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DISCIPLINE SPECIFIC ELECTIVE COURSE -17
Research Methodology for Zoology
Zoo-DSE-17

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research Methodology for Zoology Zoo-DSE-17	**04**	**03**	**Nil**	**01**	**Appeared in Sem V**	**10+2 with Biology**

Learning Objectives

The learning objectives of this course are as follows:

- to develop a comprehensive understanding of research fundamentals, including its meaning, objectives, and motivation.
- to distinguish between various research methods and methodologies, and recognize the significance of different research types.
- to learn the principles of designing robust research studies, including problem identification, experimental planning, and sample design.
- to acquire skills in data collection, processing, analysis, and the effective presentation of research findings using digital tools.
- to enhance the ability to write literature reviews, bibliographies, and references accurately using appropriate software.
- to develop critical thinking and communication skills through oral and poster seminar presentations.
- to gain awareness of ethical aspects in research, including intellectual property rights, plagiarism, patent laws, and guidelines for laboratory animal use.
- to understand the processes involved in obtaining research grants, fellowships, and commercialization of research outputs.

Learning Outcomes

By studying this course, students will be able to

- articulate the purpose and significance of research and differentiate between its various types and methodologies.
- design and implement a well-structured research plan, incorporating sound problem identification, experimentation, and sample design techniques.
- employ appropriate methods for data collection, processing, and analysis, and present findings using clear and effective visuals.

- demonstrate proficiency in writing a literature review, preparing bibliographies, and using referencing tools.
- effectively communicate research findings through oral and poster presentations.
- exhibit ethical conduct in research by adhering to guidelines for intellectual property rights, plagiarism, and laboratory animal usage.
- recognize the importance of research commercialization and navigate processes for securing research grants and fellowships.
- develop a strong foundation in research methodology, enabling lifelong learning and contributions to academic and industrial research.

Syllabus OF DSE-17

Theory **45 hrs**

Unit1: Foundations of Research **10 hrs**

Meaning, Objectives, Motivation: Research Methods *vs* Methodology, Types of Research: Analytical *vs* Descriptive, Quantitative *vs* Qualitative, Basic *vs* Applied and Industrial research.

Unit 2: Research Design **10 hrs**

Need for research design: Features of good study design, Important concepts related to good design-Observation and Facts, Prediction and Explanation, Development of Models. Developing a research plan: Problem identification, Experimentation, Determining experimental and sample designs.

Unit 3: Data Collection, Analysis and Report Writing **15 hrs**

Observation and Collection of Data-Methods of data collection- Sampling Methods, how to decide sample size/Calculation of sample size, Data Processing and Analysis Strategies; Preparation of Tables and Figures; Literature review writing; Bibliography/References using software; Data Presentation using digital tools. Seminar presentation (oral/poster).

Unit 4: Ethical Issues **10 hrs**

Intellectual Property Rights, Copyright, Royalty, Patent laws, Commercialization, Plagiarism, Citations, Acknowledgement, Research Grants/ Fellowships, Introduction to CCSEA Guidelines for laboratory animals.

Practical **60 hrs**
(Laboratory periods: 15 classes of 4 hours each)

1. Usage of search engine tools for retrieving research/review papers.

2. To generate a hypothesis and design an experiment.
3. Collection of data, interpretation and writing an article (research/review papers).
4. Graphical representation and interpretation of the data provided.
5. Title and abstract writing for a given research paper.
6. Preparation of bibliography/references in different formats as per journal requirements.
7. Usage of software tools for checking plagiarism.
8. Drug designing tools and their usage.

Suggestive readings

1. Anthony, M, Graziano, A.M. and Raulin, M.L. (2009) Research Methods: A Process of Inquiry, Allyn and Bacon.
2. Walliman, N. (2011) Research Methods- The Basics. Taylor and Francis, London, New York, USA.

Suggested Readings

1. Wadhera, B.L. (2002) Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing
2. Kothari, C.R. (2009) Research Methodology, New Age International.
3. Coley, S.M. and Scheinberg, C.A. (1990) "Proposal writing". Stage Publications.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -19

Animal Model and Experimentation

Zoo-DSC-19

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Animal Model and Experimentation Zoo-DSC-19	**04**	**02**	**Nil**	**02**	**Appeared in Sem VI**	**Basic understanding of physiology, molecular biology, and genetics.**

Learning Objectives

The learning objectives of this course are as follows:

- to acquire an in-depth knowledge importance and applications of animal models in scientific research.
- to understand theoretical concepts, ethical principles and legal frameworks governing animal experimentation to assist in comprehending the quick response to pandemics in the form of vaccines.
- to gain theoretical and practical knowledge of experimental techniques using animal models.
- to develop skills to design experiments involving animal models for disease studies, drug testing, and toxicity assessments.
- to explore alternatives to animal experimentation and their role in modern research.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the concepts of the selection criteria, types, and applications of animal models in research.
- demonstrate competence in handling, restraining, and administering treatments to animals in a humane and ethical manner.
- analyze and interpret data generated from animal experiments.
- critically evaluate the ethical considerations in using animals for research and propose alternatives when feasible.
- design small-scale experiments using appropriate animal models to investigate scientific hypotheses.

SYLLABUS OF DSC-19

Theory **30 hrs**

UNIT 1: Introduction to Animal Models **6 hrs**

Definition and Importance, Historical perspective and significance in biomedical research. Types of Animal Models: Inbred, outbred, transgenic, and knockout models. Specific examples: Rodents (mice, rats) for genetic and drug studies. Zebrafish for Developmental Biology. Drosophila as a model for genetics. Non-human primates for neurological studies. Criteria for Selecting an Animal Model: Relevance to human biology. Ethical considerations.

UNIT 2: Experimental Design and Techniques **10 hrs**

Design of Experiments (DoE): Importance of hypothesis-driven research. Sample size estimation and randomization. Reducing bias in experiments. Common Experimental Techniques: Behavioural studies: Open field test, maze tests, and anxiety models. Imaging techniques: Use of MRI, CT, and live imaging in animals. Tissue collection and processing. Gene Editing in Animal Models: CRISPR-Cas9 and its applications. Creating knockout and knock-in models.

UNIT 3: Application of Animal Models **8 hrs**

Disease Models: Oncology: Induced tumour models. Neurological disorders: Alzheimer's and Parkinson's models. Metabolic disorders: Diabetes and obesity models. Infectious diseases: Models for tuberculosis, malaria, and viral infections. Drug Discovery and Toxicology: Role of animal models in preclinical trials. Acute and chronic toxicity studies. Drug absorption, distribution, metabolism, and excretion (ADME). Regenerative Medicine and Transplantation: Use of animals in stem cell research. Organ transplantation studies in animal models.

UNIT 4: Ethical and Regulatory Aspects of Animal Experimentation **6 hrs**

Ethics in Animal Experimentation: Importance of humane treatment of animals. Principles of the 3Rs: Replacement, Reduction, and Refinement. Regulatory Frameworks: CPCSEA (India) and International Guidelines. Role of Institutional Animal Ethics Committees (IAECs). Good Laboratory Practices (GLP) for animal studies. Alternatives to Animal Testing: In-vitro models, organoids, and computational models. Advantages and limitations of alternatives.

Practical **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Selection and Handling of Animal Models: Basic handling and restraint techniques for mice, rats, and zebrafish. Observation of behaviour and physiological parameters.
2. Techniques in Experimental Research: Induction of disease models (e.g., diabetes with streptozotocin, tumors using carcinogens). Behavioral testing: Maze and anxiety tests. Sample collection: Blood and tissue collection techniques.
3. Histology and Imaging: Preparation of tissues for histological studies. Basic imaging techniques (e.g., fluorescent microscopy).

4. Ethical Simulations: Case studies on ethical dilemmas. Mock IAEC proposal writing and review.
5. Presentation of Findings - Preparation of Scientific Posters - Oral Presentation Skills for Sharing Research Outcomes
6. Project on any topic/ Project report on visit to any research institute/laboratory to study the research using any animal model.

Suggestive readings

1. Guide for the Care and Use of Laboratory Animals – National Research Council 8th Edition, 2011 9 Publisher: National Academies Press; ISBN: 978-0-309-15400-0.
2. Laboratory Animal Medicine 2nd Edition, 2002 Publisher: Academic Press; ISBN: 978-0-12-263951-7– James G. Fox, Bennett J. Cohen, Franklin M. Loew.
3. Principles of Laboratory Animal Science, Revised Edition, 2001, Publisher: Elsevier ISBN: 978-0-444-50612-2– L.F.M. van Zutphen, V. Baumans, A.C. Beynen.
4. Handbook of Laboratory Animal Management and Welfare, 4th Edition, 2013, Publisher: Wiley-Blackwell; ISBN: 978-0-470-65567-1– Sarah Wolfensohn, Maggie Lloyd.
5. Ethics of Animal Research: Exploring the Controversy, 2012, Publisher: MIT Press; ISBN: 978-0-262-01734-6– Jeremy R. Garrett.

Suggested Readings

1. Experimental Design and Data Analysis for Biologists 2002, Publisher: Cambridge University Press; ISBN: 978-0-521-00976-8– Gerry P. Quinn, Michael J. Keough.
2. Animal Models in Biomedical Research, 2010, Publisher: Humana Press; ISBN: 978-1-60761-670-2 – Timothy G. Geary, Aaron Maule (Editors).
3. Alternatives to Animal Testing: New Ways in the Biomedical Sciences, 2008, Publisher: Wiley-VCH; ISBN: 978-3-527-32090-2 – Christoph A. Reinhardt. Laboratory Manual for Animal Research, 1997, Publisher: Oxford University Press; ISBN: 978-0-19-511908-4– Tom L. Beauchamp *(A practical resource for students learning techniques in animal research and experimentation).*
4. CPCSEA Guidelines for Laboratory Animal Facility, 2003 – Committee for the Purpose of Control and Supervision of Experiments on Animals (India).
5. Zebrafish: Methods and Protocols. 2012, Publisher: Humana Press; ISBN: 978-1-61779-597-8 – Allan V. Kalueff, Adam C. Gould.
6. Behavioral Research and Animal Welfare, 2019 Publisher: Springer; ISBN: 978-3-030-13966-1 – Edward Narayan.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -18
Advanced Biotechniques and Bioinstrumentation
Zoo-DSE-18

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
Advanced Biotechniques and Bioinstrumentation Zoo-DSE-18	**04**	**03**	**Nil**	**01**	**Appeared in Sem VI**	**Basic understanding of molecular biology, biochemistry, and instrumentation techniques.**

Learning Objectives

The learning objectives of this course are as follows:

- to understand advanced techniques used in biotechnology for research, diagnostics, and industrial applications.
- to learn the principles, applications, and limitations of bioinstrumentation methods.
- to gain hands-on experience in the operation and maintenance of advanced instruments.
- to develop critical thinking to select and apply suitable techniques for solving specific biological problems.
- To learn to interpret experimental data and troubleshoot issues in instrumentation.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the diverse cellular processes and cellular interactions.
- to explain the principles and working mechanisms of advanced instruments in biotechnology.
- to demonstrate proficiency in operating instruments like spectrophotometers, chromatographs, and PCR machines.
- to design experiments using advanced techniques like chromatography, electrophoresis, and mass spectrometry.
- to analyze experimental data generated by advanced bioinstrumentation.

- to apply biotechnological tools to solve problems in diagnostics, genomics, proteomics, and drug discovery.

Syllabus of DSE-18

Theory **45 hrs**

UNIT- 1: Spectroscopic Techniques **10 hrs**

Principles and Applications: UV-Visible spectroscopy, Fluorescence spectroscopy, Circular Dichroism (CD). Advanced Techniques: Infrared (IR) spectroscopy, Atomic Absorption Spectroscopy (AAS), and Nuclear Magnetic Resonance (NMR).

Applications: Structure determination, protein folding studies, and biomolecular interactions.

UNIT-2: Chromatography and Electrophoresis **10 hrs**

Chromatography: Principles, instrumentation, and applications of HPLC, Gas Chromatography (GC), and Ion Exchange Chromatography.

Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis, 2D Gel Electrophoresis. Applications in genomics and proteomics.

UNIT-3: Molecular Biology Techniques **9 hrs**

Polymerase Chain Reaction (PCR): qPCR, RT-PCR, and digital PCR.

DNA Sequencing: Sanger sequencing and Next-Generation Sequencing (NGS).

CRISPR-Cas9 Technology: Gene editing and applications.

UNIT 4: Imaging and Analytical Tools **9 hrs**

Microscopy: Principles and applications of Confocal Microscopy, Electron Microscopy (SEM, TEM). Mass Spectrometry (MS): Principles, instrumentation, and applications in proteomics and metabolomics.

UNIT 5: Biosensor **7 hrs**

Biosensors: Principles, components, and applications in diagnostics.

Practical **30 hrs**

(Laboratory periods: 15 classes of 2 hours each)

1. Chromatography Techniques: Separation of biomolecules using Chromatography.
2. Electrophoresis Techniques: SDS-PAGE for protein separation.
3. Amplification of DNA. Gel documentation and analysis of PCR products.
4. Imaging Techniques: Demonstration of SEM/TEM.
5. Biosensors: Demonstration of glucose biosensors and ELISA techniques.

Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. 1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, 7th Edition (2010), Cambridge University Press.
2. Biophysical Chemistry: Principles and Techniques by Upadhyay, Upadhyay, and Nath, Revised Edition (2020), Himalaya Publishing.
3. Introduction to Spectroscopy by Donald L. Pavia et al., 5th Edition (2015), Cengage Learning.
4. Bioinstrumentation by John G. Webster, 1st Edition (2004), Wiley-Interscience.

Suggestive readings

1. 1. Fundamentals of Analytical Chemistry by Douglas A. Skoog et al., 9th Edition (2013), Cengage Learning.
2. Molecular Biology of the Gene by James D. Watson et al., 7th Edition (2013), Pearson.
3. Chromatography: Principles and Instrumentation by B.K. Sharma, Revised Edition (2007), Goel Publishing House.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -19
Ichthyology
Zoo-DSE-19

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ichthyology Zoo-DSE-19	**4**	**3**	**NIL**	**1**	**Appeared in Semester VI**	**Basic understanding of physiology, reproduction and animal world.**

Learning Objectives

The Learning Objectives of this course are as follows:

- To increase student familiarity with evolutionary history and taxonomic diversity of fishes.
- To improve understanding of the basic physiological and behavioural adaptations of fishes.
- To enhance student skill in studying locally available fish species.
- To expose students to some of the issues surrounding the conservation of fish biodiversity in the environment.

The Learning Outcomes

The learning Outcomes of this course are as follows:

- After studying this course, student can keep track of types of fish and morphology of fishes.
- Detailed knowledge about the physiology of fishes.
- Knowledge of various feeding habits, adaptations, parental care, and reproductions of fish.
- The advanced knowledge about the fishes would be helpful for designing experiments for research.

Syllabus- DSE-19:

Theory **45 hrs**

Unit-1 Introduction to Fishes **8 hrs**

Introduction and types of fishes, Classification, General Characters, Fish Origin: The diversification and relationships of jawless and jawed fishes.

Unit-2 Fish Morphology and Anatomy **8 hrs**

Scales, Teeth, Muscles, Swim-bladder, Gills, Fins, Skull, Weberian ossicles, Lateral-line system.

Unit-3 Fish Physiology **15 hrs**

Gas exchange, Internal transport and Homeostasis- Aquatic and Aerial respiration, Cardiovascular physiology, Hematology, Lymphoid organs, osmoionic regulation, Acid-base balance, nitrogen excretion and metabolism, Sensory systems–photoreception, chemoreception, mechanoreception, electroreception.

Unit-4 Reproduction and Development 8 hrs

Oviparity and ovoviviparity, Prolific breeders, Fecundity, Induced breeding, Fish larval stages, Parental care in fishes.

Unit-5 Food and Feeding habits of Fish and Adaptation 6 hrs

Fish foods and feeding habits, Adaptions in hill stream and deep-sea fishes, Types of migration in fishes, Abiotic factors and their influence on fish.

Practical Exercise: 30 hrs

(Laboratory periods: 15 classes of 2 hours each)

1. Identification of local fishes by physical key methods.
2. Study of different types of fish scales.
3. Study of fish chromatophores under microscopes.
4. Analysis of water quality parameters viz. temperature, pH, dissolved oxygen.
5. Fish Morphometric measurements: Standard length, Total length, Fork length, Dorsal fin height, Pectoral fin length, Ventral fin length, Anal fin height.
6. Study of anatomy of digestive systems among different types of fishes.
7. Gonado-somatic index.
8. Study of Weberian ossicles and otoliths.
9. Visit to local fish market/farm and report preparation.

Recommended Readings:

- Biology of Fishes, Bone, Q. and Moore, R., Talyor and Francis Group, CRC Press, U.K.
- The Physiology of Fishes, Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK
- The Senses of Fish Adaptations for the Reception of Natural Stimuli, von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, INDIA
- Ichthyology, Lagler, K.F., Bardach, J.E. and Miller, R.R. John Wiley and Sons Inc., New York, USA
- A textbook of fish biology and fisheries, Khanna S.S. and Singh H.R. Narendra publishing house, Delhi

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -20
Applied Entomology
Zoo-DSE-20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Applied Entomology Zoo-DSE-20	**04**	**03**	**Nil**	**01**	**Appeared in Sem VI**	**Basic understanding of Insect Biology and Animal World.**

Course Learning Objective:

The learning objectives of this course are as follows:

- to impart in-depth knowledge of various aspects of insect world.
- to gain theoretical and practical knowledge of experimental techniques using insect as research models.
- to understand immense role of insects as ecosystem providers.
- to gain theoretical and practical knowledge of insects as pests and their economic impact.
- to explore pest management measures which are effective, economical and eco-friendly.

Course Learning Outcome:

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

- Learn about the fascinating world of insects from a holistic perspective.
- Learn about the biology of insects.
- Understand the difference between various types of beneficial and destructive insects.
- Gain knowledge about important insect pests of crops, fruits, vegetables, stored grains and of medical importance.
- Analyze the advantages and limitations of the various pest management measures and then design/ customize more effective measures by targeting the lacunae in the existing methods of pest management and by integrating the various aspects of Integrated Pest Management (IPM).

SYLLABUS OF DSE-20

Theory **45 hrs**

Unit 1: Exploring the Fascinating world of Insects. **10 hrs**

Overview of the economic importance of insects: Beneficial insects (Honey bees, Silkworm, Lac insect, ecosystem service providers: flesh flies, dung beetles, termites); Insect pests of agricultural crops, stored grains, medical and household; Insects as forensic agents: role of insects/arthropods in criminal investigation by predicting time and cause of death.

Unit 2: Co-evolution of insects and plants **5 hrs**

Insect-plant relationships, Mechanisms of insect resistance in plants, Tri-trophic interactions (Plant-insect pest-natural enemies).

Unit 3: Bionomics of Insect Pests of Agricultural Crops and Stored grains **12 hrs**

Pest, Economic threshold (ET), Economic injury level (EIL), classification of pests; Identification, seasonal history, nature of damage, life history and control of pests of rice: *Leptocorisa acuta; p*ulses: *Helicoverpa armigera*; Sugarcane: *Scirpophaga nivella*; Cotton: *Earias vitella*; Vegetables: *Raphidopalpa foveicollis*; Fruits: *Papilio demoleus*, Stored grains: *Sitophilus oryzae*, *Corcyra cephalonica*, *Callosobruchus chinensis*.

Unit 4: Bionomics of Insect pests of Medical and Household importance **6 hrs**

Bionomics and management of mosquitoes, lice, fleas, house fly, cockroach, and termites.

Unit 5: Pest Management Methods **12 hrs**

Physical, Cultural, Chemical, Biological, Microbial, Genetic (SIT, F_1 sterility, etc.), Biotechnological, and Bio-rational methods (using pheromones, JH mimics, MH agonists, etc.) in pest management. Integrated Pest Management (IPM) and Integrated Vector Management (IVM).

Practical Exercise: **30 hrs**
(Laboratory periods: 15 classes of 2 hours each)

1. **Study of morphology, growth and development of insect pests**
   (a) Rearing of a hemimetabolous (e.g. Red cotton bug, *Dysdercus keonigii*)/ holometabolous (e.g. pulse beetle, *Callosobruchus chinensis*) insect pest in the laboratory. Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.
   (b) Study of life history stages of insect pests of medical and household importance – mosquitoes (*Anopheles, Culex, Aedes*), lice, sand fly, flea, house fly, cockroach (*any four*). Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.

2. **Insect Toxicology:**
   (a) Estimation of LD_{50} and LC_{50} of insecticides using mosquito larvae/ given data.
   (b) Pesticide residue analysis of contaminated soil/vegetable/water samples using TLC.

Project work/ Field visits

1. Field survey of beneficial insects and insect pests. Submission of geo-tagged photographs captured in different locations, with details of field observations.

2. Visit to the labs and/or fields. Submission of a field report.

Essential/recommended readings:

- Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
- Dennis, S. Hill (2005). Agricultural Insect Pests of the Tropics and Their Management, Cambridge University press.
- Metcalf, C. L., Flint, W.P. and R.L. Metcalf (1962). Destructive and Useful Insects: their habits and control, 4th Ed. Mc Graw-Hill.
- Pedigo, L. P. (2002). Entomology & Pest Management, Prentice Hall, New Jersey, USA.
- Service, M. (2012). Medical Entomology for students, Cambridge University Press, UK.

Suggested Readings:

- S. Pradhan (1998) (Reprint 2023). Insect Pest of Crops. National Book Trust, New Delhi.
- Schoonhoven, L. M., van Loon, J.A., & Dicke, M. Insect Plant Biology (2005). Oxford University Press, USA.
- Jolivet, P. (1998). Interrelationship between insects and Plants, CRC Press, USA.
- Norris, Caswell-Chen and Kogan, M. (2002). Concepts of IPM, Prentice-Hall, USA.

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Category I

Zoology Courses for Undergraduate Programme of study with Zoology as a Single Core Discipline

SEMESTER-VIII

DISCIPLINE SPECIFIC CORE COURSE -20
Comparative Physiology of Vertebrates
Zoo-DSC-20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Comparative Physiology of Vertebrates Zoo-DSC-20	04	02	Nil	02	Appeared in Sem VII	Basic understanding of physiology, chordate, ecology and evolution.

Learning objectives:
This course focuses on:

- understanding the physiological mechanisms that enable vertebrates to adapt and evolve over time.
- exploring how different vertebrates, from fish to mammals, have developed unique physiological adaptations to meet the demands of their environments.

Learning outcomes:
At the end of this course students should be able to:

- Appreciate the variations in the reproductive strategies in accordance with the environment.
- Understand the mechanisms of extracting oxygen from the environment using different respiratory structures.
- Learn the significance of variations in the digestive system based on different diets.
- Appreciate the design of the cardiovascular system in different vertebrates as an efficient gas transport mechanism.
- Understand the various strategies for maintaining a steady physiological state and respond to extreme environmental conditions.

SYLLABUS OF DSC-20

Theory **30 hrs**

Unit 1: Physiological Processes **16 hrs**

Respiration: Gills, swim bladder, skin and lungs as respiratory organs; **Digestion:** Monogastric, digastric and polygastric digestive systems**; Circulation:** Single-circuit and double-circuit circulatory designs**; Reproduction:** Reproductive Cycles in seasonal and non-seasonal breeders.

Unit 2: Homeostasis **10 hrs**

Osmoregulation in freshwater, marine and terrestrial vertebrates. Thermoregulation in poikilotherms and homeotherms.

Unit 3: Adaptations **4 hrs**

Physiological responses to specific environmental challenges, like desert conditions, high altitude and starvation.

Practical **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Physiological Response of Drosophila/fish/stored grain pests to environmental stressors like temperature extremes/starvation.
2. Comparison of Hemoglobin content of fish blood in fish kept in normal and low-oxygen water.
3. Comparison of blood cells in a blood smear of a fish and human.
4. Study of rat vaginal smears during different phases of the Estrous cycle using permanent slides.
5. Project report (group activity) on effect of exercise/ yoga/meditation/adequate sleep/excessive mobile gaming on cardiovascular health (Heart rate, BP and SpO2 using pulse oximetry) to be submitted at the end of the semester.

Essential Readings:

1. How Animals work by Knut Schmidt-Nielsen, Cambridge University Press
2. Animal Physiology: Adaptation and Environment by Knut Schmidt-Nielsen, Cambridge University Press

Suggested Readings:

1. Animal Physiology by Hill et al, Sinauer Associates Inc.
2. Environmental Physiology of Animals by Willmer et al, John Wiley (original)
3. Principles of General and comparative physiology by Carpenter, W B, Forgotten Books.
4. Experiments with Drosophila for Biology courses (ebook) by Lakhotia, SC, Indian National Academy of Sciences.
5. Manual of Experimental Ichthyology by Gahlawat, SK et al, Daya Publishing House.
6. Cardiopulmonary Exercise testing and cardiovascular health by Karlman Waserman, Wiley-Blackwell.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -21
Evolutionary Immunobiology of Animals
Zoo-DSE-21

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Evolutionary Immunobiology of Animals ZOO-DSE-21	3	3	NIL	1	Appeared in Sem VII	Basic understanding of Animals.

Learning Objectives

The Learning Objectives of this course are as follows:

- To improve basic understanding about evolution of immune system among animals and group specific immunological adaptations.
- To increase student understanding about the evolution of complexity in immune system as well as immunological repertoire among animals.
- To help students to analyze immunological manifestations during experimentation and research.

The Learning Outcomes of this course are as follows:

- After studying this course, learners can understand the basic organization of the immune system among different groups of animals.
- Knowledge about evolution of primitive form of immune system and their functioning among invertebrates.
- Enhance student proficiency in understanding of immune system organization and their pathology in perturbation.

SYLLABUS- DSE: 21 **45 hrs**

Unit 1: Evolution of innate immunity: **15 hrs**

Basics of unicellular to metazoan immunity, evolution of immunological armament across the animal phyla, hematopoiesis and functions of hemocytes in invertebrates (Insects, Crustaceans, Mollusks and Tunicates) humoral factors of tunicates. Evolution of Drosophila Toll-1 receptors and mammalian Toll-like receptors and antimicrobial host-defense of Drosophila.

Unit 2: Evolution of adaptive immunity: 14 hrs

Origin and evolution of adaptive immunity in animals, a comparative account of lymphocyte development in vertebrates, humoral and cell mediated immunity in vertebrates, recognition of self/non-self, development of immunological memory. Major lymphoid organs and their distribution in fishes, nonspecific defense reaction of fishes. Peripheral lymphoid organs CALT, GALT, BALT, HALT and mural nodules in birds and other vertebrates.

Unit 3: Evolution of Cytokines in Vertebrate 08 hrs

Evolutionary Diversification of Cytokines. Pro-inflammatory, inflammatory and antimicrobial mediators of vertebrates and their functions.

Unit 4: Major Histocompatibility Complex 08 hrs

Genomic organization of MHC genes in vertebrates, evolution of Major Histocompatibility Complex in Teleost.

Practical 30 hrs

(Laboratory periods: 15 classes of 2 hours each)

1. Identification of organs of immune system in Fish, Amphibia, Aves and Mammals through slides/photographs.
2. Histological study of organs of immune system of vertebrates.
3. Staining and identification of Drosophila plasmatocytes.
4. Preparation and staining of Fish/Frog blood smear for the identification of different types of cells.
5. Study of techniques for the identification and quantification of cytokines and their expression.

Suggestive readings

1. Evolutionary Concepts in Immunology by Robert Jack, Louis Du Pasquier. Publisher: Springer Nature Switzerland.
2. Evolution and Comparative Immunology of Immune Systems in Marine Organisms by Gyri T. Haugland, Sissel Jentoft, Monica Hongroe Solbakken. Publisher: Frontiers.
3. The Evolution of the Immune System Conservation and Diversification by Davide Malagoli. Publisher: Academic Press.
4. Roitt's Essential Immunology by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt. Publisher: Wiley.
5. Veterinary Immunology by Ian R. Tizard. Publisher: Elsevier.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE 22 -
Faunal Conservation and Restoration
Zoo-DSE-22

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Faunal Conservation and Restoration Zoo-DSE-22	4	3	NIL	1	Appeared in Semester VII	Basic understanding of Ecology of Animals

Learning Objectives

The Learning Objectives of this course are as follows:

- to understand the faunal diversity in context to the Indian sub-continent, and recognise it as an integral part of global ecosystem.
- to understand theoretical concepts, ethical principles and legal frameworks governing animal conservation.
- to expose students to the various threats to the biodiversity.
- to identify contemporary issues related to wildlife conservation such as habitat loss, poaching, climate change, or biodiversity decline.
- to have an in-depth exploration of different strategies used in faunal conservation, such as protected areas, captive breeding, rewilding, or community-based conservation.

The Learning Outcomes of this course are as follows:

After studying this course, learner can:

- Understand the ethical, historical, and cross-cultural context of environmental issues related to fauna.
- Provide novel perspectives or solutions to conserve faunal species.

- Provide proposals for future research, policy changes, or conservation laws.

Syllabus DSE 22:

Theory **45 hrs**

Unit 1: Fundamentals of biodiversity **5 hrs**
Species diversity, genetic diversity and ecosystem diversity. Faunal biodiversity hotspots of India: Himalayan region, western ghats and north-eastern region. Sentinel species/ environmental guardians.

Unit 2: Valuing biodiversity **3 hrs**
Ecological economics, Ethical values, Evaluating development projects (any project of India).

Unit 3: Threats to biodiversity **14 hrs**
Pollution Ecology: Air, water, soil and radioactive. Emerging contaminants. Habitat destruction, fragmentation and degradation; Overexploitation. Global climate change, acid rain; Invasion Ecology; Ecotoxicology. Wildlife forensics- forensic protocols for species identification from different parts of reptiles, birds and mammals; wildlife crime case studies.

Unit 4: Conservation **10 hrs**
Sustainable utilization of natural resources; Bioprospecting; People biodiversity register; Role of indigenous knowledge system; Ecological footprinting; Protected areas; Policies and laws; Environmental impact assessment; GIS and remote sensing.

Unit 5: Restoration **5 hrs**
Factors involved in implementing ecological restoration: Restoration of major communities; Bioremediation.

Unit 6: Social issues and environment **8 hrs**
Global issues and sustainable development; Biodiversity crisis: how biodiversity is interconnected with ecosystem processes, and it's decline with emphasis on impact on human health. Release of GMOs in the environment.

Practical **30 hrs**
(Laboratory periods: 15 classes of 2 hours each)

1. To study pollutants: phosphate, nitrates, sulphates in the water sample (control and polluted)
2. To analyze and compare phosphorus, nitrogen, organic matter, particle size of the soil samples.
3. To perform toxicological bioassay tests: LC50/ EC50 on organisms such as zooplankton, stored grain pests etc.
4. Study any eight endangered animal species of India with focus on their conservation efforts

5. To study principle of Global Positioning System (GPS) and Geographic Information System (GIS)
6. Project Report on hypothesizing and designing experiment based on field or laboratory visit

Recommended Readings:

1. Richard, B. Primack, Essentials of Conservation Biology. (6th edition), Sinauer Associates.
2. Gabriel, M. Biodiversity and Conservation, Oxford and IBH Publishing.
3. Sharma, P.D., Ecology and Environment, Rastogi Publications.
4. Nair, S.M. Endangered Animals of India and their Conservation, National Book Trust of India.
5. Joseph, B., Environmental studies, Tata Mc Graw Hill.
6. Ghosh, S.K., Singh, R. 2003. Social Forestry and Forest Management. Global Vision Pub.
7. Sinha, S. 2010. Handbook on Wildlife Law Enforcement in India. TRAFFIC, India.
8. Mohapatra Textbook of Environmental Biotechnology, IK Publication.
9. Thakur, I. S., Environmental Biotechnology, IK Publication.
10. Divan Rosencraz, Environmental Laws and Policies in India, Oxford Publication.
11. Allabay, M., Basics of Environmental Science, Routledge Press.
12. Rana SVS, Environmental pollution – Health and Toxicology, Narosa Publication.
13. Miller, G.T. 2002. Sustaining the Earth, an Integrated Approach. (5th edition) Books/Cole, Thompson Learning, Inc.
14. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and Applications (2nd edition) Cambridge University Press.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE 23 -
Reproductive Endocrinology
Zoo-DSE-23

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reproductive Endocrinology Zoo-DSE-23	4	3	NIL	1	Appeared in Semester VII	Basic understanding of physiology, reproduction and reproductive disorders.

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the reproductive anatomy, physiology and endocrinology of male and female.
- To introduce and discuss the interrelationships between reproductive hormones produced by the brain and reproductive glands and how they interact to control the reproductive processes like pregnancy, parturition and lactation.
- To introduce and discuss reproductive management practices and understand endocrine disorders.

The Learning Outcomes of this course are as follows:

At the end of this course students should be able to:

- Appreciate the reproductive anatomy
- Learn the significance of physiology of the reproductive system, pregnancy and post pregnancy.
- Understand the various reproductive disorders

SYLLABUS- DSE-23

Theory **45 hrs**

Unit 1: Reproductive Anatomy- Male Reproductive System **10 hrs**

Primary and accessory sex organs and secondary sex characters. Histology of testis. Endocrine functions of testis. Spermatogenesis. Hypothalamic control of testicular functions.

Unit 2: Reproductive Anatomy- Female Reproductive System **15 hrs**

Histology of ovary. Ovarian hormones and their functions. Oogenesis and ovulation. Formation and functions of corpus luteum. Hypothalamic control of ovarian functions. Menstrual cycle and its regulation. Abnormalities in menstrual cycle. Onset of menopause and postmenopausal changes.

Unit 3: Physiology of Pregnancy, parturition and lactation **10 hrs**

Structure and functions of placenta. Maintenance of pregnancy and role of hormones. Development of mammary gland and lactation - role of hormones. Parturition. Pregnancy tests. Development of mammary glands, lactation and their hormonal control.

Unit 4: Reproductive Disorders **10 hrs**

Sexual differentiation & developmental abnormalities – male & female Menstrual disorders – Precocious, delayed or absent puberty; Amenorrhea Fertility disorders – Sexual dysfunction; Infertility; Spontaneous pregnancy loss Pregnancy disorders – Pre-eclampsia, IUGR, Labour abnormalities Endocrine disorders – Hyperprolactinemia Autoimmune Disorders Genetic disorders (mutations and syndromes) Cancers and biomarkers – Testicular; Prostate; Ovarian; Endometrial; Cervical and Breast.

Essential Readings

1. Endocrinology, Mac E. Hadley, Pearson Education.
2. Vander's Human Physiology, E.P. Widmaier et al., McGraw-Hill, Higher Education.
3. Endocrinology. Vols. I , II and III by L.O. DeGroot. W.B. Saunders Co.

Suggested Readings:

1. Human Physiology An Integrated Approach by D.U. Silverthorn,Pearson.
2. Medical Physiology, A.B. Singha Mahapatra, Current Books International.
3. "Pathways to Pregnancy and Parturition" (3rd Edition 2012, P. L. Senger)

Practical **30 hrs**

(Laboratory periods: 15 classes of 2 hours each)

1. To study surgical techniques via videos 1. Ovariectomy 2. Castration.
2. Histological and histochemical techniques - Study of rat vaginal smears during different phases of the estrous cycle using permanent slides.
3. To study sections of ovary, uterus, fallopian tube, testis.
4. Study of Sperm count and motility and effect of some antifertility agents.
5. Study of modern contraceptive devices.
6. Submission of project report on survey of reproductive health in any small human community.

Essential Readings

1. Endocrinology, Mac E. Hadley, Pearson Education.
2. Vander's Human Physiology, E.P. Widmaier et al., McGraw-Hill, Higher Education.
3. Endocrinology. Vols.I, II and III by L.O. DeGroot. W.B. Saunders Co.

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