Semester	Course Opted	Course Code	Course Name	Credits
V	Core Course-XI	**ZOO711C**	Developmental Biology & Immunology	4
	Core Course-XI Practical	**ZOO711CP**	,,	2
	Core Course-XII	**ZOO712C**	Cell Biology & Genetics	4
	Core Course-XII Practical	**ZOO712CP**	,,	2
	Generic Elective Course (GEC) -III	**ZOO703G**	Fundamentals of Zoology – III ***[Students of Zoology are to choose GEC of other subjects like Chemistry/Botany]**	4
	Generic Elective Course (GEC) -III Practical	**ZOO703GP**	,,	2
	Value addition Courses (VAC) - VII	**VAC - 7**	**One to be chosen from VAC list sl. no. 49 -56 of Univ order no.523 dated 20th Sept 2022 https://www.manipuruniv.ac.in/p/ syllabus-for-ug-programmes-2**	2
	Discipline Specific Elective (DSE) Course - I	**ZOO701D(a) or ZOO701D(b) or ZOO701D(c)**	Wildlife & Bioresource management **or** Integrated Pest management **or** Fish & Fisheries	4
	Discipline Specific Elective (DSE) Course - I Practical	**ZOO701DP(a) or ZOO701DP(b) or ZOO701DP(c)**	Wildlife & Bioresource management **or** Integrated Pest management **or** Fish & Fisheries	2
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Courses for B.Sc. (Hons.) Zoology

SEMESTER V

Core Course -XI : ZOO711C (Developmental Biology & Immunology)

Objective: Developmental Biology provides knowledge on the embryonic and post embryonic developmental processes. The course is aimed to make the undergraduate students realize the aspects of developmental biology. The course explains the basic principles and concepts underlying the developmental processes at the cellular and molecular level. By understanding the developmental processes, the students shall be able to relate to the errors occurring during development leading to congenital disorders and human diseases. The course in immunology is to apprise the student with the working of the immune system in normal health and its role in fighting diseases. This course is also designed to enable understanding the molecular and cellular basis of the development and function of the immune system, identification of its biological, clinical and therapeutic implications.

Outcome:

The students shall be able to have knowledge on the followings on completion of the Course

- Acquire basic knowledge on the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote including the knowledge of the cellular processes of development and the molecular mechanisms underlying these.
- Knowledge on the general patterns and sequential developmental stages during embryogenesis; the general mechanisms involved in morphogenesis; the process under which different cells and tissues interact in a coordinated way to form various tissues and organs.
- Ideas on the processes of Teratogenesis, functional interplay of innate and adaptive immunity, cellular/molecular pathways of humoral/cell-mediated adaptive responses including the role of Major Histocompatibility Complex, the cellular and molecular aspects of lymphocyte activation, homeostasis,differentiation, and memory shall be imparted.
- The molecular basis of complex, humoral (Cytokines and Complement) and cellular processes involved in inflammation and immunity, in states of health and disease, vaccination, autoimmunity,immunodeficiency, hypersensitivity, tolerance and State of the Art experimental methods and technologies shall be elaborated.

Course Content:

Theory [Credits: 4] 60 hrs/100 marks

Unit 1: Introduction to Developmental Biology 12 hrs/20 marks

Historical perspective and basic concepts: Phases of development, cell-cell interaction, pattern formation, differentiation and growth, differential gene expression, cytoplasmic determinants and asymmetric cell division, Gametogenesis, Spermatogenesis, Oogenesis; Types of eggs, Egg membranes; Developmental biology & merits, types of development, Fertilization (External and Internal): mechanism, general sequence & molecular events during fertilization, Changes in gametes, Blocks to polyspermy; Planes and patterns of cleavage; Chemical changes during Cleavage, Types of Blastula; Fate maps.

Unit 2: Embryonic Development 12 hrs/20 marks

Early development of frog and chick up to gastrulation; Embryonic induction and organizers, Fate of Germ Layers; Formation of neural tube, Extra-embryonic membranes in birds;Implantation of embryo in humans, elementary concept of Transplantation, Determination, Competence, embryonic induction and organizers; Placenta (Structure, types and functions of placenta); Metamorphosis: Changes, hormonal regulations in amphibians and insects; Regeneration:Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: Concepts and Theories.

Unit 3: Teratogenesis and overview of Immune system 12 hrs/20 marks

Teratogenesis: Teratogenic agents and their effects on embryonic development; Teratogenesis as an environmental assault on human development;
Overview of Immune system: Historical perspective of Immunology, Early theories of Immunology, Clonal Selection Theory, Cardinal features of vertebrate immune system, Hematopoiesis, Cells and organs of the Immune system. Anatomical barriers, Inflammation, Cell and molecules involved in innate Immunity,Adaptive Immunity (Cell-mediated and Humoral), Passive immunity; Active: Artificial and natural Immunity, Immunological Tolerance.

Unit 4: Antigens, Antibodies, and Immunoglobulins: 12 hrs/20 marks

Structure of antibodies; Functional properties of antibodies. Generation of antibody diversity – molecular mechanism, role of major histocompatibility complex in immune response. Antigenicity and immunogenicity, Immunogens, Adjuvants and haptens, Factors influencing immunogenicity, B and T-Cell epitopes, Structure and functions of different classes of immunoglobulins, Antigenic determinants on Immunoglobulins, Antigen-antibody interactions (Precipitation reactions, Agglutination reactions, Immunofluorescence and ELISA), Polyclonal sera, Hybridoma technology: Monoclonal antibodies in therapeutics and diagnosis.

Unit 5: MHC, Cytokines, Complement system, Diseases: 12 hrs/20 marks

Structure and functions of Major histocompatibility complex (MHC) molecules (MHC I and II), Endogenous and exogenous pathways of antigen processing and presentation, concept of Cytokines, Properties and functions of cytokines, Complement system, Components and pathways of complement activation, biological consequences of complement activation. Tumor immunology, Immunization, Immunodeficiency diseases – Primary, Combined, severe combined, acquired, secondary immunodeficiency diseases; Hypersensitivity; recent developments in antibodies and immune therapy.

Core Course -XVII Practical : ZOO711CP (Developmental Biology & Immunology)

Practical [Credits: 2] **30 hrs/ 50 marks**

Part A

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula, tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): Stage 3 (Intermediate Streak)-13 hours, Stage 4 (Definitive Streak)-18 hours, Stage 5 (Head Process)-21 hours, Stage 7-24 hours, Stage 8-28 hours, Stage10-33 hours, Stage 11-40 hours, Stage 13-48 hours, Stage 19-72 hours and Stage 24-96 hours of incubation
3. Demonstration of culture of chick embryo from fertilized eggs to study various developmental stages.
4. Study of different sections of placenta (photomicrographs/ slides).

Part B

5. Histological study of spleen, thymus and lymph nodes through slides/photographs.
6. Preparation of stained blood film to study various types of blood cells.
7. Basic patterns of precipitation by Ouchterlony's double immuno-diffusion method.
8. ABO Blood group antigen determination by hemagglutination.
9. Demonstration of: ELISA, Immunoelectrophoresis

Examination evaluation Structure:

1. Identification of Slides with Characters (at least three Characters) : 3 each from Part A & B : 6 (1 + 3) = 24
2. Whole mount of Part A : Characters & Identification (only 2) : (1 + 2) 2= 6
3. Blood smear to show blood components or blood group : Procedure = 3, experiment = 2
4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, power point presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questions on start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition,International Thompson Computer Press.

Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-HillPublishers.

David, M., Jonathan, B., David, R. B. and Ivan, R. (2006). Immunology, VII Edition,Mosby, Elsevier Publication.

Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc.Publishers, Sunderland, Massachusetts, USA

Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006). Immunology,VI Edition, W.H. Freeman and Company.

Suggested Reading:

- Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology.V Edition, Saunders Publication.
- Kalthoff, K. (2001). Analysis of Biological Development. II Edition, McGraw Hill Publishers.
- Kenneth Murphy and Casey Weaver (2016). Janeway's Immunobiology, IX Edition, Garland Science
- Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell
- Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Online Tools and Web Resources:

- https://www.hhmi.org/biointeractive/human-embryonic-development
- https://www.khanacademy.org/science/biology/developmental-biology
- https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm
- https://embryology.med.unsw.edu.au/embryology/index.php/Main_Page

e-PG Pathshala portal of Government of India: https://epgp.inflibnet.ac.in Fundamentals of immunology;https://www.coursera.org/specializations/immunology.

Core Course -XII: ZOO712C (Cell Biology & Genetics)

Objective:

This course provides a comprehensive understanding of Cell Biology, emphasizing the cell as the fundamental unit of life and Genetics as the basis of inheritance. Students will explore the structure and function of cellular organelles, regulatory mechanisms, and genetics, from Mendelian principles to contemporary insights like epigenetics and gene regulation. The course prepares students for higher studies & research in Genetics and related fields.

Outcome: Upon completion of the course, students shall be able to:

- Understand core concepts of cell biology and genetics, including genomics and metagenomics.
- Explain the structure and functions of cellular organelles involved in key processes.
- Grasp how cells grow, divide, signal, and regulate vital functions.
- Analyze the principles of inheritance and how they extend beyond Mendel's laws.
- Understand genetic regulation, mutations, and chromosomal abnormalities in diseases.
- Develop critical thinking and data analysis skills in genetics and cell biology research.
- Explore model organisms and their role in advancing genetics research.
- Gain insight into epigenetics and gene regulation in health and disease.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Overview of Cells, Cellular Organelles and Membrane Dynamics 12 hrs/20 marks

Overview of prokaryotic and eukaryotic cell types and their key differences. Comparative structure of plant and animal cells. An overview of structure and function of the following cellular components: Plasma Membrane, Mitochondria, Nuclear Membrane, Cytoskeleton, Endoplasmic Reticulum (ER types), Golgi Apparatus, Lysosomes, Peroxisomes, Mitochondria, Nucleus, Nucleolus, Vacuoles, Chloroplasts, Ribosomes, Centrosomes and Centrioles. Structure and functions of microtubules, microfilaments and intermediate filaments; Transport across membranes: diffusion, osmosis, ion channels; ion pumps, active & passive transport, facilitated transport.

Unit 2: Chromosome Structure & Types, Cell Division and Cell signaling & communication 12 hrs/20 marks

Structure and types of chromosomes, Specialized chromosomes – Polytene and Lamp brush chromosomes, nucleosome organization: DNA – histone complex, higher order chromatin folding. Chromosomal variations and abnormalities. Cell Division: Phases of Mitosis and Meiosis: Key steps and regulation of the processes. Overview of Cell Cycle and mechanisms of cell cycle control. Cell-Cell junctions and general principles of cell communication, Cell adhesion, roles of different adhesion molecules, gap junctions, integrins, neurotransmission & its regulation, Apoptosis.

Unit 3: Principles of Inheritance – Mendelian Genetics 12 hrs/20 marks

Mendelian Genetics: Mendel's laws of segregation and independent assortment. Monohybrid and dihybrid crosses, test crosses, and backcrosses. Concepts of dominance, recessiveness, and co-dominance. Concept of gene, allele, pseudo allele, multiple alleles. Extensions of Mendelian Genetics: Incomplete dominance, co-dominance, multiple alleles, lethal alleles. Penetrance and expressivity, epistasis, pleiotropy. Sex-linked, sex-influenced, and sex-limited traits. Polygenic Inheritance: Traits controlled by multiple genes (e.g., skin color, height). The role of multiple genes in producing continuous variation in traits.

Unit 4: Non-Mendelian & Extra-nuclear Inheritance, Gene Regulation & Epigenetics
12 hrs / 20 marks

Non-Mendelian and Extra-nuclear Inheritance: Cytoplasmic Inheritance and Genomic Imprinting: Maternal effects and genomic imprinting (e.g., shell coiling in *Limnaea*). Organelle Inheritance: Mitochondrial inheritance, antibiotic resistance in *Chlamydomonas*, mitochondrial mutations in *Saccharomyces* and related human disorders. Infective Heredity: Inheritance patterns in *Paramecium*. Prokaryotic and Eukaryotic Gene Regulation: Mechanisms of gene regulation in prokaryotes (e.g., lac operon) and eukaryotes. Epigenetics: DNA methylation, histone modifications, and chromatin remodeling. Epigenetic Control of Gene Expression: Epigenetic mechanisms in development and diseases (e.g., cancer, imprinting disorders). Environmental Influence on Epigenetic Traits: Impact of environmental factors on epigenetic modifications and the heritability of epigenetic traits.

Unit 5: Linkage, Chromosomal Mapping, Mutations, Sex Determination and Quantitative genetics

12 hrs/20 marks

Linkage, Crossing Over, and Chromosomal Mapping. Gene mapping techniques, including somatic cell hybridization. Mutations – physical and chemical mutagens, types of mutations and their detection methods. Chromosomal aberrations. Sex Determination: Genetic and environmental mechanisms of sex determination in *Drosophila* and humans. Dosage compensation mechanisms: X-inactivation in mammals, hyperactivation of the X chromosome in *Drosophila*. Mechanism of Sex Reversal in Animals such as fish and amphibians and the factors influencing sex reversal. Pedigree analysis, Karyotypes, genetic disorders, polygenic inheritance, heritability and its measurements.

Recommended Books:

- Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). ***Molecular** Biology of the Cell*, 6th Edition. Garland Science, Taylor & Francis Group.
- Becker, Kleinsmith and Hardin (2009): The world of the Cell, VIII Edition. Benjamin Cummings Publishing, San Francisco.
- Cooper,G.M. and Hausman,R.E. (2009): The Cell : A molecular approach, V edition, ASM Press and Sinauer associates.
- Klug, W.S., Cummings, M.R., Spencer, C.A., & Palladino, M.A. (2018). *Concepts of Genetics*, 12th Edition. Pearson Education.
- Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. (2016). *Molecular Cell Biology*, 8th Edition. W.H. Freeman & Company.
- Snustad, D.P., & Simmons, M.J. (2015). *Principles of Genetics*, 7th Edition. John Wiley & Sons.
- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., & Doebley, J. (2020). *Introduction to Genetic Analysis*, 12th Edition. W.H. Freeman & Company.

Suggested Readings:

- De Robertis, E.D.P., & De Robertis, E.M.F. (2018). *Cell and Molecular Biology*, 9th Edition. Lippincott Williams & Wilkins.
- Karp, G. (2018). *Cell and Molecular Biology: Concepts and Experiments*, 8th Edition. John Wiley & Sons Inc.
- Pierce, B.A. (2017). *Genetics: A Conceptual Approach*, 6th Edition. W.H. Freeman & Company.
- Becker, W.M., Kleinsmith, L.J., & Hardin, J. (2018). *The World of the Cell*, 9th Edition. Pearson Education.
- Russell, P.J. (2016). *Genetics: A Molecular Approach*, 3rd Edition. Pearson Education.

Online Tools and Web Resources:

- https://swayam.gov.in/course/150-cell-biology
- https://swayam.gov.in/courses/5173-biochemistry-and-cell-biology
- https://www.jove.com/science-education-library/9/cell-biology
- https://www.khanacademy.org/science/biology/crash-course-bio-ecology/crash-course-biology-science/v/crash-course-biology-123
- https://opentextbc.ca/biology2eopenstax/chapter/chordates/

Core Course – XII Practical: ZOO712CP

Practical [Credits 2] 30 hrs/50 marks

1. Preparation of temporary stained squash of onion root tip to study various stages of mitosis.
2. Simulation exercises using beads or seeds to study the Mendel's laws and gene interactions.
3. Study of various stages of meiosis.
4. Verification of Mendelian ratios using Chi-square analysis/test, Pedigree analysis.
5. Preparation of temporary stained mount to show the presence of Barr body in human femaleblood cells/ cheek cells.
6. Linkage maps based on data from conjugation.
7. Cytochemical staining and preparation of permanent slide to demonstrate:
    (a) DNA by Feulgen reaction
    (b) Mucopolysaccharides by PAS reaction
    (c) Proteins by Mercuric Bromophenol Blue/Acid Fast Green.

Examination evaluation Structure:

1. Temporary slide preparation : 2 numbers (Procedure = 05, Slide = 04, Display = 03) Total = 24 marks
2. Identification of Meiotic stages (2 slides) (Identification : 01, Character = 02) Total = 06
3. Cytochemical staining and preparation of permanent slide (Procedure = 03, Display/result = 02) Total = 5 marks
4. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Generic Elective Course (GEC) -III : ZOO703G

(Fundamentals of Zoology – 3: Protozoa & Phyla of Invertebrates)

[**NOTE** : Zoology discipline offers six generic elective courses titled " Fundamentals of Zoology 1 to 6 for six semesters of UG course (Semester III to VIII). GEC in Zoology shall be opted by Students of other Subjects other than those of Zoology (Zoology students are not allowed to take GEC in Zoology). Based on the ordinance for UG programs, GEC is a course chosen generally from an unrelated discipline/ Subject with an intention to seek a wide exposure. A core subject offered in a subject may be treated as a GEC. However, as per resolution of the Deans' committee meeting held on 4.3.2024 and subsequent circular of the Registrar MU/4-133/2024/1266 dated the 5th March 2024 GEC syllabi may be formed in the line of the CBCS in Master's course.]

Objective: The course will make the students aware about the different groups of Animals. It is aimed at providing knowledge on the diversity of animals right from the simple Poriferans up to the highest form i.e. Man

Outcome:

- Provide knowledge about types of animals, their characters and representative Species
- Increase knowledge on the relationships between the different groups.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit I: Protozoa & Porifera 12 hrs/20 marks

General Characters and different classes of Protozoans with examples, Structure, life Cycle and clinical significance of *Plasmodium* sp. General Characters and different classes of Poriferans with examples, Canal system in Sponges, integumentary system in Sponges.

Unit II: Cnideria & **Platyhelminthes** 12 hrs/20 marks

General Characters and different classes of Cnideria with examples, Polymorphism in Coelenterates, Corals & Coral reef formation; General Characters and different classes of Platyhelminthes with examples, Life cycle of *Fasciola hepatica* and *Taenia solium*.

Unit III: Nemathelminthes & Annelida 12 hrs/20 marks

General Characters and different classes of Nematodes with examples, Life cycle of *Ascaris lumbricoides,* its parasitic adaptation and medical importance. General Characters and different classes of Annelida with examples, Significance of medicinal Leeches.

Unit IV: Mollusca & Echinodermata 12 hrs/20 marks

General Characters and different classes of Mollusca with examples, Torsion in Gastropods. General Characters and different classes of Echinodermata with examples, Water vascular system in Asteroidea.

Unit V: Arthropoda & Hemichordata 12 hrs/20 marks

General Characters and different classes of Arthropoda with examples, metamorphosis in Insects, Economic and medical importance of Insects. General Characters of Hemichordata , Affinities of Balanoglossus with Chordates and non-Chordates.

Generic Elective Course (GEC) -III Practical : ZOO703GP

Practical [Credits 2] **30 hrs/ 50 marks**

1. Identification of slides of Protozoans and museum specimen representing the Invertebrates.

2. Slide making of free living Protozoans / Blood smears to show malarial parasites.

3. Visit on foot to a place near the Institute to get familiarized with different invertebrates available in the area & submission of a report.

Examination evaluation Structure:

1. Slide identification: 2 Numbers/ 4 marks each (Identification =1, Comments = 3) Total = 8 marks
2. Museum Specimen identification: 6 Numbers/ 3 marks each (Identification =1, Comments = 2) Total = 18 marks
3. One slide preparation: 9 marks (experiment and display = 6 marks, procedure = 3 marks)
4. Field report submission: 5 marks (Subject Knowledge, Presentation)
5. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

Information and concepts about cell and tissues of animals willbe imparted through classroom lectures to inculcate a conceptual base among the students about the subject and through observations through slides and experiments. Hands-on exposure would be provided to the students leading to more comprehensive learning. Blended learning using chalk-n-talk method and e-learning using presentations, animations, etc. would be used to enhance their conceptual understanding. Inquiry-based collaborative learning environment through presentations, group discussions and round tables on the various aspects of cell biology would be created to ensure effective learning and

understanding of the concepts. Field-based project activities can be included to create interest among the students to study and explore the cell organelles and cell division processes of animals inculcating research aptitude. Curriculum-related assignments would improve the reading, writing and abstracting skills and enhance the critical thinking of the students. After completion of each unit there should be a doubt clearing session/class in order to test whether the teaching imparted had been followed by the Students. Power point presentation on any topic of the Unit (both theory and practical syllabi) shall be compulsory for all the Students.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Recommended Books:

- Barnes, R.D. (2006). Invertebrate Zoology, VII Edition, Cengage Learning, India.
- Pechenik, J. A. (2015). Biology of the Invertebrates. VII Edition, McGraw-Hill Education
- Ruppert, E.E., Fox, R.S., Barnes, R. D. (2003). Invertebrate Zoology: A Functional Evolutionary Approach. VII Edition, Cengage Learning, India
- Barrington, E.J.W. (2012). Invertebrate Structure and Functions. II Edition, EWP Publishers

Discipline Specific Elective (DSE) Course - I: ZOO701D(a)
Wildlife & Bioresource management

Objective:

The Discipline Specific Paper on Wildlife Conservation and Management is designed to acquaint students with varied aspects of wildlife conservation, including its importance, major threats, management of their habitats and populations. The emphasis will be on developing interest and invoking a sense of responsibility among students towards wildlife conservation.The course also explores different techniques, perspectives, and approaches to both identifyand achieve wildlife management goals. This course will motivate students to pursue career in the field of wildlife conservation and management.

Outcome:

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

- Become aware about the importance of wildlife in general, and its conservation andmanagement in particular.
- Comprehend the application of the principles of ecology and animal behaviour toformulate strategies for the management of wildlife populations and their habitats.
- Understand the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Know the key factors for loss of wildlife and important strategies for their *in situ* and *exsitu* conservation.
- Recognize the techniques for estimation, remote sensing and Global Position Trackingfor wildlife.
- Gain knowledge about the wildlife diseases and the quarantine policies.
- Know about the Protected Area Networks in India, Ecotourism, Ecology of perturbationand Climax persistence.
- Perform critical thinking, literature review; scientific writing as well as presentations; and participation in citizen science initiatives with reference to wildlife.

Course Content:

Theory [Credits: 4] 60 hrs/ 100 marks

Unit 1: Introduction , evaluation & management of Wildlife 12 hrs/20 marks

Values of wildlife - positive and negative; Conservation ethics; Importance of conservation; Causes of depletion; World conservation strategies: WCS, CBD, Agenda 21. Habitat analysis: a) Physical parameters: Topography, Geology, Soil and water; b) Biological Parameters: food, cover, forage, browse and cover estimation; Standard evaluation procedures: remote sensing and GIS.

Unit 2: Management of Habitats , Population estimation 12 hrs/20 marks

Setting back succession: Grazing logging; Mechanical treatment; Advancing the successionalprocess: Cover construction; Preservation of general genetic diversity; Restoration of degraded habitats. Population density, Natality, Birth rate, Mortality,

fertility schedules and sex ratio computation; Faecal analysis of ungulates and carnivores: Faecal samples, slide preparation,and Hair identification; Pug marks and Census methods

Unit 3: Excess population of Wildlife & Protected Areas– Management & Planning

12 hrs/20 marks

Estimation of carrying capacity; Human-wildlife conflict; Eco tourism / wild life tourism in forests; Climax communities: characteristics and theories; Ecology of purterbance. Bio- telemetry; Care of injured and diseased animal; Quarantine; Common diseases of wildanimals: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and Mouth Disease, *Mycobacterium* TB, Bovine and Avian Flu

Unit 4 : Protected areas 12 hrs/20 marks

Biodiversity hotspots, Biosphere reserves, National parks and sanctuaries; Biosphere reserves; Conservation and Community reserve; Important features of protected areas in India; Tiger conservation - Tiger reserves in India andManagement, challenges in Tiger reserve; Brow Antlered Deer conservation & Challenges

Unit 5 : Bioresource 12 hrs/20 marks

Bioresource Concepts and types – Animals, Plants, Cells, Genes, Microorganisms. Significance of Bioresources and threats faced by them, Insect resources, Fishes and Livestock, Animal products & processing, Biomass, Bioenergy and Biomaterials; basic biomolecules and Water; Antigen & antibodies, Bioremediation.

Recommended Books:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHIlearning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley,G. (2006). Wildlife Ecology, Conservationand Management. Wiley-Blackwell, Oxford, UK.
- Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.

Suggested Readings:

- Hudson, P.J., Rizzoli, A., Grenfell, B.T. Heestrbeek, H. and Dobson, A.P. (2002). TheEcology of Wildlife Diseases. Oxford University Press, Oxford.
- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas.Agrobios, India.
- Sharma, B.D. (1999). Indian Wildlife Resources Ecologyand Development. DayaPublishing House, Delhi.
- Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc.Sunderland, MA.
- Hossetti, B. B. (1997). Concepts in Wildlife Management. Daya Publishing House, Delhi.

Online Tools and Web Resources:

- https://swayam.gov.in/courses/4687-july-2018-wildlife-conservation
- https://swayam.gov.in/courses/5364-jan-2019-wild-life-ecology
- https://papaco.org/mooc-on-species-conservation/
- https://www.iucn.org/theme/protected-areas/our-work/capacity-development/moocs
- https://www.zsl.org/united-for-wildlife-free-conservation-courses
- https://wildlife.org/next-generation/career-development/online-courses/ https://www.openlearning.com/umtmooc/courses/wildlife-management

Discipline Specific Elective (DSE) Course –I Practical :
ZOO701DP(a)
Wildlife & Bioresource management

Practical [Credits 2] **30 hrs/50 marks**

1. Identification of mammalian fauna, avian fauna, herpeto-fauna through direct and indirectevidences seen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System,Varioustypes of Cameras and lenses).
3. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, nests and antlers.
4. Demonstration of different field techniques for flora and fauna: PCQM.
5. Trail / transect monitoring for abundance and diversity estimation of mammals and bird (direct and indirect evidences).
6. Identification of big cats: Lion, tiger, panther, cheetah, leopard and jaguar.
7. A report based on a visit to National Park/Wildlife Sanctuary/Biodiversity Park or any other wildlife conservation site.

Examination evaluation Structure:

1. Identification of Fauna from models/ Pictures/Photos: 5 numbers x 4 marks (Identification=1, Characters=3): Total = 20
2. Identification of pug marks, hoof marks, scats, nests and antlers from models/ Pictures/Photos: 5 numbers x 2 marks (Identification=1, Character=1): Total = 10
3. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
4. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)
5. Field visit report : 5 marks

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student. The case study approach with real-life examples from the field will give a better understanding of the subject and its applications. The traditional chalk and talk method will be supplemented with LCD projection system and use of visualizer for theory classes. Projection of videos or short movies available on the subject will enhance the understandingof the subject. Digital collection of pictures of pugmarks, hoof marks, bird's nests, wild faunaand flora will facilitate observation of their characteristic features with ease.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium will be adopted to achieve this. Project based reports, assignments and E-posters can also form an important part of learning regime.
- Laboratory sessions will constitute an important part of the course along with its

theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text. Field-based research projects will develop interest in the subject and motivate students to peruse research as a career in future. Visits to renowned institutions and Zoological Park will provide students a practical or hands on knowledge of the subject. Students should participate in citizen science initiatives related to wildlife such as bird counts and uploading of the data on E-bird.org.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Discipline Specific Elective (DSE) Course - I: ZOO701D(b)
Integrated Pest management

Objective:

The course is designed with an aim to provide the students the knowledge of balance of nature, understand the life cycles, behaviours, and interactions of pests within ecosystems. Develop the ability to accurately identify pests and beneficial organisms, Learn about the safety measures and regulatory aspects of pesticide use.

Outcome:

Upon completion of the course, students shall be able to recognize and identify various pest species and their life cycles, have Strong critical thinking and problem-solving skills tailored to addressing pest management challenges, Understand the safety protocols and regulatory requirements associated with pesticide use and to implement IPM plans effectively in real-world agricultural settings.

Course Content:

Theory [Credits: 4] **60 hrs/ 100 marks**

Unit 1: Introduction to IPM 12 hrs/20 marks

Introduction: Definition and Importance of IPM; Historical development of IPM; Pests definition and categories. Plant pathology, Concept of pest management, Ecological aspects as foundation for IPM; Principles of IPM, mechanical strategy for IPM.

Unit 2: **Components of IPM-I** 12 hrs/20 marks

Economic thresholds, Sampling & monitoring of Pests, Legal approach to IPM, ecological management, diverting pest population away from the crop.; managing insects with resistant plants; history, mechanism of resistance and use of plants as resistant means in pest management.

Unit 3 : **Biological and Genetic control** 12 hrs/20 marks

Biological control; predators, parasitoids and microbes. Merits & demerits of Biological control, Pest management by modifying insect development and behaviour; Sterile insect technique. Sterile Insect release method; Botanical pest management. Genetic control and transgenic plants, insect growth regulators like repellants, attractants, inhibitors etc.

Unit 4: Chemical and Innovative approaches for IPM 12 hrs/20 marks

Chemical means of pest management. Types of Insecticides, adjuvant & formulation, Chemical control with reference to organochloride, organophosphate, carbamates, synthetic pyrethroids ; Pest management through innovative approaches like biotechnological approach,; Adoption of IPM; pros and cons.

Unit 5: **IPM and sustainable agriculture** 12 hrs/20 marks

Implementation of IPM in cereals (paddy), pulses (pigeon pea and Soybean) and commercial crops (sugarcane), vegetable crops (cabbage and tomato), Pesticide in IPM & Pesticide management, Host plant resistance, Weed management

Recommended Books:

1. Handbook of Integrated Pest Management by Govt. of India Indian Council of Agricultural Research (ICAR).
2. General and Applied Entomology by David B.V and Ananthakrishnan T.N; Tata McGraw Hills, New Delhi.
3. Biopesticides and Pest management by Dhaliwal G.S and Opendro Koul. Kalyani Publishers, New Delhi.

Suggested Readings:

1. A manual of practical Entomology (field and Laboratory guide) by M.M Trigunayat. Scientific publishers (India)
2. Elements of Economic Entomology by David B.V and Ramamurthy V.V. Namrutha publication, Chennai

Online Tools and Web Resources:

1. http://www.eagri.org/eagri50/ENTO232/index.html
2. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=12468

Discipline Specific Elective (DSE) Course –I Practical : ZOO701DP(b)

Integrated Pest management

Practical [Credits 2] **30 hrs/50 marks**

Examination evaluation Structure:

Examination evaluation Structure

1. Identification of Pest, Parasitoid species. 5x4=20 Mark
2. Pesticide formulation. 5 Mark
3. Submit a report of field visit (Paddy field, Vegetable farm, Fruit Orchard). 10 Mark

6. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
7. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

- The teaching strategy will emphasize on problem-based learning to develop the requisite knowledge, skills and learning attitude of the student.
- A variety of approaches to teaching-learning process, including lectures, seminars, powerpoint presentations, workshops, peer teaching/learning, assignments, project-based learning, simulation videos, group or co-operative learning, book reviews, research colloquium willbe adopted to achieve this.
- Laboratory sessions will constitute an important part of the course along with its theoretical background. The laboratory sessions will include pre-lab questions and post-lab questionson start and completion of experiment. The experiments will be presented in the form of laboratory reports, which will train the students to write and formulate scientific text.

Assessment Methods:

Measures to be adopted for assessment are as follows.

- **Class Tests**: Regular class tests will judge the grasp of the topics by the students.
- **Projects and Assignments**: Individual/group projects will inculcate independent thinking as well as the team work skills among the students.
- **Regular Presentations**: Presentations by the students on a particular topic will enhance student's learning and confidence. The presentations will be assessed based on the content, novelty, explanation and response to queries raised by peers.
- ***Viva-voce****: Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.

Discipline Specific Elective (DSE) Course - I: ZOO701D(c)
Fish & Fisheries

Objective:

The course is designed with an aim to provide the students the knowledge to learn about taxonomic identification of various cultivable fishes, basic idea of production of fish seed, rearing of spawn stage fry and fingerling, basic fish physiology, feed formulation, harvesting, processing of fishery products and marketing.

Outcome:

Upon completion of the course, students shall be able to:

- identify various cultivable fish species,
- breed and rear cultivable fishes,
- formulate fish feed,
- harvesting and processing of fishery products and marketing.

Course Content:

Theory [Credits: 4] **60hrs/ 100 marks**

Unit1: Integrative Fish Taxonomy: Morphological, Anatomical (osteology) and Molecular Approach (Fish DNA barcoding), characteristics of Chondrichthyes & Osteichthyes, dichotomous key, type specimens, invasive species, commercially important endemic and exotic food fishes, ornamental fishes, brackish water and coldwater fishes, hill stream fishes and its adaptive modification, cultivable species of prawn. 12 hrs/20 marks

Unit2: Fish Physiology and biotechnology: Types of scales, modification of alimentary canal based on food and feeding habits, digestion of food, circulation in fish, aquatic respiration, osmoregulation in migratory fishes. Cryopreservation of milt, Hybridization, production of monosex population, transgenic fish: its merits and demerits. Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals. 12 hrs/20 marks

Unit3: Fish reproduction, breeding and seed production: Functional morphology of gonads, types and modes of reproduction, Fecundity, Bundh breeding, induced breeding by using pituitary extract; induced breeding by injecting commercial synthetic hormones, hatcheries: Double-walled hatching hapa, clay pots, glass jars, Chinese circular hatcheries; stages of fish seeds, conditioning, packing, and transport of brood fishes and fish seed. 12 hrs/20 marks

Unit4: Fish farming and ecological parameters: Fish farm construction and layout of different types of ponds; Pre-stocking preparation of Ponds; Post-stocking management. Physico-chemical properties of pond water and soil and their maintenance. Different types of aquaculture systems based on stocking density and management practices. Climate Resilient Aquaculture Technologies: Recirculatory Aquaculture System (RAS), Biofloc, Aquaponics.

12 hrs/20 marks

Unit5: **Fish Nutrition and health; Harvesting & preservation techniques, extension and marketing**: Components of fish feed; principle of fish feed formulation, fish food organisms. Fish diseases: Infectious and Non-infectious Pathogens (bacterial, viral, fungal, protozoan, helminth diseases of fish, nutritional disease). Inland fishing crafts and gears, Spoilage of fish and causative agents, methods of fish preservation and processing, methods of fishery extension, fish marketing channels.

12 hrs/20 marks

Recommended Books:

1. Jhingran, V.G.: Fish and Fisheries of India 3rd. En Today and Tomorrow Book Agency, New Delhi
2. Pillay, T.V.R. 1990: Aquaculture, principles and Techniques. Fishing News Bk. Ltd.
3. Edmonson, W.I.: Freshwater Biology, War and Weipel.
4. Abidi, R.: Fish Pathogen & Diseases in India.
5. Amlacher, E.: Text Book of Fish Diseases.
6. Gupta, S. K. & P.C. Gupta: General and Applied Ichthyology (Fish and Fishery), S. Chand & Co. Ramnagar, New Delhi, 110055.
7. Lagler, K. F., Bardach, J. E., Miller, R. R., & Dora, R. May Passino (1977) Ichthyology.
8. Lucas, J. S., Southgate, P. C., & Tucker, C. S. (Eds.). (2019). *Aquaculture: Farming aquatic animals and plants*. John Wiley & Sons.
9. Hoar, W. S., Randall, D. J., & Donaldson, E. M. (1983). *Fish physiology*. Academic Press.
10. Vishwanath, W. (2021). *Fishes of Eastern Himalayas*. Academic Press.
11. Darshan, A., Abujam S., & Das, D.N. (2019). Biodiversity of Fishes in Arunachal Himalaya. Academic Press.
12. Timmons, M. B., Guerdat, T., & Vinci, B. J. (2018). *Recirculatory Aquaculture System*, 4th Edition, Ithaca Publishing Company LLC.
13. Goddek, S., Joyce, A., Kotzen, B, & Burnell, G.M. (2019). *Aquaponics Food Production Systems.* Springer.
14. Wedmeyer, A.F.S.: Fish Hatchery & Management.
15. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub.
16. George Borgstrom Elsevier,: Fish as Food, Vol.I & II.
17. Chonder, S. L. (1994): Induced Carp breeding. CBS Publishers & Distributors, New Delhi-110002.
18. Roberts, R. J. (2012). Fish pathology. John Wiley & Sons.
19. Pandey, P. K., Mallik, S. K., & Yumnam, R. (Eds.). (2024). Handbook of Aquatic Microbiology. CRC Press.
20. Biswas, K. P. (1990). A Text Book of Fish, Fisheries & Technology. Narendra Publishing House.

21. Thomas, P.C., Rath, S.C., Mohapatra, K. D. (2013). Breeding and seed production of Fin Fish and Shell fish. Astral publication, Gaya.

Suggested Readings:

1. Piper, R. G., McElwain, I. B., Orme, L. E., McCraren, J. P., Fowler, L. G., Leonard, J. R. (1986). Fish Hatchery Management. US Government Printing Office.
2. Wedmeyer, A.F.S.: Fish Hatchery and Management.
3. Von Brandt's: Fish Catching Techniques of the World. Blackwell Pub.
4. George Borgstrom Elsevier: Fish as Food, Vol. I & II.

Online Tools and Web Resources:

1. Eschmeyer's Catalog of Fishes Online Database (https://www.calacademy.org/scientists/projects/eschmeyers-catalog-of-fishes)
2. Food and Agriculture Organisation of the United Nations (https://www.fao.org/home/en/)
3. Indian Council of Agricultural Research (https://icar.org.in/)

Discipline Specific Elective (DSE) Course –I Practical : ZOO701D(c)

Fish & Fisheries

Practical [Credits 2] **30 hrs/50 marks**

Examination Evaluation Structure:

6. Identification and classification of endemic food fishes, weed fishes and predatory fishes using morphometric and meristic characters, and taxonomic keys.
7. Identification of exotic invasive fish species using morphometric and meristic characters.
8. Identification of predatory insects and common aquatic weeds in fish pond.
9. Identification of common fish parasites.
10. Fecundity: Estimation the number of eggs by gravimetric and volumetric methods.
11. Water and soil sampling from fish farms. Physico-chemical analysis of water - turbidity, temperature, dissolved oxygen, carbon dioxide, alkalinity, pH, BOD, TAN, Ammonia, TSS
12. Dissection of Weberian Ossicles
13. Study of food and feeding habits of fishes: Bucco-pharynx of economically important fishes, Pharyngeal teeth.
14. Note Book: 5 marks (Based on the neatness, inclusiveness, overall presentation)
15. Viva-Voce: 10 marks (Testing of Knowledge in the said Course)

Examination evaluation Structure:

1. Identification, Classification, Types & Characters of Fishes – (1+2+1+2=6) x 4=24 marks
2. Physico-Chemical analysis of Water; Dissection of Weberian Ossicles; (Procedure =3,experiment = 3, result= 2) = 8 marks
3. Identification of Food and feeding habits of fishes (Identification=1;remark=2)=3

marks

4. Note Book: 5 marks (Based on the neatness, regularity, overall presentation)
5. Viva-Voce : 10 marks (Testing of Knowledge in the said Course)

Teaching and Learning Process:

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- **Viva-voce**: *Viva-voce* is another critical component of assessment of the practical component of a course. Inquiry-based learning blended with hands-on learning will develop critical thinking and competencies among students.
- **Semester-end Examination**: Semester-end examination and grading of students based on their performance in the exams is an indicator of student's learning throughout the semester. A comparative assessment of students through final exams, analyses comprehensive knowledge gained by each student.