts: animal products in medicine, animal physiology, understanding
4. Zoological themes in Jataka tales, Panchatantra, and Puranic stories (behavioral insights)
5. Case study: Nāgashastra (serpent knowledge) in Indian tradition
6. Debate: separating myth from ethnozoological facts

UNIT III: Indigenous Taxonomy and Ethnozoology (5 Lectures)

1. How indigenous communities classify animals: folk taxonomy vs. Linnaean system
2. Ethnozoological practices: knowledge of local fauna by tribes and rural people
3. Fish classification and folk knowledge in coastal and inland fishing communities
4. Indigenous insect knowledge: bees, silkworms, lac insects

UNIT IV: Traditional Practices and Animal Use (5 Lectures)

1. Traditional animal husbandry and breeding practices (cattle, buffalo, goats, poultry)
2. Ethno-veterinary medicine: herbal treatments, disease management
3. Traditional pest control, use of natural enemies, biocontrol methods
4. Pedigree analysis of the marriage system in Mithila (Sourasthra Sabha)

UNIT V: Conservation, Ethics, and Integration with Modern Zoology (5 Lectures)

1. Sacred groves, totem animals, and conservation ethics in traditional societies
2. Cultural taboos and their role in species protection. Sacred water bodies and aquatic biodiversity conservation
3. Integrating IKS with modern wildlife management and policy
4. Challenges: documentation, intellectual property rights, biopiracy, ethical concerns
5. Case study: Involving local communities in conservation projects (successes and failures)
6. Course review, student presentations, open discussion

PART-B: HUMAN PHYSIOLOGY

UNIT I: Digestive system: (8 Lectures)

1. Digestion, absorption, and assimilation of digested food.
2. Energy balance, BMR.
3. Diseases- Gastritis, Irritable Bowel Syndrome (IBS)

UNIT II: Respiratory system: (8 Lectures)

1. Transport of respiratory gases,
2. Chemical regulation of respiration
3. Disease – Asthma, Chronic Obstructive Pulmonary Disease, COVID-19

UNIT III: Cardiovascular System: (8 Lectures)

1. Comparative anatomy of heart structure, myogenic heart, specialized tissue,
2. ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above
3. Diseases – Hypertension, Myocardial Infarction

UNIT IV: Excretory system: (7 Lectures)

1. Structure and function of kidney
2. Physiology of excretion
3. Diseases – Kidney Stones (Renal Calculi), Chronic Kidney Disease (CKD)

UNIT V: Thermoregulation: (4 Lecture)

Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.

Suggested Readings:

Text Books:

1. Guyton, A. C., & Hall, J. E. (2021). *Guyton and Hall Textbook of Medical Physiology* (14th ed.). Elsevier.
2. Ganong, W. F., Barrett, K. E., Barman, S. M., Brooks, H. L., & Yuan, J. X.-J. (2020). *Ganong's Review of Medical Physiology* (26th ed.). McGraw Hill Education.

Reference Books:

1. Gadgil, Ramakrishnan, Jain, and Saini focus on India's indigenous environmental and zoological knowledge.
2. Singh, R. H. (2007). *Ayurveda: The Science of Life*. Chaukhambha Surbharati Prakashan.
3. Vrikshayurveda by Surapala – Translated by Nalini Sadhale (Agri-History Foundation)
4. Dravyaguna Vigyana – P.V. Sharma (Vol. 1 & 2)
5. EthnoZoology: Principles and Applications – C.M. Cotton
6. Posey, D. A. (1999). *Cultural and Spiritual Values of Biodiversity*. United Nations Environment Programme & Intermediate Technology Publications.
7. Saini, D. C. (2020). *Ethnozoology of India: An Annotated Bibliography*. Indian National Science Academy (INSA).
8. The Sacred Groves of India – M.D. Subash Chandran
9. Biology in the Vedas – B.G. Matapurkar
10. Vedic Zoology – N. Sivarajan
11. Textbook of Pharmacognosy – Trease & Evans
12. Sherwood, L. (2015). *Human Physiology: From Cells to Systems* (9th ed.). Cengage Learning.
13. Tortora, G. J., & Derrickson, B. (2017). *Principles of Anatomy and Physiology* (15th ed.). Wiley.
14. Chatterjee, C. C. (2018). *Human Physiology: Volume 1 & 2* (13th ed.). CBS Publishers & Distributors Pvt. Ltd.
15. Sembulingam, K., & Sembulingam, P. (2019). *Essentials of Medical Physiology* (8th ed.). Jaypee Brothers Medical Publishers.
16. Vander, A. J., Sherman, J. H., & Luciano, D. S. (2014). *Human Physiology: The Mechanisms of Body Function* (13th ed.). McGraw Hill Education.
17. Bijlani, R. L. (2004). *Understanding Medical Physiology* (3rd ed.). Jaypee Brothers Medical Publishers.

II. SKILL ENHANCEMENT COURSE - A [ECZOO322A]
FISHERIES

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives

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

1. Understand the taxonomy, biology, and physiological adaptations of inland and marine fin fishes with emphasis on economically important species.
2. Gain practical insights into aquaculture systems, fishery resources, fish health management, and processing technology.
3. Develop research aptitude through exposure to modern applications such as transgenic fish production, model fish systems, and ornamental fish culture.

Course Outcomes

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

1. Identify and classify major taxa of freshwater and marine fin fishes of India up to the order level, recognizing key morphological features.
2. Describe the structure and function of major organ systems, physiological processes (including osmoregulation, respiration, and sensory mechanisms), and adaptations to diverse aquatic habitats.
3. Diagnose common fish diseases, suggest preventive and curative measures, and implement scientific fish health management practices.
4. Compare and evaluate various aquaculture systems (pond, pen, cage, biofloc, RAS) and apply principles to design sustainable fish culture operations.
5. Demonstrate understanding of fish preservation, processing, and by-product utilization, as well as research applications like transgenic fish and zebrafish models.

Course Contents:

FISHERIES

UNIT I: Taxonomy of Fin Fish (08 Lectures)

1. Major taxa of inland and Marine fishes up to order.
2. Commercially important freshwater and marine fishes of India. Morphological characteristics.

UNIT II: Biology of Fin Fish (10 Lectures)

1. A brief idea of the Circulatory, Respiratory, Nervous, Urinogenital system, Endocrine system, Skeletal system and sensory system of fin fishes.

UNIT III: Physiology of Fin Fish (10 Lectures)

2. Effects of environmental factors on the physiology of Fin fish.
3. Study of Osmoregulation, excretion and stress related changes, bioluminescence, electric organs
4. ARO (accessory respiratory organs)
5. Lateral line organ system

UNIT IV: Fish pathology and Health management (04 Lectures)

1. A brief idea of Fish parasites, diseases, and their treatment

UNIT V: Fish and Adaptation (04 Lectures)

1. Hill stream fishes
2. Cold-water fisheries of India. Fishing crafts and gears.

UNIT VI: Marine fishery (04 Lectures)

1. Marine fishery resources in India, Estuarine fishes.

UNIT VII: Aquaculture (10 Lectures)

1. Principles of Aquaculture: Definition and scope
2. Systems of Aquaculture – Pond culture, Pen culture, Cage culture, Biofloc culture, RAS
3. Extensive and intensive fish culture
4. Monoculture, Polyculture, Composite and integrated culture system, fish culture system of India.

UNIT VIII: Fish technology and research (10 Lectures)

1. Preservation and processing of harvested fish, fishery by-products, transgenic fish, and Zebra fish as a model of research. Introductory Ornamental fish culture and aquarium maintenance.

Suggested Readings:

1. The Laboratory Fish (A Hand book of Experimental Animals) : Gary Ostrander
2. Fish feeding Experiments: T. Lovell
3. Laboratory Fish in Biomedical Research – Springer. Link
4. Laboratory Zebra Fish: Claudia Harper.
5. Eco-immunotoxic studies on a fish during Experimental plumbism (Pb) clarias batrachus: Dr. P.C. Rout
6. Fish of U.P. and Bihar: C.B.L. Srivastav
7. An Introduction to the Study of Fishes – Albert C.L.G. Gunther, Discovery Publishing House, New Delhi – 110 002
8. Q Bone and R Moore, Biology of Fishes, Talyor and Francis Group, CRC Press, U.K.
9. D.H. Evans and J.D. Claiborne, The Physiology of Fishes, Taylor and Francis Group, CRC Press, UK von der Emde, R.J. Mogdans and B.G. Kapoor. The Senses of Fish: Adaptations for the Reception of Natural Stimuli, Springer, Netherlands
10. C.B.L. Srivastava, Fish Biology, Narendra Publishing House
11. J.R. Norman, A history of Fishes, Hill and Wang Publishers
12. S.S. Khanna and H.R. Singh, A text book of Fish Biology and Fisheries, Narendra Publishing House
13. Modern Ichthyology, S.M. Shafi, Inter India Publications
14. Feeding and Digestive Functions of Fishes, J.E.P. Cyrino, D.P. Bureau, B.G. Kapoor, CRC Press, Taylor & Francis Group, Boca Raton, London, New York

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OR SKILL ENHANCEMENT COURSE - B [ECZOO322B]

SERICULTURE

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives

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

1. Understand the historical background, biology, and diversity of silkworms with emphasis on their economic and cultural significance.
2. Acquire knowledge of silkworm rearing technology, pest and disease management, and mulberry cultivation for quality silk production.
3. Develop entrepreneurial insights into sericulture as a sustainable livelihood and commercial enterprise in India.

Course Outcomes

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

1. Identify exotic and indigenous silkworm races, describe their life cycle, silk gland structure, and chemistry of silk.
2. Apply scientific methods in mulberry cultivation, silkworm rearing, cocoon harvesting, and pest/disease control to maximize yield and quality.
3. Evaluate the economic potential of sericulture, design small-scale sericulture projects, and explore entrepreneurial opportunities in mulberry and non-mulberry silk production.

Course Content:

SERICULTURE

UNIT I: Introduction **(6 Lectures)**

1. Sericulture: Definition, history and present status; Silk route.
2. Types of silk worms
3. Distribution and Races- exotic and indigenous races.
4. Mulberry and non-mulberry Sericulture.

UNIT II: Biology of Silkworm **(12 Lectures)**

1. Life cycle of *Bombyx mori* and *Antheraea mylitta*
2. Structure of the silk gland and the secretion of silk
3. Chemistry of silk

UNIT III: Rearing of Silkworm **(26 Lectures)**

1. Selection of mulberry variety and establishment of mulberry garden
2. Rearing house and rearing appliances
3. Disinfectants: Formalin, bleaching powder, RKO
4. Silk worm rearing technology: Early age and Late age rearing
5. Types of Spinning, harvesting, and storage of cocoons mountages

UNIT IV: Pests and Diseases **(10 Lectures)**

1. Pests of silk worm: Uzifly, dermestid beetles, and vertebrates.
2. Pathogenesis of silk worm diseases: Protozoan, viral, fungal, and bacterial control and prevention of pests and diseases

UNIT V: Entrepreneurship in Sericulture **(6 Lectures)**

Prospectus of Sericulture in India: Sericulture industry in different states, employment, potential in mulberry and non-mulberry sericulture.

Suggested Readings:

1. A Textbook of Sericulture, Hemraj, Vinesh Publication, India
2. Handbook of Practical Sericulture: S.R. Ullaland M.N. Narasimhanna CSB, Bangalore
3. Appropriate Sericultural Techniques; Ed. M.S. Jolly, Director, CSR & TI, Mysore.
4. Handbook of Silkworm Rearing: Agriculture and Technical Manual-1, Fuzi Pub.Co. Ltd., Tokyo, Japan 1972.
5. Manual of Silkworm Egg Production; M.N. Narasimhanna, CSB, Bangalore 1988.
6. Silkworm Rearing; Wupang —Chunand Chen Da-Chung, Pub. By FAO, Rome 1988.
7. A Guide for Bivoltine Sericulture; K. Sengupta, Director, CSR & TI, Mysore 1989.
8. Improved Method of Rearing Young age silkworm; S. Krishnaswamy, reprinted CSB, Bangalore, 1986

III. CORE COURSE [CCZOO323]
REPRODUCTIVE PHYSIOLOGY AND DEVELOPMENTAL BIOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objective

1. To understand the structure, function, and hormonal regulation of the reproductive system, including gametogenesis, fertilization, pregnancy, and reproductive technologies in humans and animals.
2. To study the molecular and cellular mechanisms of embryonic development, from fertilization to organogenesis, using model organisms and focusing on gene regulation, differentiation, and developmental disorders.

Course Learning Outcomes

1. To describe the structure and functions of the male and female reproductive systems.
2. Explain the hormonal regulation of reproductive cycles and reproductive events.
3. Illustrate the processes of gametogenesis, fertilization, implantation, and parturition. Analyze the physiological basis of pregnancy, lactation, and menopause. Interpret causes of infertility and evaluate assisted reproductive technologies (ART).

Course Content:

PART-A: REPRODUCTIVE PHYSIOLOGY

UNIT I: Anatomy and Histology of Reproductive Organs: (08 Lectures)

Overview of reproduction: sexual vs. asexual, Male reproductive system

Female reproductive system

Histology of gonads and accessory reproductive organs

UNIT II: Reproductive Cycles and Hormonal Regulation: (10 Lectures)

Estrous and menstrual cycles: phases, hormonal control, physiological changes, Puberty and menopause

Placenta: structure, types, function, hormone secretion, Physiological changes in the maternal body during pregnancy, Mechanism of labour and parturition, Role of oxytocin and prostaglandins

UNIT III: Reproductive Health and Disorders: (06 Lectures)

Infertility: causes (male and female), diagnosis, treatment. Polycystic ovarian syndrome (PCOS), endometriosis, azoospermia, oligospermia. Sexually transmitted diseases (STDs). Hormonal contraceptives and family planning methods

UNIT IV: Assisted Reproductive Technologies (ART): (06 Lectures)

In vitro fertilization (IVF), ICSI, GIFT, ZIFT. Embryo transfer and cryopreservation. Preimplantation genetic diagnosis (PGD), Ethical issues and regulations in ART

PART-B: DEVELOPMENTAL BIOLOGY

UNIT I: Gametogenesis, fertilization, and early development: (12 Lectures)

Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development.

Zygote formation, cleavage, blastula formation, gastrulation and formation of germ layers in animals; embryogenesis.

UNIT II: Embryonic Induction: (09 Lectures)

Potency, commitment, specification, induction (Eye lens induction), competence, determination and differentiation. Fate maps and cell lineages

UNIT III: Morphogenesis and organogenesis in animals: (09 Lectures)

Regeneration: Morphallaxis, regeneration in vertebrates.

Differentiation of neurons, muscle, post-embryonic development, larval formation and metamorphosis.

Environmental regulation of normal development.

Sex determination.

Suggested Readings:

Text Books:

1. Reproductive Physiology by H. H. Cole, H. H. Cole, Academic Press (Elsevier), London / New York (commonly Academic Press imprint)
2. Developmental Biology by Scott F. Gilbert (and Barresi in recent editions), Scott F. Gilbert (co-author Michael J.F. Barresi in later editions), Sinauer Associates (an imprint of Oxford University Press), Oxford / Sunderland, MA, USA

Reference Books:

1. Knobil & Neill's Physiology of Reproduction, Ernst Knobil & Jimmy D. Neill (plus numerous contributors; e.g. Tony M. Plant & Anthony J. Zeleznik in later editions), Academic Press (Elsevier Science & Technology Books), based in San Diego / Amsterdam / Boston
2. Human Reproductive Biology by Richard E. Jones & Kristin H. Lopez, Elsevier Academic Press, Amsterdam / Boston (hardcover ed. c. 2006; later editions through Academic Press / Elsevier)
3. Guyton & Hall's Textbook of Medical Physiology, John E. Hall (following Arthur C. Guyton's original editions), and Michael E. Hall in recent editions, Elsevier (Saunders / Elsevier Health Sciences), based in Philadelphia / St. Louis / United States
4. Ganong's Review of Medical Physiology, William F. Ganong, Kim E. Barrett, Susan M. Barman, Heddwen L. Brooks, Jason X.-J. Yuan (latest editions: 26th, 27th), McGraw-Hill Education (Medical), New York, USA

IV. CORE COURSE [CCZOO324]
NON-CHORDATES AND PARASITOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Learning Objective:

1. To understand functional anatomy and physiological processes of non-chordates.
2. To understand the phylogeny of non-chordates.

Course Learning Outcomes:

On successful completion of this course, the student will:

1. Be able to understand functional anatomy and physiological processes of non-chordates.
2. Be able to learn the concept of non-chordate phylogeny.

Course Content :

GROUP A: NON-CHORDATE

UNIT I: Locomotion **(07 Lectures)**

Locomotion in protozoa
Hydrostatic movement in coelenterata
Water Vascular System in *Asterias*

UNIT II: Nutrition **(07 Lectures)**

Nutrition in protozoa
Feeding pattern and digestion in *Palaemon* and *Pila*

UNIT III: Respiration **(06 Lectures)**

Organs of respiration
Respiratory mechanism in *Periplaneta* and *Pila*

UNIT IV: Excretion **(06 Lectures)**

Organs of excretion
Excretion and osmoregulation in Protozoa
Mechanism of excretion in *Palaemon*

UNIT V: Larval forms **(04 Lectures)**

Larval forms in Helminths, Crustacea and Echinodermata

GROUP B: PARASITOLOGY **(30 Lectures)**

1. Types of parasites and parasitism
2. Host–parasite interaction and adaptation
3. Morphology, life cycle, pathogenicity, prophylaxis of *Plasmodium*, *Entamoeba, Fasciola, Wuchereria*
4. Parasitic Zoonoses: Introduction, nature and epidemiology of zoonotic

Suggested Readings:

Test Books:

1. Invertebrates by Richard C. Brusca, Wendy Moore, Stephen M. Shuster.
2. Textbook of Zoology: Invertebrates Vol I 7/e by Haswell.

Reference Books:

1. Protozoa to Echinodermata, Ashok Verma, Publisher- Narosa Publishing House.
2. Invertebrate Zoology, E. L Jordan and P. S. Verma, Publisher: S. Chand and Company Ltd.
3. Invertebrate Zoology, 3rd edition, Paul A. Meglitsch and Fredrick R. Schram, Publisher – Oxford University Press.
4. Introduction to General Zoology Vol. I & II, Korak Kanti Chaki, Gautam Kundu and Supriti Sarkar, New Central Book Agency (P) Ltd.
5. Medical Zoology and Prasitology, Singh S., Keshari S. & Abhishek K. S., Jharkhand Jharokha, India
6. Modern Text Book of Zoology: Invertebrates. R. L. Kotpal.
7. Invertebrate Zoology: A Functional Evolutionary Approach, Authors: Richard Fox, Robert D. Barnes, Edward E. Ruppert.
8. An Introduction to Mollusca by G. S. Sandhu and Harshvardhan Bhaskar, Campus Book International.
9. An Introduction to Echinodermata by G. S. Sandhu and Harshvardhan Bhaskar, Campus Book International.
10. Invertebrate Zoology by P. S. Dhami and J. K. Dhami.

VII. CORE COURSE PRACTICAL [CPZOO325]

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instructions to Question Setter for
Scheme of Examination **Time: 6 Hrs**

End Semester Examination (ESE):
There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

a. *Experiments from Unit I/II* = *20 marks*
b. *Experiment from Unit IV* = *20 marks*
c. *Spotting Unit I/II* = *20 marks*
d. *Practical Records (include IKS)* = *20 marks*
e. *Viva-voce* = *20 marks*

List of Practicals:

UNIT I: Non-Chordates and Parasitology:

1. Digestive system of *Palaemon* and *Pila*
2. Permanent slides: Larval form of Helminths, Crustacea and Echinodermata.
3. Museum Specimen: *Pheretima, Nereis*, *Hirudo*, *Arenicola, Sacculina*, *Palaemon, Balanus, Chiton, Pila, Unio, Sepia*, *Asterias*
4. Study of Non-chordate Taxonomy & Morphometrics
5. Microanatomy and Histology of Invertebrates

UNIT II: Reproductive Physiology & Developmental Biology:

1. Permanent Slides: Different stages of development in Frog and Chick
2. Histological slides of testis and ovary
3. Sperm Motility, Sperm Count
4. Study of Vaginal Smear in rats by temporary mounting
5. Gonad Histology & Gametogenesis Study
6. Experimental Embryology

UNIT III: Indian Knowledge System (IKS) & Human Physiology:

1. Ethnozoological Survey & Documentation
   a. Field-based collection of indigenous knowledge related to animal use in medicine, agriculture, and ecosystem management.
2. Physiological Experiments
   a. Blood pressure measurement, reflex studies, and interpretation.
   b. Impact of yoga/pranayama on physiological parameters (experimental design).

UNIT IV: Fisheries or Sericulture:
(Choose one branch depending on specialization)

Fisheries Option:

1. Water quality analysis (DO, pH, salinity, hardness) for aquaculture suitability.
2. Study of induced breeding techniques in fish – hormonal injection simulation & spawning observation.

Sericulture Option:

1. Identification of silkworm races and their morphological features.
2. Rearing of silkworm larvae & assessment of cocoon parameters (shell ratio, reliability).

Suggested Readings:

1. Kotpal, R.L. (Latest Edition). *Modern Textbook of Zoology: Invertebrates*. Rastogi Publications, Meerut. *(for Non-Chordates)*
2. Barnes, R.D. (Latest Edition). *Invertebrate Zoology*. Cengage Learning. *(Comprehensive international text for morphology & systematics)*
3. Fox, S.I. (Latest Edition). *Human Physiology*. McGraw-Hill Education. *(Clear concepts with applied lab examples)*
4. Knobil, E. & Neill, J.D. (Eds.) (Latest Edition). *Encyclopedia of Reproduction*. Academic Press. *(Advanced coverage of reproductive physiology)*
5. Gilbert, S.F. (Latest Edition). *Developmental Biology*. Sinauer Associates. *(Gold-standard text for experimental and molecular embryology)*
6. Jhingran, V.G. (Latest Edition). *Fish and Fisheries of India*. Hindustan Publishing Corporation. *(Indian standard reference for Fisheries science)*
7. Krishnaswami, S. (Latest Edition). *Sericulture: Science & Technology*. Central Silk Board, Bangalore. *(Definitive Indian text for Sericulture research)*

SEMESTER IV

I. ELECTIVE COURSE-A [ECZOO421A]
FISH AND FISHERIES-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
By the end of this course/unit, students will be able to:

1. To understand the biological, ecological, and economic aspects of fishes, including their nutritional value, adaptations, and ecological roles in freshwater and marine ecosystems.
2. To acquire knowledge of aquaculture practices, fish classification, anatomy, physiology, and specialized adaptations, with emphasis on Indian fish diversity and culture techniques.

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

1. Explain the taxonomy, adaptations, anatomy, physiology, and ecological significance of various groups of fishes, including their economic and nutritional value.
2. The ability to describe aquaculture methods, identify important fish species of India, and analyze adaptations in relation to habitat and environmental conditions.

Course Contents:

1. Nutritional value and economic importance of fishes: a brief account of byproducts **(4 Lectures)**
2. Aquaculture – Definition and classification **(4 Lectures)**
3. Outlines of fish culture in ponds **(4 Lectures)**
4. Ornamental fishes, larvivorous fishes **(5 Lectures)**
5. Classification of living fishes up to orders **(5 Lectures)**
6. Freshwater and important marine fishes of India **(5 Lectures)**
7. Adaptations in teleosts- hill stream, cave dwelling, antifreeze, colouration, bioluminescence **(5 Lectures)**
8. Migratory behaviour in fishes **(5 Lectures)**
9. Locomotion in teleosts **(4 Lectures)**
10. Aquatic respiration in teleosts **(5 Lectures)**
11. Structure of gills, gill areas and their significance, gas exchange and ventilation of gills **(4 Lectures)**
12. Digestive system of teleosts **(5 Lectures)**
13. Alimentary canal and its modification about food and feeding habits in teleosts **(5 Lectures)**

Suggested Readings:

1. Jhingran, V. G. (1997). *Fish and fisheries of India* (3rd ed.). Delhi: Hindustan Publishing Corporation.
2. Pandey, K., & Shukla, J. P. (2019). *Fish and fisheries*. New Delhi: Rastogi Publications.
3. Lagler, K. F., Bardach, J. E., Miller, R. R., & May Passino, D. R. (1977). *Ichthyology* (2nd ed.). New York, NY: John Wiley & Sons.
4. Pillay, T. V. R., & Kutty, M. N. (2005). *Aquaculture: Principles and practices* (2nd ed.). Oxford, UK: Blackwell Publishing.
5. Moyle, P. B., & Cech, J. J. (2004). *Fishes: An introduction to ichthyology* (5th ed.). Upper Saddle River, NJ: Prentice Hall.
6. Khanna, S. S., & Singh, H. R. (2019). *A textbook of fish biology and fisheries*. New Delhi: Narendra Publishing House.
7. Qureshi, T. A., & Qureshi, N. A. (2002). *Ornamental fish culture and aquarium management*. New Delhi: CBS Publishers & Distributors.

OR ELECTIVE COURSE-B [ECZOO421B]

ENTOMOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. Provide comprehensive knowledge of insect external and internal morphology, including specialized adaptations across orders.
2. Explain the physiological systems of insects with emphasis on endocrine regulation, reproduction, and developmental processes.
3. To develop analytical skills for interpreting insect structure–function relationships with ecology, behaviour, and evolution.

Learning Outcomes:

After successful completion of this module, students will be able to:

1. Identify and describe the key morphological structures and physiological systems of insects with correct terminology.
2. Analyze the roles of endocrine glands and hormones in insect growth, metamorphosis, reproduction, and embryonic development.
3. Apply morphological and physiological knowledge to solve entomological problems in research, pest management, and biodiversity studies.

Course Contents:

UNIT I: Classification and phylogeny of Insects **(12 Lectures)**

1. Classification of the Apterygote Orders: Thysanura, Diplura, Protura, and Collembola
2. Classification of Exopterygote Orders: Orthoptera, Dictyoptera, Hemiptera
3. Classification of Endopterygote Orders: Lepidoptera, Diptera, Hymenoptera, and Coleoptera

UNIT II: Structures and life processes: **(10 Lectures)**

1. Integument: Structure and chemistry, cuticular modifications, Apolysis, Ecdysis, and sclerotization
2. Head and Thorax: Its appendages and their modifications

UNIT III: Sense organs and perception: **(8 Lectures)**

1. Sense organs: Visual organs and Auditory organs,
2. Receptor organs: Mechanoreceptors, Chemoreceptors, Thermoreceptors, Humidity receptors
3. Effector organs: The sound and light-producing organs

UNIT IV: Insect Physiology: **(12 Lectures)**

1. Digestive system: Alimentary canal, salivary glands, mechanism of digestion, micro-organisms of the intestine
2. Respiration - Respiration in aquatic, terrestrial, and endoparasitic insects
3. Excretion - Malpighian tubules and other organs of excretion, Metabolic pathways of nitrogenous excretion, i.e., urea, uric acid, ammonia, and amino acids
4. Endocrine system and hormones & pheromones

UNIT V: Reproductive Physiology: **(8 Lectures)**

1. Oogenesis, yolk formation, ovulation, and oviposition
2. Spermatogenesis, transfer of sperm and spermatophores,
3. Mating and fertilization

UNIT VI: Post-embryonic development of insects: **(10 Lectures)**

1. Types of metamorphosis
2. General features and types of larvae and pupae
3. Axes formation of *Drosophila melanogaster*

Suggested Readings:

1. Richards, O. W., & Davies, R. G. (Eds.). (1977). *Imms' General Textbook of Entomology: Volume I: Structure, Physiology and Development* (1st ed.). Springer Dordrecht.
2. Kerkut, G. A., & Gilbert, L. I. (Eds.). (1985). *Comprehensive insect physiology, biochemistry and pharmacology: Vol. 7: Endocrinology I*. Pergamon Press.
3. Tembhare, D. B. (1984). *A Text Book of Insect Morphology, Physiology and Endocrinology*. S. Chand.
4. Nijhout, H. F. (1994). *Insect hormones*. Princeton University Press.
5. Chapman, R. F. *The insects: Structure and function* (5th ed.). Hodder Arnold.
6. Fakhri, M. S. A., Gindaba, A., & Negeri, M. (2022). *Handbook of insect morphology, physiology & taxonomy* (1st ed.). AkiNik Publications.

OR ELECTIVE COURSE-C [ECZOO421C]

ECOLOGY-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. To develop a comprehensive understanding of ecosystem structure, function, and processes, including energy flow, productivity, community dynamics, and population ecology.
2. To analyze ecological patterns across habitats, assess biodiversity, and evaluate environmental challenges such as pollution and conservation needs.

Course Learning Outcomes:

Students will be able to

1. Explain ecosystem functions, productivity types, energy transfer, community organization, niche concepts, and ecological adaptations in major biomes.
2. The analytical skills in evaluating population models, biodiversity conservation approaches, habitat characteristics, and ecological implications of pollution.

Course Content:

UNIT I: Understanding Ecology **(10 Lectures)**

1. Basic Concept of ecosystem
2. Concept of Limiting Factor: Shelford's Law of Tolerance, Leibig's Law of Minimum
3. Energy Flow in Ecosystem: Food chain, Food web, Food pyramid, Lindeman's Trophic Dynamic concept, Energy flow models.
4. Concept of Productivity: Primary, Secondary and Tertiary; Factors and Methods of measurement.

UNIT II: Population Ecology **(10 Lectures)**

1. Population Growth and attributes: Exponential, Sigmoid, Time lag Model, Stochastic Model; Natural Regulation of Population: Theories and Model for Population Regulation
2. Competition: Intra and Interspecific competition, Competitive ability, Lotka & Volterra models for competing species.

UNIT III: Community Ecology **(15 Lectures)**

1. The community concept. Development of the community through succession.
2. Community organization and stratification.
3. Classification of the community based on life forms
4. Ecological Dominants, Species Diversity, Ecotypes, Ecotone and Edge Effect
5. Concept of Ecological Niche: Niche Overlap, Niche Breadth, Ecological Release and Ecological Compression. Periodicity (Seasonal, Lunar and Diel) as a niche dimension.

UNIT IV: Major Biomes of the world: Forests, Tropical, Tundra, Grassland & Deserts, and adaptations. **(5 Lectures)**

UNIT V: Habitat Ecology **(10 Lectures)**

1. Physico-chemical and Biological Characteristics of Freshwater and Marine Systems
2. Origin and Classification of Lakes, Types and Significance of Freshwater Biota.

UNIT VI: Biodiversity **(10 Lectures)**

1. Definition, Status, monitoring and documentation, Major factors affecting biodiversity destruction
2. Biodiversity conservation and management strategies
3. Hot spots

Suggested Readings:

1. Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of ecology* (5th ed.). Belmont, CA: Thomson Brooks/Cole.
2. Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Malden, MA: Blackwell Publishing.
3. Smith, R. L., & Smith, T. M. (2015). *Elements of ecology* (9th ed.). Boston, MA: Pearson Education.
4. Krebs, C. J. (2014). *Ecology: The experimental analysis of distribution and abundance* (6th ed.). San Francisco, CA: Benjamin Cummings.
5. Pandey, B. N., & Shukla, J. P. (2019). *Ecology and environmental biology*. Meerut: Rastogi Publications.
6. Dash, M. C. (2017). *Fundamentals of ecology* (4th ed.). New Delhi: McGraw Hill Education.
7. Chapin, F. S., Matson, P. A., & Vitousek, P. (2011). *Principles of terrestrial ecosystem ecology* (2nd ed.). New York, NY: Springer.

II. ELECTIVE COURSE-A [ECZOO422A]
FISH AND FISHERIES-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
By the end of this course/unit, students will be able to:
1. To understand the physical, chemical, and biological parameters of aquatic environments that influence fish culture and productivity.
2. To acquire technical knowledge of aquaculture practices, including breeding, feeding, weed control, culture systems, seed production, and fishing technologies.

Course Learning Outcomes:
By the end of the course, students will be able to:
1. Analyze water quality parameters, identify natural food resources, and explain the role of plankton, benthos, and fertilizers in fish culture.
2. Proficient in describing aquaculture techniques, seed production methods, culture systems, and the use of fishing gear and modern technologies.

Course Contents:

UNIT I: Cultivable water – quality and quantity **(25 Lectures)**
1. Physical and chemical properties of water influencing fish culture
2. Natural food for fish in pond
3. Role of plankton, blooms and benthos in fish culture
4. Fertilizers and their role
5. Supplementary feeding and artificial feeds
6. Sewage-fed fisheries, Integrated fish culture, paddy field fish culture and cage culture.
7. Important reservoirs and rivers of Jharkhand – their problems and commercial
8. Common aquatic weed and their control

UNIT II: Cultivable species **(10 Lectures)**

Introduction of exotic species – Composite culture, extensive and intensive culture

UNIT III: Fish seed production **(15 Lectures)**
1. Induced breeding – importance, technique, physiology and new generation of commercial agents
2. Collection of seeds from natural resources - transport of carp seeds and breeders
3. Management of nursery, rearing and stocking ponds

UNIT IV: Fishing technology – nets, crafts, gears, acoustic and other recent techniques. **(10 Lectures)**

Suggested Readings:

1. Jhingran, V. G. (1997). *Fish and fisheries of India* (3rd ed.). Delhi: Hindustan Publishing Corporation.
2. Pillay, T. V. R., & Kutty, M. N. (2005). *Aquaculture: Principles and practices* (2nd ed.). Oxford, UK: Blackwell Publishing.
3. Bhatnagar, A., & Singh, G. (2010). Culture fisheries in village ponds: A multi-location study in Haryana, India. *Agricultural Biology Journal of North America, 1*(5), 961–968.
4. Khan, A. A., & Khan, M. (2014). *Textbook of fish biology and fisheries*. New Delhi: Anmol Publications.
5. Qureshi, T. A., & Qureshi, N. A. (2002). *Ornamental fish culture and aquarium management*. New Delhi: CBS Publishers & Distributors.
6. Santhanam, R., & Srinivasan, A. (1994). *A manual of freshwater ecology*. New Delhi: Oxford & IBH Publishing.
7. Boyd, C. E., & Tucker, C. S. (1998). *Pond aquaculture water quality management*. New York, NY: Springer Science & Business Media.

OR ELECTIVE COURSE-B [ECZOO422B]

ENTOMOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. Understand the mode of entry and action of various insecticides.
2. Identify commonly used insecticides and their chemical classes.
3. Evaluate the toxicological effects of insecticides on humans and non-target organisms.

Course Learning Outcomes:

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

1. Differentiate between stomach, contact, and fumigant poisons
2. Describe the chemical structure and mode of action of chlorinated hydrocarbons, organophosphates, carbamates, and pyrethroids
3. Analyze insecticide toxicity concerning the respiratory, integumentary, and nervous systems in humans

Course Contents

UNIT I: Cultural Control **(12 Lectures)**

1. Ecological management of the crop environment
2. Sanitation, destruction, or modification of alternate hosts and habitats
3. Tillage, irrigation, and water management
4. Trap cropping and strip harvesting

UNIT II: Chemical Control **(20 Lectures)**

1. Classification of insecticides based on- Mode of entry (stomach poison, contact poison, & Fumigants), Mode of action (Respiratory and Nervous poisons), Chemical nature (Inorganic and Organic insecticides)
2. Liquid and Dry formulations of insecticides
3. Structure and mode of action of – Chlorinated hydrocarbons, Organophosphates, Carbamates, and Pyrethoids
4. Common insecticides used in pest control
5. Mode of action of insecticides and toxicity to humans.

UNIT III: Biological Control **(8 Lectures)**

1. Definition of Biological control, agents of Biological Control: Parasites, Parasitoids, Predators and Pathogenic microorganisms.
2. Mass production and distribution. Advantages and disadvantages of Biological control

UNIT IV: Integrated Pest Management (IPM) **(15 Lectures)**

1. History, concept, and principles of IPM, Critical uses of IPM, Procedures of integrated control of pests
2. Other Methods of Insect Pest Management
3. Management of Insect Pests by Sterile-Insect Technique (Chemosterilants)
4. Attractants, Repellants, Antifeedants, and Pheromones.

UNIT V: Insect – Plant Interaction **(5 Lectures)**

1. Theory of coevolution
2. Role of allochemicals in host-plant, medication, and host plant selection

Suggested Readings:

1. Dent, D. (2000). *Insect pest management*. CABI Publishing.
2. Metcalf, R. L., & Luckmann, W. H. (1994). *Introduction to insect pest management* (3rd ed.). Wiley-Interscience.
3. Pedigo, L. P., & Rice, M. E. (2014). *Entomology and pest management* (6th ed.). Waveland Press.
4. Koul, O., & Cuperus, G. W. (Eds.). (2007). *Ecologically based integrated pest management*. CABI Publishing.
5. Subramanyam, B., & Hagstrum, D. W. (Eds.). (2012). *Integrated management of insects in stored products*. CRC Press.
6. Dhaliwal, G. S., Jindal, V., & Mohindru, B. (2013). *Crop losses due to insect pests*. Indian Journal of Entomology, 75(2), 165–176.
7. Flint, M. L., & Dreistadt, S. H. (1998). *Natural enemies handbook: The illustrated guide to biological pest control*. University of California Press.
8. van Emden, H. F., & Harrington, R. (2017). *Aphids as crop pests* (2nd ed.). CABI Publishing.
9. Norris, R. F., Caswell-Chen, E. P., & Kogan, M. (2003). *Concepts in integrated pest management*. Prentice Hall.
10. Dhaliwal, G. S., Singh, R., & Chhillar, B. S. (2006). *Essentials of agricultural entomology*. Kalyani Publishers.
11. Thakur, A. K. A Journey into Entomology (Vol. 1 & 2). Lekh Publications, India

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OR ELECTIVE COURSE-C [ECZOO422C]

ECOLOGY-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

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

1. understand population ecology concepts, models, and interactions, and their application in agriculture, fisheries, and forestry management.
2. gain comprehensive knowledge of ecotoxicological principles, including toxicant behavior, dose-response relationships, and biotransformation processes in organisms.

Course Learning Outcomes:

Students will be able to:

1. Explain population attributes, growth models, species interactions, and regulatory mechanisms, and apply these concepts to real-world ecological and resource management problems.
2. Demonstrate the ability to analyze toxicological processes, environmental influences on toxicity, and mechanisms of toxicant transformation and effects in ecosystems.

Course Content:

UNIT I: Pollution Ecology **(20 Lectures)**

1. Pollution - Types, entry of pollutants in biological systems
2. Air, Water, Soil, Noise, and Radioactive – Sources, Effects and Control measures
3. Solid waste management

UNIT II: Ecotoxicology **(20 Lectures)**

1. Toxicology: Routes and rate of administration
2. Environmental and behavioral factors affecting Toxicity
3. Synergism and Antagonism; Mechanism of action
4. Basic Principle of Dose Response Relationship
5. Biotransformation of Toxicants
6. Translocation of Toxicants Antidotes; Toxicity Tests, Xenobiotics

UNIT III: Environment Assessment, Management, and Legislation **(15 Lectures)**

1. Environmental Impact Assessment (EIA), and Environmental Management Plan (EMP).
2. Overview of Environmental Laws in India – Wildlife Protection Act, 1972, amendments 1991; The Solid Waste Management Rules, 2016, and The E-Waste (Management) Rules 2016

UNIT IV: Contemporary Environmental Issues **(05 Lectures)**

Global Environmental Issues – Biodiversity Loss, Climate Change, Greenhouse Effects, Ozone Layer Depletion, and Carbon Neutrality

Suggested Readings:

Textbook:

1. J. Jeffrey Peirce, P. Aarne Vesilind & Ruth F. Weiner (1997). Environmental Pollution and Control, 4th Ed., Elsevier Science & Technology Books
2. Ernest Hodgson (2010). A textbook of modern toxicology, 4th edition, John Wiley & Sons, Inc.
3. Krebs, C. J. (2014). *Ecology: The experimental analysis of distribution and abundance* (6th ed.). San Francisco, CA: Benjamin Cummings.

Reference Books:

1. Begon, M., Townsend, C. R., & Harper, J. L. (2006). *Ecology: From individuals to ecosystems* (4th ed.). Malden, MA: Blackwell Publishing.
2. Newman, M. C. (2015). *Fundamentals of ecotoxicology: The science of pollution* (4th ed.). Boca Raton, FL: CRC Press.
3. Rand, G. M., & Petrocelli, S. R. (1985). *Fundamentals of aquatic toxicology: Methods and applications*. Washington, DC: Hemisphere Publishing.
4. Connell, D. W., & Miller, G. J. (2006). *Chemistry and ecotoxicology of pollution* (2nd ed.). Hoboken, NJ: John Wiley & Sons.
5. Odum, E. P., & Barrett, G. W. (2005). *Fundamentals of ecology* (5th ed.). Belmont, CA: Thomson Brooks/Cole.
6. Sibly, R. M., Hone, J., & Clutton-Brock, T. H. (2003). Population growth rate and its determinants: An overview. *Philosophical Transactions of the Royal Society B: Biological Sciences, 358*(1438), 1429–1436.

III. CORE COURSE [CCZOO423]
CHORDATES

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

After completion of the course, the learner will be able to understand:

1. To equip learners with the knowledge of the evolutionary progression of Protochordates and Chordates.
2. To familiarize the learner with the origin, morphology, and phylogeny of the Protochordates and Chordates.

Course Learning Outcomes:

1. Learners would be equipped with an understanding of the morphology and phylogeny of Protochordates and Chordates.

Course Content:

UNIT-I: PROTOCHORDATES (20 Lectures)

1. **Protochordates:** Origin and ancestry of Protochordates, affinities with Invertebrates and Chordates
2. **Urochordates:** Life history of *Herdmania* and its phylogenetic affinities,
3. **Cephalochordates:** General features and affinities, Life history of *Branchiostoma*
4. **Cyclostomes:** Resemblance with Cephalochordates, Vertebrates, and differences from Fishes, Life history of *Petromyzon*

UNIT II: PHYLOGENY OF CHORDATES (20 Lectures)

1. Ancestry of Chordates
2. **Pisces:** General characters of Dipnoi and affinities with Fishes, Elasmobranchs and Amphibia. Origin of air bladder and its relationship with tetrapod lungs, Deep sea adaptations of fishes, and Origin of fins.
3. Evolutionary significance Crossopterygians, Placoderms
4. **Amphibia:** Origin of Tetrapods, Pedomorphosis, Adaptive radiation in amphibians, Lepospondyli and Lissamphibia
5. Evolutionary significance of Labyrinthodonts
6. **Reptilia:** Origin of Reptiles and Affinities with Amphibia. Terrestrial adaptations in Reptiles, Skull of reptiles
7. **Aves:** Origin of Birds and affinities with Reptiles, Adaptive radiation in Birds – Ratitae (Flightless Birds) and Carinatae (Flying Birds), Origin of Flight – Theory of Cursorial and Arboreal origin
8. **Mammals:** Phylogeny of mammals

UNIT III: UNDERSTANDING CHORDATES (20 Lectures)

1. Retrogressive metamorphosis in Ascidians
2. **Pisces:** Lateral line sense organ and electric organs
3. **Amphibia** – Neoteny, Parental Care
4. **Aves:** Migration, Flight adaptations
5. **Mammalia:** Dentition in mammals

Suggested Readings:

Text Books:

1. Romer, A. S., & Parsons, T. S. (1986). *The vertebrate body* (6th ed.). Saunders College Publishing.
2. Kotpal, R. L. (2015). *Modern text book of zoology: Vertebrates*. Rastogi Publications.

Reference Books:

1. Young, J. Z. (1981). *The life of vertebrates* (3rd ed.). Clarendon Press.
2. Pough, F. H., Janis, C. M., & Heiser, J. B. (2012). *Vertebrate life* (9th ed.). Pearson Education.
3. Kardong, K. V. (2019). *Vertebrates: Comparative anatomy, function, evolution* (8th ed.). McGraw-Hill Education.
4. Saxena, R. K., & Saxena, S. (2010). *Comparative anatomy of vertebrates*. Viva Books Private Limited.
5. Ekambaranatha Ayyar, C. N., & Ananthakrishnan, T. N. (2002). *Manual of zoology: Chordata*. S. Viswanathan (Printers & Publishers) Pvt. Ltd.

IV. ELECTIVE COURSE-A [EPZOO424A]
PRACTICAL-A

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Scheme of Examination **Time: 6 Hrs**

Topics		Marks Distribution
Anatomical observation		10
Gut analysis and determination of feeding habit		10
Temporary slides		10
Spotting – 5 [Representative of major classes–1, histological slides–1, Endocrine section–1, fish showing adaptation–1, exotic/ornamental/ larvivorous fish-1]		15
Plankton identification		5
Taxonomic identification of freshwater fishes	(2x5)	10
Fish showing adaptive feature	(2x5)	10
Records and Sessional work		10
Viva voce		20

List of Practical

UNIT I: Anatomical observation of a bony fish:

1. General anatomy, Digestive system of herbivore and carnivore fishes, Reproductive system
2. Pituitary gland, Weberian Ossicle.
3. Representatives of major groups (except teleosts)
4. Taxonomic identification of important freshwater and marine fishes up to genus

UNIT II: Study of histological slides of various organs:

1. Study of slides, related to annual breeding cycles - ovary, testis, pituitary etc.
2. Study of the skeletal system of bony fish
3. Study of exotic, ornamental, larvicidal fishes
4. Study of adaptive features: hill stream fishes, fishes showing parental care, bioluminescence, adaptations - feeding, respiratory, flying, poisonous, electric organs, etc
5. Haematology – blood corpuscles, T.C., D.C., and Hb content/ Haematocrit

UNIT III: Study of fishing gears and ecological equipment:

1. Collection, identification of plankton, weeds, and aquatic plants
2. Determination of feeding habit based on gut/ gut content

Visit to fish market, landing site, fish pond, and fish farm, breeding centers, fish reservoir and National Institutes of Fisheries Research

Suggested Readings:

1. Lagler, K. F., Bardach, J. E., Miller, R. R., & May Passino, D. R. (2021). *Ichthyology*. Wiley.
2. Khanna, S. S., & Yadav, P. R. (2020). *A Textbook of Fish Biology and Fisheries*. Narendra Publishing House.
3. Bhatnagar, G. K., & Singh, H. D. (2016). *Practical Zoology: Vertebrates*. Rastogi Publications.
4. Biswas, S. P. (1993). *Manual of Methods in Fish Biology*. South Asian Publishers.
5. Qureshi, T. A., & Qureshi, N. A. (2011). *Fish Biology and Ecology*. APH Publishing.

OR ELECTIVE COURSE-B [EPZOO424B]

PRACTICAL-B

Marks: 100 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Practical-04, 120 Hours)

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Scheme of Examination **Time: 6 Hrs**

Topics		Marks Distribution
Adapting feature of aquatic/Semiaquatic/terrestrial insects		10
Temporary mounting of any body parts of insects		10
Calculation of species diversity of insects by Shannon-Weiner index from generated data		10
Taxonomic description of a member of any order studied		10
Pest studies/life cycle of beneficial insects		10
Spotting	(2x10)	20
Records and Sessional work		10
Viva voce		20

List of Practical

Taxonomic description & identification of the following order:

1. Orthoptera, Dictyoptera, Hemiptera, Hymenoptera, Diptera, Coleoptera & Lepidoptera.
2. Study of permanent slides of body parts.
3. Study of Histological slides.
4. Pest study on affected objects.
5. Life history of beneficial insects like- lac & tasar.
6. Study of parasites, predators, parasitoids & pathogens.
7. Embryological study through *Drosophila* culture.
8. Study of adaptive features in some order of insects.
9. Minor dissection: Temporary mounting of special types of mouth parts, wings, legs, ovpositer
10. Sting apparatus antennae- adaptation – arista.
11. Calculation of species diversity by Shannon-Weiner index from generated data
12. Study of the external morphology of an insect, wings, halteres, and elytra
13. Study of the adaptive feature of terrestrial and aquatic insects
14. Study of parasitic insects (Fleas and Lice)
15. Study of the mouthparts of the representatives of the order: Orthoptera, Dictyoptera, Hemiptera, Lepidoptera and Hymenoptera.
16. Study of respiratory structure of terrestrial, semi-aquatic, and aquatic insects.
17. Study of the life cycles of Termites, Honeybees, and Mosquitoes.

Suggested Readings:

1. Imms, A. D. (1977). *A General Textbook of Entomology: Including the Anatomy, Physiology, Development and Control of Insects*. Chapman and Hall.
2. Borror, D. J., Triplehorn, C. A., & Johnson, N. F. (2017). *An Introduction to the Study of Insects*. Cengage Learning.
3. Saxena, S. C. (2015). *Entomology: At a Glance*. Scientific Publishers, India.
4. Tembhare, D. B. (2012). *Modern Entomology*. Himalaya Publishing House.
5. Snodgrass, R. E. (1993). *Principles of Insect Morphology*. Cornell University Press.

OR ELECTIVE COURSE-C [EPZOO424C]
PRACTICAL-C

Marks: 100 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Practical-04, 120 Hours)

Course Contents:

There will be one Practical Examination of 6 Hrs duration. Evaluation of Practical Examination will be as per the following guidelines:

Scheme of Examination **Time: 6 Hrs**

Topics	Marks Distribution
Water analysis	15
Soil analysis	15
Biotic analysis	10
Bio-statistical analysis	15
Adaptation Study Spotting (5 X 3)	15
Records and Sessional work	10
Viva voce	20

List of Practicals

UNIT I: Water Analysis

1. Estimation of BOD of water sample
2. Estimation of Carbonate, Bicarbonate and Hydroxide & chloride in sample water
3. Estimation of Hardness & Oxygen and Carbon of sample water
4. Estimation of Magnesium and Calcium in sample water

UNIT II: Soil Analysis

1. Estimation of OMC / Total Carbon of a soil sample
2. Estimation of $CaCO_3$ in a soil sample
3. Estimation of Soil Respiration rate in a sample

UNIT III: Biotic Analysis

1. Sampling and identification of freshwater planktons.
2. Qualitative, quantitative assessment and working of the indices of diversity and dominance of Plankton, Benthos, Soil fauna, Soil microbes

UNIT IV: Biostatistical Analysis

1. Analysis of the correlation coefficient and simple linear regression in a set of data
2. Estimation of density and relation frequency by quadrate analysis
3. Analysis of similarity index in the species composition by 2X2 contingency table

UNIT V: Adaptation study

1. Aquatic insects, Terrestrial Insects, Freshwater fish (Hill Stream fish)
2. Marine fish & Higher Vertebrates
3. Ecological Equipments
4. Ecological significance of plants and earthworms
5. Identification of Aquatic Plants and Bioindicator Species

Suggested Readings:

1. APHA, AWWA, & WEF. (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). American Public Health Association.
2. Piper, C. S. (1966). *Soil and Plant Analysis*. Hans Publishers.
3. Welch, P. S. (1948). *Limnological Methods*. McGraw-Hill.
4. Mishra, S. R., & Pani, K. C. (2008). *Practical Ecology and Environmental Science*. Discovery Publishing House.
5. Krebs, C. J. (2014). *Ecological Methodology* (3rd ed.). Pearson.

V. PROJECT [PRZOO425]

DISSERTATION/ PROJECT/ TEACHING APTITUDE

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 120 Hours)

Guidelines to Examiners for <u>End Semester Examination (ESE):</u>

Evaluation of project dissertation work may be as per the following guidelines:

Project model (if any) and the Project record notebook = 70 marks

Project presentation and viva-voce = 30 marks

The evaluation of the dissertation will be done in 100 marks (70 marks + 30 marks of the session). The sessional component will be evaluated by the concerned supervisor.

The end term evaluation (70 marks) will be done by a board of examiners. The end term evaluation in 70 marks will include the literary and scientific presentation of the dissertation and the performance in the viva-voce.

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organisation*
- *Application of Research techniques in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:

1. To develop research skills and scientific inquiry through independent investigations on a topic/ problem.

Course Outcomes:

On successful completion of this course, the student should know:

1. About conducting research with approved stages of research methodology.
2. A dissertation will enable students to further investigate and navigate different aspects and events of life through research.

PROJECT WORK

Each student has to submit three copies of hard-bound dissertation work (along with the raw data), duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the concerned University Department, Ranchi University, Ranchi for evaluation (one month before the viva voce examination).

The paper may involve:

a) Field work/ Lab work related to the project.
b) Survey research, Case Study or any other type of research related to the subject.
c) One Large study/ Experiment or several studies/ Experiments, depending on the objectives of the research.
d) The writing of the dissertation must be within 80 to 100 pages, including references and appendices.
e) Content must be typed in Font: Times New Roman with Line Spacing: 2.0 and Font Size 12 points.

The project work will be presented in a seminar on the assigned topic in the concerned department of Ranchi University, Ranchi, followed by an open viva voce examination.

Topics: As decided by the Supervisor/Guide

Teaching Aptitude: As an alternative to a dissertation, only a few selected meritorious candidates may be assigned the responsibility to teach the pre-decided topics in selected colleges. The performance may be evaluated based on the structured feedback for the candidate.
