**Appendix-4**
**AC dated - 11.08.2023**

# INDEX
## DEPARTMENT OF ZOOLOGY
## Semester-VI

**DISCIPLINE SPECIFIC CORE COURSE -16 – :**
**Animal Biotechnology**
**Zoo-DSC-16**

## 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 Biotechnology Zoo-DSC-16** | **04** | **02** | **Nil** | **02** | **Appeared in Sem V** | **NIL** |

## Learning Objectives

The learning objectives of this course are as follows:

- to introduce students to the principle, practices and application of biotechnology.
- to familiarize the students with the basic concept of genetic engineering.
- to enable students to solve problems focusing on health, medicine, agriculture and environment etc.
- to learn scientific and engineering principles related to the processing/production of the recombinant proteins.
- to equip the students with the skills advanced tools and techniques used in biotechnology to acquire skills to pursue a career in biotechnology.
- to make the students aware of the scope of biotechnology which encompasses almost every field of science like engineering, research, commercialization and academics.

## Learning Outcomes

By studying this course, students will be able to:

- Enable students to make a strategy to manipulate genetic structure of an organism for improvement of any trait.
- Comprehend the ethical and social issues regarding GMOs.
- Gain knowledge of DNA isolation, Agarose gel electrophoresis, PCR, transformation etc.
- Execute the application of recombinant DNA technology in designing research project.
- Acquire technical skills required for joining research labs/industry/institute/pharmaceutical etc. including entrepreneurship.

## SYLLABUS OF DSC-16

**UNIT- 1: Overview of Biotechnology** **1 hr**

Aim and scope; applications in biotechnology.

**UNIT- 2: Basic Tools for Gene Manipulation** **10 hrs**

Cloning vectors: Plasmids, Cosmids, Phagemids, Lambda Bacteriophage, M13, BAC, YAC, MAC and Expression vectors (characteristics); Restriction enzymes; DNA modifying enzymes; Transformation techniques: Calcium chloride method, electroporation and biolistic methods, construction of genomic and cDNA libraries and screening by colony and plaque hybridization.

**UNIT- 3: Advance Tools and Techniques** **3 hrs**

Gene Editing Tool: Zinc Finger, TALEN, Clustered regularly interspaced short palindromic repeats (CRISPR/Cas9) system.

**UNIT- 4: Genetically Modified Animals** **8 hrs**

Production of cloned and transgenic animals: Nuclear Transplantation, Retroviral Method, DNA microinjection; Applications of transgenic animals; Production of pharmaceuticals, production of donor organs, knock-out mice.

**UNIT- 5: Applications of Genetic Engineering** **8 hrs**

Molecular diagnosis of genetic diseases (Cystic fibrosis, Sickle cell anemia): RFLP based, Allele specific oligonucleotide dot blot method, PCR- Oligonucleotide ligation assay; Recombinant DNA in medicines: recombinant insulin and human growth hormone, Gene therapy.

**Practical** **(60 hrs)**

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

1. Isolation of genomic DNA from *E. coli.*
2. Isolation of plasmid (pUC 18/19) from *E. coli.*
3. Detection/ Visualization of DNA using Agarose gel electrophoresis.
4. Construction of circular and linear restriction map from the data provided.
5. Calculation of transformation efficiency from calcium chloride method.
6. Study of different blotting techniques: Southern, Northern and Western.
7. DNA sequencing: Sanger method, Next generation sequencing (Illumina).
8. Study of Polymerase Chain Reaction (PCR) and DNA microarrays.
9. Study and interpretation of DNA fingerprinting.
10. Submission of Project report based on any of the topics above (theory/practical)

**Essential/recommended readings**


1. Brown, T.A. (2010) Gene Cloning and DNA Analysis. VI Edition, Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Glick, B.R., Pasternak, J.J. and Patten, C.L. (2010). Molecular Biotechnology-Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
3. Primrose, S.B., and Twyman, R. M. (2006). Principles of Gene Manipulation and Genomics. VII Edition, Blackwell publishing (Oxford, UK)


**Suggestive readings**


1. Clark, D. P. and Pazdernik, N.J. (2012) Biotechnology, Academic Press.
2. Watson, J.D., Myers, R.M., Caudy, A. and Witkowski, J.K. (2007) Recombinant DNA Genes and Genomes- A Short Course. III Edition, Freeman and Co., N.Y., USA.


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

## DISCIPLINE SPECIFIC CORE COURSE -17 – :
## Methods in Biostatistics
## Zoo-DSC-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 | | |
| **Methods in Biostatistics Zoo-DSC-17** | **04** | **02** | **Nil** | **02** | **Appeared in Sem V** | **NIL** |

### Learning Objectives

The learning objectives of this course are as follows:

- to provide an overview of the fundamental concepts of biostatistics.
- to apprise students to the various statistical methods and software tools for understanding data analysis in biological sciences.
- to familiarize students with basic training and develop skills required for analysis of experimental data in biological sciences.
- to encourage students to pursue higher studies or career in biostatistics as Data Analyst, Data Scientist, Software Developer, Machine Learning Analyst, Research Scientist, Academicians, etc.

### Learning Outcomes

By studying this course, students will be able to

- better understand the basic concepts of Biostatistics and its various applications in different fields of biological sciences.
- acquire basic skills to set up hypothesis and design research studies.
- enable students to differentiate among various experimental designs and apply appropriate statistical tests.
- develop the skills to collect and represent data in tabular and graphical forms.
- analyze data and interpret experimental results using calculator, spread sheets software and online/offline software tools.

### Syllabus of DSC-17

**UNIT- 1: Introduction to Biostatistics** **1 hr**

Aim and scope; applications in biological sciences.

**UNIT- 2: Statistical Data** **4 hrs**

Sampling methods; Primary and secondary data; Qualitative and quantitative data; Discrete and continuous data; Presentation of data- graphical representation of data.

**UNIT- 3: Descriptive Statistics** **9 hrs**

Concepts of statistical population and samples, parameter and statistics; Measures of Central tendency and Dispersion - Mean, Median and Mode (grouped and ungrouped data); Variance, Standard Deviation and Standard Error; Coefficient of Variance.

**UNIT- 4: Probability and Distributions** **2 hrs**

Normal, Binomial and Poisson; Skewness and Kurtosis.

**UNIT- 5: Testing of Hypothesis** **4 hrs**

Null and Alternative hypotheses; Concepts of statistical errors - Type I and Type II errors; Confidence Intervals and Confidence levels.

**UNIT- 6: Statistical tests** **6 hrs**

Chi Square tests; Z test, t Tests - paired and unpaired; F test (one way ANOVA).

**UNIT- 7: Correlation and Regression** **4 hrs**

Correlation Coefficient; Linear regression analysis.

**Practical** **(60 hrs)**

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

1. To learn calculation and graphical representation of data with computers (e.g. MS Excel/SPSS/SigmaStat/Prism).
2. To compute Coefficient of Variance from data collected and measure variability.
3. To collect data on different parameters (e.g. height/weight) of animal/plant samples and test for significance, difference between mean, mode and median.
4. To compute 'test of independence' and 'goodness of fit' with samples/data provided using Chi square test.
5. To perform Z test/ F test (ANOVA) for given samples/data provided.
6. Submission of Project report based on field studies (sample collection, data analysis and interpretation using above statistical tests).

**Essential/recommended readings**


1. Daniel, W.W. and Cross, C.L. (2018) Biostatistics: Basic Concepts and Methodology for the Health Sciences 11th Edition, John Wiley & Sons, Inc.
2. Motulsky, H. (2016) Essential Biostatistics: A Non-mathematical Approach Oxford University Press


**Suggestive readings**


1. Zar, Jerrold H. (1999). Biostatistical Analysis, IV Edition, Pearson EducationInc and Dorling Kindersley Publishing Inc. USA


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

**DISCIPLINE SPECIFIC CORE COURSE– 18:**

**Evolutionary Biology**
**Zoo-DSC-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 | | |
| **Evolutionary Biology Zoo-DSC- 18** | **04** | **02** | **Nil** | **02** | **Appeared in Sem V** | **NIL** |

### Learning Objectives

The learning objectives of this course are as follows:

- to understand evolutionary forces leading to the variations and diversification of species.
- to learn about deciphering evidences ranging from fossil records to molecular data and to establish phylogenetic relationships of species.
- to gain knowledge of the processes and patterns of biological evolution.
- to get acquainted with origin and evolution of man.
- to acquire problem solving and high order analytical skills by attempting numerical problems as well as performing simulation studies of various evolutionary forces in action.

### Learning Outcomes

By studying this course, students will be able to:

- gain knowledge about the relationship of the evolution of various species and the environment they live in.
- apply knowledge gained, on populations in real time, while studying speciation, behaviour and susceptibility to diseases.
- better understand the study of variations, genetic drift to ensure that conservation efforts for small threatened populations are focused in right direction.
- predict the practical implication of various evolutionary forces acting on the human population in the field of human health, agriculture and wildlife conservation.
- use various software to generate interest towards the field of bioinformatics and coding used in programming language.

## SYLLABUS OF DSC-18

**UNIT- 1 Historical Review of Evolutionary Concepts** **2 hrs**

Lamarckism, Darwinism, Neo-Darwinism

**UNIT- 2: Beginning of Life** **3 hrs**

Chemogeny, RNA world, biogeny, origin of photosynthesis, endo-symbiotic theory

**UNIT- 3: Evidences of Evolution** **5 hrs**

Palaeontological: geological time scale; phylogeny of horse;
Molecular: neutral theory of evolution, molecular clock, example of globin gene family, rRNA/Cyt c.

**UNIT- 4: Raw Material for Evolution** **3 hrs**

Variations: Heritable variations and their role in evolution

**Unit 5: Process of Evolution** **6 hrs**

**Qualitative studies:** Natural selection, types of natural selection, artificial selection, kin selection, adaptive resemblances, sexual selection, frequency dependent selection.
**Quantitative studies:** Natural selection (concept of fitness, selection coefficient), genetic drift (founder's effect, bottleneck phenomenon), migration and mutation (genetic load).

**UNIT- 6: Product of Evolution** **4 hrs**

Speciation: micro-evolutionary changes (inter-population variations, clines, Ring species, races), species concept, isolating mechanisms.

**UNIT- 7: Extinction** **3 hrs**

Mass extinctions (events, causes and effects), Detailed explanation of K-T extinction

**UNIT- 8: Origin and Evolution of Man** **4 hrs**

Unique hominin characteristics contrasted with primate characteristics, primate phylogeny from *Dryopithecus* leading to *Homo sapiens*, molecular evidences in evolution of modern human.

**Practical** **(60 hrs)**

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

1. Study of fossils (types, forms and dating) from models/pictures.
2. Study of homology, analogy and homoplasy from suitable specimens.
3. Study different modes of speciation and Adaptive radiation/macroevolution by suitable examples.

4. Study of variations in a sample human population: (a) Continuous variation: Height/Weight in relation to age and sex (b) Discontinuous variation: Ability/Inability to taste Phenylthiocarbamide (PTC).
5. Study of Hardy-Weinberg Equilibrium: statement, assumptions, derivation of the equation and its verification by chi square analysis.
6. Demonstration of role of natural selection and genetic drift in changing allelic frequencies using simulation studies.
7. Construction of cladograms based on morphological characters.
8. Introduction and construction of Phylogenetic trees with the help of bioinformatics tools (Clustal X/W, Phylip, MLK/MP/NJ) and its interpretation.

**Essential/recommended readings**


1. Roberts, A. (2018) Evolution: the human story, Dorling, Kindersley Ltd.
2. Hall, B.K. and Hallgrimson, B. (2013). Evolution. V Edition, Jones and Barlett Publishers.
3. Campbell, N.A. and Reece J.B. (2011). Biology. IX Edition. Pearson, Benjamin, Cummings.
4. Barton N.H., Briggs D.E.G., Eisen J.A., Goldstein D.B. and Patel N.H., (2007) 1st Ed. Evolution, Cold Spring Harbor Laboratory Press.


**Suggestive readings**


1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press.
2. Zimmer C. and Emlen D. J., (2013) 1stEd. Evolution: Making Sense of Life, Roberts & Co.
3. Pevsner, J. (2009). Bioinformatics and Functional Genomics. II Edition, Wiley Blackwell.
4. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.


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# POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

**SEM VI**

| |
|---|
| ZOOLOGY- DSE-14: Nanobiotechnology |
| ZOOLOGY- DSE-15: Human Endocrinology |
| ZOOLOGY- DSE-16: Toxicology |
| ZOOLOGY- DSE-17: Research Methodology |

## DISCIPLINE SPECIFIC ELECTIVES (DSE-14): Nanobiotechnology
## Zoo-DSE-14

### 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 | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **Nanobiotechnology Zoo-DSE-14** | **04** | **03** | **Nil** | **01** | **Appeared in Sem V** | **NIL** | **Zoology** |

### Learning Objectives

The learning objectives of this course are as follows:

- to make the students aware of concept of Nanobiotechnology.
- to acquire the knowledge to introspect and understand the core concepts of nanotechnology.
- to equip the students with the concepts of biotechnology required for understanding the behaviour of nano-biomaterials.
- to develop a holistic understanding of the complex cellular processes occurring after treatment with nanoparticles.
- to provide in-depth knowledge of the body's response to nanotherapeutics.
- to appreciate the potential benefits and challenges of nanomedicine.

### Learning Outcomes

By studying this course, students will be able to

- better understand the basics of nanobiotechnology and the nanoscale paradigm in terms of properties at the nanoscale dimension.
- acquire skills to optimize the synthesis of nanoparticles.
- appreciate the interaction between biomolecules and nanoparticle surfaces and theirapplications.
- analyze the process of nanoparticle internalization inside the cell and to evaluate

the process and interactions of nanoparticles within the cells.

- better understand the practical, real world biosensing technologies such as enzyme-based biosensors.
- ability to understand the ethical, societal responsibilities and identify the risk assessments involved in using bio-nanobiomaterials.
- to provide a critical and systematic understanding of cutting-edge technology at the forefront.

## SYLLABUS OF DSE-14

**UNIT- 1: Introduction to Nanobiotechnology**, **2 hrs**

Overview of nanobiotechnology - timelines and progress.

**UNIT- 2: Fundamentals of Nanobiomaterials** **12 hrs**

Properties of Materials: Bulk materials *vs* nanomaterials, Biomaterials and synthetic materials; Types of nanocarriers/nanoparticles: Metals, Lipids, Polymeric nanoparticles (Liposomes, polymeric micelles, quantum dots, iron nanoparticles, carbon nanotubes), nanoscale assembly of microorganisms (virus, diatoms, bacteria); Nanofabrication: Top-down- Ball Milling; Bottom- up approaches-synthesis of metal oxides by green synthesis and chemical synthesis; nano-herbal formulations.

**UNIT -3: Nanocarriers for Drug Delivery** **10 hrs**

Drug Delivery Systems (DDS): Oral delivery, Systemic delivery, Controlled drug release; Transdermal drug delivery (Examples: Intranasal Drug Delivery and Ocular Drug Delivery); Active and passive nanocarriers- Concept of targeting, Multifunctional Nanoparticles: Inorganic and organic nanoparticles and their biomedical applications; Improvements in pharmacokinetics, bioavailability, biodistribution.

**UNIT- 4: Applications of Nanobiotechnology** **14 hrs**

***Health and Diseases*** - Infectious and chronic diseases; Vaccines - Lipid nanoparticles, Viral nanoparticles

***Diagnostics:*** Enzyme Biosensors and Diagnostics, DNA-Based Biosensors and Diagnostics, nano-immunosensors. Improved diagnosis by *in vivo* imaging- detection of tumours and genetic defects.

***Environmental Pollution:*** Environmental Nanoremediation Technology- Thermal, Physico-Chemical and Biological Methods, nanofiltration for treatment of waste removal of organics, inorganics and pathogens.

**UNIT- 5 Nanotoxicity:** **7 hrs**

Basics of cellular toxicity: Effect of size, shape, surface properties and composition on the toxicity of nanoparticles; genotoxicity and carcinogenicity – Mechanisms and

Tests. Risk assessment of Nanoparticle exposure, Prevention and control of nanoparticles exposure.

**Practical** **(30 hrs)**

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

1. Biosynthesis of nanoparticles: plants/microbial and its follow up with visible spectroscopy.
2. Synthesis of Iron oxide nanoparticles by using chemical methods.
3. Characterization of nanoparticles: Electron microscopy (scanning and transmission), atomic force microscopy; nanoparticle analyzer, zeta potential measurement, spectroscopic techniques including spectrophotometer.
4. Cell counting and cell viability study of a non-adherent cell (Hepatocyte) culture.
5. Antibacterial studies of nanoparticles by minimum inhibitory concentration (MIC) method.
6. Isolation of DNA and demonstration of apoptosis by DNA fragmentation.
7. Study of cell and nanoparticle interaction (Video demonstration).
8. Enzyme-based biosensors, e.g., the blood glucose sensor (Video demonstration).
9. Array-based DNA "biochip" sensors with fluorescence detection (video demonstration).

**Essential/recommended readings**


1. Niaounakis, M. (2015) "Biopolymers: Applications and Trends", 1st Edition, Elsevier.
2. Guterres, N., Silvia S., Alves, O. L. (Eds.) (2014) Nanotoxicology: Materials, Methodologies, and Assessments, Springer New York, USA.
3. Hillery, A. M.et al. (2010) "Drug Delivery and Targeting", CRC Press.
4. Torchillin, V. (2006) Nanoparticulates as Drug Carriers, Imperial College Press,


**Suggestive readings**


1. Kesharwani, P., Singh, K. K. (Eds) (2021) Nanoparticle Therapeutics: Production Technologies, Types of Nanoparticles, and Regulatory Aspects; Academic Press Inc.

2. Pieter Stroeve and Morteza Mahmoudi (2018) Drug Delivery Systems, World Scientific Series: From Biomaterials towards Medical Devices, Vol I.

3. Mao Hong Fan, Chin-Pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. (2010) Environanotechnology; Elsevier.

4. N. Yao and Z. L. Wang, Handbook of Microscopy for Nanotechnology, Springer New York, NY (2005).


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

## DISCIPLINE SPECIFIC ELECTIVES (DSE-15): Human Endocrinology
## Zoo-DSE-15

### 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 | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **Human Endocrinology Zoo-DSE- 15** | **04** | **03** | **Nil** | **01** | **Appeared in Sem V** | **NIL** | **Zoology** |

### Learning Objectives

The learning objectives of this course are as follows:

- to enable students to learn endocrinology with special emphasis on the human endocrine system covering the anatomy, physiology and biochemistry of the system, biological phenomenon at cellular level
- to provide detailed information on the release, effect and functioning of hormones.
- to acquire knowledge about the role of hormones as therapeutic agents.
- to acquaint students with experimental skills used in clinical and research laboratories

### Learning Outcomes

By studying this course, students will be able to:

- comprehend the endocrine system and properties of hormones.
- understand the importance of endocrine system and its role in maintenance of homeostasis.
- gain in-depth knowledge of the molecular mechanism of hormone action and its regulation.
- better appreciate the regulation of physiological process and its implication in diseases.
- acquire information about human endocrine disorders.

### SYLLABUS OF DSE- 15

**UNIT- 1: Introduction to Endocrine Physiology** **8 hrs**

Introduction to the endocrine system and major glands (pituitary, pineal, adrenal, thyroid, parathyroid, testis, pancreas, ovaries, and GI tract), Classes of hormones, Modes of hormone secretion.

**UNIT- 2: Neuroendocrinology** **12 hrs**

General organization of nervous system and neuroendocrine organs; Neurons: Structure, types, distribution and characteristics; Introduction to Neuropeptides, Neurosteroids and neurohormones.

The hypothalamo-hypophyseal axis; Hypothalamo-vascular system; hypothalamic hormones: chemistry, physiology and its regulation. Hypothalamo-hypophyseal interactions with the gonads, adrenal and other endocrine glands.

Neuroendocrine regulation of immune system; Stress hormones and immune response. Neuroendocrine disorders: genetic *versus* environmental causes (sleep apnea, precocious puberty).

**UNIT- 3: Molecular Endocrinology** **10 hrs**

Hormones as chemical messengers for control and regulation of physiological processes. Structure and biosynthesis of peptide, protein and steroid hormones; Storage, secretion and regulation of hormones; Mechanisms of hormone action: Receptor and non-receptor mediated signalling; Feedback mechanisms in signalling pathways.

**UNIT- 4: Hormones as Therapeutic Agents** **15 hrs**

Therapeutic use of hormones in health and disease (cancer, biological clock regulation, metabolic dysfunction, stress management, growth hormone disorders).

Current developments in design and production of hormonal contraceptives.

Recombinant protein hormones: production and application in regulation of fertility (Hormone replacement therapy, hypogonadism, PCOS/PCOD, xeno-estrogens and its effects on male fertility).

**Practical** **(30 hrs)**

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

1. Simulation of dissection and virtual display of endocrine glands in rat model.
2. Study of the permanent slides of the major (pituitary, pineal, adrenal, thyroid, parathyroid, testis, pancreas, ovaries, and GI tract) endocrine glands.
3. Estimation of plasma level of any hormone using Immunoblot/ELISA.
4. Chromatographic separation of steroid hormones using paper chromatography.
5. Visit to endocrine laboratory/hospitals/clinics.
6. Project work/survey-based project on any endocrine disorder.

**Essential/recommended readings**


1. David O. Norris, James Carr (2021) Vertebrate Endocrinology, V Edition, Elsevier.
2. J. Larry Jameson, Leslie De Groot (2010). Endocrinology, VI Edition, Elsevier.
3. Hadley, M.E. and Levine J.E. (2009). Endocrinology. VI Edition. Pearson Prentice Hall, Pearson Education Inc., New Jersey.
4. Franklin F. Bolander (2004) Molecular Endocrinology. III Edition, Academic Press, USA.

**Suggestive readings**

1. Handbook of Physiology published by American Physiological Society by Oxford University Press, Section 7: Multiple volumes set, 1998.

2. Endocrinology: An Integrated Approach. BIOS Scientific Publishers (https://www.ncbi.nlm.nih.gov/books/NBK22/).

3. Turner, D. (1977) General Endocrinology. VI Edition, Saunders.

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

## DISCIPLINE SPECIFIC ELECTIVES (DSE-16): Toxicology
## Zoo-DSE-16

### 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 | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| **Toxicology Zoo-DSE- 16** | **04** | **03** | **Nil** | **01** | **Appeared in Sem V** | **NIL** | **Zoology** |

### Learning Objectives

The learning objectives of this course are as follows:

- to gain insight about basic toxicology, nature and classification of toxins and its mechanism.
- to learn about daily exposure types, dose response curve and toxicity episodes of toxic substances.
- to understand the chemistry, kinetics, metabolism and excretion of toxins.
- to enable the students to understand the aspects of environmental, medical and forensic toxicology.
- to elucidate the role of instruments and techniques in studying toxicology.

### Learning Outcomes

By studying this course, students will be able to:

- acquire in-depth knowledge of the principles of toxicology, exposure and dose-response assessment.
- use technical and analytical skills to quantify the level and effect of xenobiotics on environment.
- better understand the mechanism of action and effects of toxic chemicals at multiple levels of biological organization.
- identify relationship between chemical exposure and its effect on physiological system.
- perform, analyse and interpret technical aspects and experimental approaches for toxicological research testing and risk assessment.

### SYLLABUS OF DSE- 16

**UNIT- 1: Principles of Toxicology** **8 hrs**

History and scope of toxicology, nature and classification of toxins, mechanism of toxicity, risk assessment-animal bioassays, dose-response assessment.

**UNIT- 2: Toxicokinetics: 10 hrs**

Transportation, absorption, distribution, metabolism and excretion of toxins, enzyme mediated biotransformation (hydrolysis, reduction, oxidation, conjugation), and toxicokinetics (one-and two-compartment, elimination, clearance, saturation).

**UNIT-3: Applied Toxicology 20 hrs**

***Environmental Toxicology:*** Ecotoxicology, Food, Agrochemical and Industrial Toxicology- Fertilizers and pesticide toxicology, Heavy metal toxicity, solvent & vapors toxicity, radiation/ radioactive toxicity.

***Medical, and Forensic Toxicology:*** Organ's responses to toxins (pulmonary, hepatic, renal, cerebral, cardiac-blood vascular, nervous system, organs of immune system, ocular, dermal, reproductive and endocrine systems) toxicity, Poisons: definition, classification of poisons, types of poisoning, mode of action, antidotes & factors modifying the action of poisons, Nanotoxicology, Carcinogens, Immunotoxicity (immune modulation, xenobiotic-inducedhypersensitivity & autoimmunity).

***Developmental and Occupational Toxicity***: Dosemetrics, Dysmorphogenesis, maternal & environmental effects on fetus, workplaces, associated agents, routes and span of exposures and standards, dose determination, diseases/ ailments, risk evaluation.

**UNIT- 4: Tools and Techniques in Toxicology: 4 hrs**

Instruments (Chromatography- TLC, GLC, HPLC), Soxhlet apparatus, flash evaporator, Lyophilization

**UNIT- 5: Regulatory Units 3 hrs**

Role of institutes *viz.* EPA (Environmental Protection Agency), TERI, CSE (Center for science and environment) and CPCB, FAO, European union norms etc.

**Practical (30 hrs)**

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

1. Determination of the $LD_{50}$ /$LC_{50}$ with the help of data.
2. Minimum inhibitory concentration of a toxin/ pesticide/ heavy metal/ tobacco.
3. Effect of a toxin/ pesticide/ heavy metal on any live organism (microbes/ animal/ plants).
4. Comparative study of normal and intoxicated sections of organs with the help of permanent slides/ pictorial representation (pulmonary, hepatic, renal, cerebral, cardiac-blood vascular, nervous system, organs of immune system, ocular, dermal, reproductive and endocrine systems - any three organs).
5. Separating techniques for toxin/s- Chromatography: Paper/ Thin Layer/ Column.
6. Techniques of HPLC, GLC (Dry Lab).
7. Routes of administration of drugs for the treatment regimens (Dry Lab).

8. Project work based on visit to institute of toxicology/ forensic science/ public health/ laboratory /hospital.

**Essential/recommended readings**


1. Woolley, D. and Woolley, A. (2017). Practical Toxicology- Evaluation, Prediction and Risk, Third edition, CRC press, Taylor and Francis Group/
2. Stine, K. E. and Brown, T. M. (2015). Principles of Toxicology, Third edition, CRC press, Taylor and Francis Group
3. Hayes, W. and Kruger, C. L. (2014). Hayes' Principles and Methods of Toxicology, VI edition, CRC press, Taylor and Francis Group.
4. Eroschenko, V. P. (2008), De Fiore's Atlas of Human Histology with functional correlations, Eleventh edition, Wolter Kluwer, Lippincott William and Wilkins.
5. Tortora, G.J. & Grabowski, S (2006) Principles of Anatomy & Physiology, XI edition. John Wiley & Sons.


**Suggestive readings**


1. Pani, B (2019). Textbook of Toxicology, Dreamtech press.
2. Gad, S. C. (2018). Regulatory Toxicology, III edition, CRC press, Taylor and Francis Group.
3. Casarett & Doull's Essentials of Toxicology (2015), III Edition, A & L Lange Series.
5. Pandey, G. and Sahni, Y. (2013) Toxicology Laboratory manual. International E-Publication.
6. Freifelder, D. (1999). Physical Biochemistry: Applications to Biochemistry and Molecular Biology, Second Edition, W. H. Freeman and Company.


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# COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

## CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

### GENERIC ELECTIVES (GE-14): Model Organisms in Research
### Zoo-GE-14

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Model Organisms in Research Zoo-GE-14 | 04 | 02 | Nil | 02 | Appeared in Sem V | NIL | Zoology |

### Learning Objectives

The learning objectives of this course are as follows:

- to make the students aware about the requirement of model organisms in biological research.
- to understand the simulation of human traits in model organisms.
- to familiarize the students about the suitability and availability of different model organisms.
- to aware students about the ethical issues involved in using animals for research in laboratories.
- to give insight about the database systems available of different model organism.

### Learning Outcomes

By studying this course, students will be able to

- better understand the concept of model organisms and their advantages.
- appreciate various types of model organisms used in biological research.
- gain better knowledge of how the model organisms can be used for modelling of human diseases.
- have an insight on the ethical issues related to handling and maintaining laboratory animals and plants.
- design simple experiments with model organism.
- determine the type of model organisms that are suitable to answer the specific research questions.

## SYLLABUS OF GE-14

**UNIT- 1: Introduction** **2 hrs**

Model organisms: Definition, requirement, characteristics and selection.

**UNIT- 2: Commonly used Model Organisms** **20 hrs**

Characteristics, establishment and maintenance, specific application of following model organisms in research:

Viruses (Bacteriophage λ-phage, T4); Bacteria (*Escherichia coli*); Fungi (*Saccharomyces cerevisiae*); Ciliates (*Tetrahymena*); Annelids (*Caenorhabditis elegans, Lumricusterrestris*); Arthropods (*Drosophila melanogaster*); Pisces (*Danio rerio*); Amphibians (*Xenopus laevis*); Mammals [Rodents (*Mus musculus*), *Rattus rattus* (Rat) and Primates]; Plants (*Arabidopsis thaliana*).

**UNIT- 3: Model organism specific databases** **6 hrs**

*Saccharamyces* genome Database, EcoCyc, Flybase, Xenbase, Wormbase, Zfin, Mouse genome informatics, Tetrahymena genome Database, The Arabidopsis Information Resource etc.

**UNIT- 4: Ethical consideration** **2 hrs**

Brief introduction about CPCSEA, IAEC and related regulatory bodies.

**Practical** **(60 hrs)**

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

1. Preparation of culture medium for *E. coli* and study the growth kinetics of *E. coli*.
2. Preparation of culture medium for *Drosophila* and study different stages of life cycle of *Drosophila*.
3. Preparation of culture medium for ciliates and their growth kinetics.
4. Study different phases of cell cycle in ciliates.
5. Culturing of *C. elegans*/ earthworm and Zebra fish and perform eco-toxicological studies.
6. Demonstration of culturing of mammalian cell lines/ visit to eukaryotic cell culture facility.
7. Visit to animal house and/ or plant culture facility and prepare the report on maintenance of laboratories animal/plant.

**Essential/recommended readings**

1. Jarret, R. L. and McCluskey, K. (2021) The Biological Resources of Model Organisms, 1st Ed, CRC Press.

2. Ankeny, R. A. and Leonelli, S. (2020) Concept of Model Organisms; Cambridge University Press.
3. Emerging model organisms: A laboratory manual, Volume 2, lab manual edition (2010), New York, USA: Cold Spring Harbor Laboratory Press.

**Suggestive readings**

1. Wang, W., Rohner, N., Wang, Y. (2023) Emerging Model Organisms; SpringerLink.
2. Jarret, R. L. and McCluskey, K. (2021) The Biological Resources of Model organisms, Taylor and Francis group.
3. Carroll, P. M. and Fitzgerad, K. (2003) Model Organisms in Drug Discovery, Wiley.

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

## GENERIC ELECTIVES (GE-15): Nanobiology
## Zoo-GE-15

### 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 | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Nanobiology Zoo-GE-15 | 04 | 02 | Nil | 02 | Appeared in Sem V | NIL | Zoology |

### Learning Objectives

The learning objectives of this course are as follows:

- to acquaint students with the basic concepts of Nanobiology.
- to equip the students with the concepts, properties and behaviour of nano-biomaterials.
- to provide a critical and systematic understanding of cutting-edge technology.
- to give an overall concept regarding the prominence of nanomaterials and their classification, synthesis process

### Learning Outcomes

By studying this course, students will be able to

- better understand the interaction of biomolecules with surfaces of different chemical and physical species.
- appreciate the different applications of various types of nanostructured materials.
- gain knowledge of the types of nanoparticles based on size, shape, surface properties and composition.
- interpret/ analyse and get insight into the applications in the field of medicine.
- use basic principles of microfluidics to solve biotechnical and bioanalytical problems.
- appreciate the multidisciplinary nature of Nanobiology.
- develop skills in high-tech instrumental techniques suited for characterization of the micro/nano- structural properties.

### SYLLABUS OF GE-15

**UNIT- 1: Nanobiology** **2 hrs**

Definition and concepts, Development of nanobiotechnology/nanobiology, timelines and progress.

**UNIT- 2: Biomaterials** **8 hrs**

Bulk materials *vs* nanomaterials. Different types of materials used to synthesize nanoparticles, Top-down approach, and bottom-up approach. Classification of nanoparticles based on size, shape, surface properties and composition; bio-inspired

nanomaterials. Nanoscale assembly of cellular components (cell membrane and liposomes). Nanoscale assembly of microorganisms (virus, diatoms, bacteria).

**UNIT- 3**: **Nanomedicine** **10 hrs**

Drug encapsulation, drug delivery and gene delivery, Active and passive targeting by ligands and receptor-mediated delivery, Interactions of nanoparticles with biological membranes and ion channels. Applications of nanomedicines in diagnostics: biosensor-based techniques like optical, colorimetric, and electrochemical, point-of-care diagnostics tools like lab-on-chip device, lateral flow immunoassay.

**UNIT- 4: Environmental applications** **6 hrs**

Nanoadsorbents, release of nutrients and pesticides, Nanoremediation, Nanopollution: air - water - soil contaminants, Treatment of industrial wastewaters using nanoparticles.

**UNIT- 5: Nanotoxicity** **4 hrs**

Effect of nanomaterials on human health, nanomaterial-cell interaction, Concept of cytotoxicity and genotoxicity, Future perspectives of Nanobiology.

**Practical** **(60 hrs)**

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

1. Synthesis of silver/gold nanoparticles from plants extracts and follow up with visible spectroscopy.
2. Synthesis of Iron oxide nanoparticles by using chemical methods (Tyndall effect).
3. Characterization of nanoparticles: Electron microscopy (scanning and transmission), atomic force microscopy; nanoparticle analyzer, zeta potential measurement, electrochemical analyzer, flow cytometry, spectroscopic techniques including spectrophotometer, spectro-fluorimeter.
4. Cell counting and cell viability study of a non-adherent cell (Hepatocyte) culture.
5. Study of cell and nanoparticle interaction (video demonstration).
6. Antibacterial studies of nanoparticles by MIC method.
7. Assessing cytotoxicity of nanoparticles by MTT.
8. Isolation of DNA and demonstration of apoptosis by DNA fragmentation.
9. Nano microbial degradation of various xenobiotics (e.g. pesticides, organochlorines, pyrethroids, PAH).

**Essential/recommended readings**


1. Kesharwani, P., Singh, K. K. (Eds) (2021) Nanoparticle Therapeutics: Production Technologies, Types of Nanoparticles, and Regulatory Aspects; Academic Press Inc.
2. Kenneth E. Gonsalves, Craig R. Halberstadt, Cato T. Laurencin, Lakshmi S. Nair, (Eds) (2008) "Biomedical Nanostructures" Wiley-Interscience, John Wiley & Sons, Inc.
3. Niemeyer, C.M. (2006) Nanobiotechnology: Concepts, Applications and Perspectives; Wiley VCH.
4. Ralph S. Greco, Fritz B. Prinz, R. Lane Smith Eds. (2005) Nanoscale Technology in Biological Systems, CRC PRESS, Taylor & Francis.


**Suggestive readings**


1. Stroeve, P and Mahmoudi (2018) Drug Delivery Systems, World Scientific Series: From Biomaterials towards Medical Devices, Vol I.
2. Hillery, and Anya M et al. (2010 "Drug Delivery and Targeting", CRC Press.
3. Hong-fan, M, Huang, C.P., Bland, A. E., Honglin, W. Z., Sliman,R., Wright, I (2010) Enviro-nanotechnology; Elsevier.


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

## GENERIC ELECTIVES (GE-16): Forensic Biology
## Zoo-GE-15

### 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 | Department offering the course |
|---|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | | |
| Forensic Biology Zoo-GE-16 | 04 | 02 | Nil | 02 | Appeared in Sem V | NIL | Zoology |

### Learning Objectives

The learning objectives of this course are as follows:

- to introduce the concept of forensic biology and DNA analysis.
- to identify and analyse the crime scene for biological evidence.
- to familiarize the students about the scientific methods in forensic biology.
- to emphasis on the practical techniques of biological principles that includes sample recovery, sample handling, different analytical techniques and DNA profile comparison.
- to highlight the importance and application of forensic science.

### Learning Outcomes

By studying this course, students will be able to

- Comprehend the fundamentals of forensic biology and DNA analysis.
- better understand the concepts of proper collection and preservation of biological.
- exhibits and crime scene investigation of biological evidence.
- rationalize the significance of criminal profiling.
- Develop skills based on the practical techniques of biological principles that includes sample recovery, sample handling, different analytical techniques and DNA profile comparison.

### SYLLABUS OF GE-16

**UNIT- 1: Principles of DNA Forensics and DNA Typing** **8 hrs**

Definition and fundamental concepts of forensic biology, DNA as biological blueprint of life, Structure of DNA, collection of DNA sample, extraction, profiling, restriction fragment length polymorphism (RFLP), polymerase chain reaction (PCR), short tandem repeat markers, single nucleotide polymorphism markers (SNP), determination of ethnicity, determination of physical appearance, determination of personality traits, mitochondrial DNA, RNA and DNA database. Result interpretation.

**UNIT- 2: Parentage Testing** **4 hrs**

Principles of heredity, genetics of paternity, DNA testing in disputed paternity, Mendelian laws of parentage testing.

**UNIT- 3: Biological Evidence** **12 hrs**

Nature and importance of study of biological evidences in crime cases:

**a)** Forensic examination of hair: Transfer, persistence and recovery of hair evidence, Structure of human hair, Comparison of hair samples, Morphology and biochemistry of human hair.

**b)** Comparison of human and animal hair.

**c)** Identification of wild life materials such as skin, fur, bones, nails, horn, teeth, plants, plant parts and products by conventional and modern methods, Identification of Pug marks of various animals

**d)** Types and identification of microbial organisms of forensic significance

**e)** Forensic odontology: structural variation in teeth (human and non-human), types of teeth and their functions, determination of age from teeth: eruption sequence, Gustafson's method, dental anomalies, their significance in personal identification. **Bites marks:** Forensic significance, collection and preservation of bite marks, photography and evaluation of bite marks, Lip prints in forensic investigations.

**UNIT- 4: Forensic Importance of Body fluids** **6 hrs**

**Blood:** Composition and functions, Collection and preservation of blood evidence, Distinction between human and non-human blood, Determination of blood groups; Forensic characterization of bloodstains, typing of dried stains;

**Semen:** Forensic significance of semen, Composition, functions and morphology of spermatozoa, Collection, evaluation and tests for identification of semen, Individualization on the basis of semen examination.

**Other Fluids:** Composition, functions, identification tests and forensic significance of saliva, sweat, milk and urine.

**Practical** **(60 hrs)**

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

1. Prepare slides of scale pattern of human hair and examine morphology of hair to determine the species to which the hair belongs.
2. Chemical identification of human blood.
3. Determination of blood group from fresh and dried blood samples.
4. Crime scene Blood Stain Pattern Analysis, using photographs and videos.
5. Identification of saliva and urine.
6. Separation of amino acids by thin layer chromatography (TLC).
7. Case study of evidences based on: DNA finger printing (disputed paternity)/ Bite marks/ Hair.
8. Visit to any Forensic Lab/Institute.

**Essential/recommended readings**

1. Tilstone, W.J., Hastrup, M.L. and Hald, C. (2013) Fisher's Techniques of Crime Scene Investigation, CRC Press, Boca Raton.
2. Saferstein, R. (2010) Criminalistics: An Introduction to Forensic Science (10th Edition), Pearson.
3. Butler, J.M. (2005) Forensic DNA Typing, Elsevier.
4. L. Stryer, (1988) Biochemistry, 3rd Edition, W.H. Freeman and Company, New York.
5. Chowdhuri, S. (1971) Forensic Biology, BPRD, New Delhi.

**Suggestive readings**

1. Duncan, G.T. and Tracey, M.I. (1997) Introduction to Forensic Sciences, 2nd Edition, W.G. Eckert (Ed.), CRC Press, Boca Raton.
2. Inman K. and Rudin, N. (1997) An Introduction to Forensic DNA Analysis, CRC Press, Boca Raton.

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