UNIVERSITY OF DELHI

CNC-II/093/1(28)/2023-24/281

Dated: 06.10.2023

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following departments under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23 :

(i) Botany

(ii) Geology

(iii) Zoology

(iv) Zoology Component for BSc. Life Science

DEPARTMENT OF BOTANY
SEMESTER - IV
Category-I
BSC (Hons.) BOTANY

DISCIPLINE SPECIFIC CORE COURSE - 10: Mycology

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		
MYCOLOGY **DSC-10**	4	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	Nil

Learning Objectives:

- To introduce students with various fungal groups and lichens, their ecology, classification, characteristics, reproduction and economic Importance
- To introduce students to the role of fungi in biotechnology, food industry, agriculture, human health and diseases etc.

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

- understand the world of fungi, lichens and pathogens of plants
- understand characteristics the ecological and economic significance of the fungi and lichens
- understand the application of mycology in various fields of economic and ecological significance

Unit 1: Introduction **04 hours**

General characteristics; Thallus organization; Cell wall composition; Nutrition; Heterokaryosis and Parasexuality; Classification - Webster and Weber (2007) and Introduction to Phylogenetic system of classification.

Unit 2: Chytridiomycota **01 hour**

General characteristics; Life cycle of *Synchytrium*, *Allomyces*

Unit 3: Zygomycota **02 hours**

General characteristics; Distribution; Thallus organization; Classification; Life cycle of *Rhizopus* &*Mucor*.

Unit 4: Ascomycota **05 hours**

General characteristics; Distribution; Classification, Life cycles of *Saccharomyces, Penicillium, Alternaria, Neurospora* and *Peziza.*

Unit 5: Basidiomycota **05 hours**

General characteristics; Distribution; Classification, Life cycle of *Puccinia graministritici*, *Agaricus*; Bioluminescence, Fairy Rings, Mushroom cultivation.

Unit 6: Oomycota **02 hours**

General characteristic (with emphasis on difference with fungi); Distribution; Classification, Life cycle of *Albugo*.

Unit 7: Myxomycota **02 hours**

General characterises (with emphasis on difference with fungi); Distribution; Types of plasmodia; Types of fruiting bodies; Life cycle of *Stemonitis*.

Unit 8: Symbiotic associations **04 hours**

Lichen - Distribution; General characteristics; Growth forms and range of thalli; Economic importance of lichens. Mycorrhiza - Ectomycorrhiza, Endomycorrhiza and their significance.

Unit 9: Applied Mycology **05 hours**

Application of fungi in Food Industry- Fermentation, Organic acids, Enzymes, Mycoproteins; Introduction to Plant Pathology**,** Nematophagous fungi, Entomogenousfungi , Mycoparasites, Mycoremediation, Medical mycology and Mycotoxins.

Practicals **60 hours**

1. *Rhizopus* & *Mucor*: Study of asexual stage from temporary mounts and sexual stage through permanent slides.
2. *Saccharomyces:* Study of vegetative cell and buddingfrom temporary mounts.
3. *Penicillium*: Study of asexual stage from temporary mounts and sexual stage from permanent slides.
4. *Peziza*: Study of sexual stage from temporary preparation of V.S of ascocarp.
5. *Alternaria solani*: Study of symptoms of early blight of Potato. Study of asexual stages through temporary mounts.
6. *Puccinia graminitritici*: Herbarium specimens of Black stem rust of wheat and barberry leaves; sections / mounts of spores (Uredospores and Teleutospores) on wheat. Permanent slides showing spore stages on both the hosts.
7. *Agaricus:* Specimens of button stage and mature basidiocarp; V.S of gills of *Agaricus*.
8. Study of Phaneroplasmodium of *Physarum* and sporangia of *Stemonitis.*
9. *Albugo candida*: Study of symptoms of white rust on *Brassica* sp.; Asexual stage study through section / temporary mounts. Sexual structures through temporary mounts / permanent slides.
10. Lichens: Study of different types of lichens - Crustose, Foliose and Fruticose. Study of Internal structure of thallus; Apothecium through permanent slides.

Suggested Readings:

1. Agrios, George N. (2005). Plant Pathology, 5th Edition, Academic Press / Elsevier.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, 4th edition, John Wiley & Sons, Singapore.
3. Moore, David et. al. (2020). 21st Century Guidebook to Fungi, 2nd Edition, Cambridge University Press.
4. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and Their Allies, Medtech Publishers.
5. Webster, J., Weber, R. (2007). Introduction to Fungi, 3rd edition. Cambridge, U.K.: Cambridge University Press, UK.

Additional Resources:

1. Kavanagh, Kevin (2017). Fungi: Biology and Applications, 3rd Edition, Wiley-Blackwell.
2. Maheshwari, Ramesh (2012). Fungi: Experimental Methods in Biology, 2nd Edition, CRC Press.
3. Ownley, Bonnie and Trigiano, Robert N. (2017). Plant Pathology: Concepts and Laboratory Exercises, 3rd Edition, CRC Press.
4. Watkinson, Sarah et. al. (2015). The Fungi, 3rd Edition, Academic Press / Elsevier.

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

DISCIPLINE SPECIFIC CORE COURSE – 11: Ecology and Conservation

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		
Ecology and Conservation **DSC – 11**	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To introduce the students with environmental factors affecting the plants, the basic principles of ecology and phytogeography.
- To make them understand community patterns and processes, and ecosystem functioning.

Learning Outcomes:

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

- the interrelationship between organisms and environment.
- methods to study vegetation, community patterns and processes, ecosystem functions, and principles of phytogeography.
- evolving strategies for sustainable natural resource management and biodiversity conservation.

Unit 1: Introduction **01 hour**

Basic concepts, Interrelationships between the living world and the environment

Unit 2: Soil **05 hours**

Origin & Formation; physical, chemical and organic components; soil profile; forms of water in soil

Unit 3: Water **02 hours**

Importance; States of water in the environment; Atmospheric moisture; Water table

Unit 4: Abiotic interactions **03 hours**

Abiotic factors and plant adaptations, variations in light, temperature & wind conditions.

Unit 5: Biotic interactions **02 hours**

Definition; types of positive and negative biotic interactions

Unit 6: Population ecology **02 hours**

Characteristics of populations; population growth models and introduction to population regulation (density-dependent and independent); ecotypes; metapopulation (history, concept and applications to conservation)

Unit 7: Plant Communities **04 hours**

Community characters (General account of analytical and synthetic characters); Ecotone; Succession: processes, types (Lithosere, Hydrosere, Xerosere, Psammosere)

Unit 8: Ecosystems **04 hours**

Types, components, trophic organisation; food chain & food webs, ecological pyramids. models of energy flow; production and productivity; a brief outline of biogeochemical cycles (Carbon and Nitrogen)

Unit 9: Phytogeography **04 hours**

Principles; Continental drift; Theory of tolerance; Endemism; Phytogeographical division of India

Unit 10: Conservation **03 hours**

In-situ, ex-situ; gene banks, institutions - National & International; sacred groves, on-farm conservation.

Practicals **60 hours**

1. Principle and operation of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH and detection of carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from atleast two soil samples by rapid field tests.
3. Determination of pH & dissolved oxygen from polluted and unpolluted water samples.
4. Determination of soil organic carbon and organic matter of different soil samples by Walkley & Black rapid titration method.
5. Study of ecological adaptations of hydrophytes and xerophytes (four each).
6. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes, Predation (Insectivorous plants).
7. Determination of minimal quadrat size and number for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
8. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

9. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus.
10. Species distribution pattern based on A/F ratio (regular, random, clumped).
11. Field visit to familiarize students with ecology/conservation of different sites.

Suggested Readings:

1. Daubenmire, R.F. (1975). Plant and Environment.London: J. Wiley and Sons Inc.
2. Kormondy, E.J. (1996). Concepts of Ecology. New Delhi, India: PHI Learning Pvt. Ltd. 4th edition.
3. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Learning India Pvt. Ltd., 5th edition.
4. Sharma, P.D. (2010). Ecology and Environment. Meerut, India: Rastogi Publications. 8th edition.
5. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.

Additional Resources:

1. Ambasht, R.S. and Ambasht, N.K. (2008). A text book of Plant Ecology, CBS Publishers & Distributors PVT. LTD.
2. Majumdar, R and Kashyap, R (2019). Practical Manual of Ecology and Environmental Science, New Delhi, India: Prestige Publishers
3. Singh, J.S., Singh, S.P., Gupta, S. R. (2006). Ecology, Environment and Resource Conservation. New Delhi, India: Anamaya Publications.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology. USA: An Earth Systems Approach. Oxford University Press.
5. Hanski, I.A., & Gilpin, M.E. (1997). Metapopulation biology: Ecology, genetics, and evolution. Academic Press.

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

DISCIPLINE SPECIFIC CORE COURSE – 12: Developmental Biology of Angiosperms: Form, Anatomy & Function

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		
Developmental Biology of Angiosperms: Form, Anatomy & Function DSC-12	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To understand the basics of plant cell structure, and development, growth and organisation of the plant body.

Learning Outcomes:

Upon completion of the course, the students will

- become familiar with the structure and functions of various components of plant cell
- understand the process of cell growth and its regulation
- comprehend the structure and functions of tissues organising the various plant organs
- get acquainted with the reproductive processes involved in the life cycle of angiosperms
- be able to appreciate the interactions between the developmental pathways resulting in the differentiation of plant body
- recognise the importance of plant developmental biology in the improvement and conservation of plants.

Unit 1: Introduction to diversity of plant forms **05 Hours**

Historical perspective, methods/tools and techniques (fixation, sectioning, macerations); terms for describing plant cells; basic plant growth-meristems and cell differentiation; Primary and Secondary plant body (introduce terms);Classification of tissues; Simple and complex tissues, Vascular system.

Unit 2: Tissue organisation in stem **05 Hours**

Organization of shoot apex -Apical cell theory, Histogen theory, Tunica Corpus theory, Neuman's Theory of Continuing Meristematic Residue, Cyto-Histological Zonation Theory; Types of vascular bundles; Structure of dicot and monocot stem; Shoot Chimeras

Unit 3: Tissue organisation in leaf **03 Hours**

Initiation and development of leaf; leaf lamina, venation and vascular differentiation in leaf; dermal tissue system, cuticles and special epidermal cells - cuticle; epicuticular waxes; trichomes (uni-and multicellular, glandular and non-glandular, two examples of each); stomata (classification); structure of dicot and monocot leaf, Kranz anatomy

Unit 4: Tissue organisation in root **04 Hours**

Organisation of root apex -Apical cell theory, Histogen theory, Korper - Kappe theory; structure and function of root apex- quiescent centre; root cap; Structure of dicot and monocot root; Endodermis, exodermis and origin of lateral root.

Unit 5: Vascular Cambium **03 Hours**

Structure (Axially and radially oriented elements); function and seasonal activity of cambium; Secondary growth in root and stem, Cambial variants in secondary growth in stem: Included phloem and Phloem wedges.

Unit 6: Wood and Periderm **04 Hours**

Types of rays and axial parenchyma; Cyclic aspects and reaction wood; Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses; Pits and plasmodesmata; Wall ingrowths and transfer cells; Ergastic substances; Development and composition of periderm; rhytidome and lenticels.

Unit 7: Adaptive and Defensive Systems **03 Hours**

Anatomical adaptations of xerophytes and hydrophytes.; Adcrustation and incrustation;

Unit 8: Secretory System **02 Hours**

Hydathodes, cavities, lithocysts and laticifers.

Unit 9: Application of Plant Anatomy **01 hour**

Applications in systematics, plant development, physiology, forensics and pharmacognosy. Dendrochronology and dendroclimatology.

Practicals **60 Hours**

1. Prepare temporary whole mounts/ sections to study organisation of apical meristem of root, shoot and vascular cambium.
2. Distribution and types of parenchyma, collenchyma and sclerenchyma through temporary preparations / digital resources/ permanent slides.
3. Prepare temporary stained mounts (maceration, sections) to observe xylem: tracheary elements-tracheids, vessel elements; thickenings; perforation plates; xylem fibres.
4. Study the types and features of wood: ring porous; diffuse porous; tyloses; heartwood and sapwood through specimens, permanent slides and digital resources.

5. Prepare temporary whole mounts/ sections to observe phloem: sieve tubes-sieve plates; companion cells; phloem fibres.
6. Study epidermal system: cell types, stomata types; trichomes: non-glandular and glandular through temporary whole mounts/peels/using enamel.
7. Prepare temporary whole mounts/ sections to study organisation of root: monocot, dicot, secondary growth in roots.
8. Prepare temporary whole mounts/ sections to study organisation of monocot, dicot - primary and secondary growth; phloem wedges in *Bignonia*, included phloem in *Leptadenia/Salvadora*; periderm; lenticels.
9. Prepare temporary whole mounts/ sections to study organisation of leaf: isobilateral, dorsiventral, Kranz anatomy.
10. Study the adaptive anatomy in xerophytes and hydrophytes (two each) through temporary preparations / digital resources/ permanent slides.
11. Study secretory tissues: cavities, lithocysts and laticifers through permanent slides / digital resources.
12. Project: submission of permanent slides

Suggested Reading:

1. Beck, C.B. (2010). Plant Structure and Development. Second edition. Cambridge University Press, Cambridge, UK, New York, USA.
2. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
3. Esau, K. (1977). Anatomy of Seed Plants. John Wiley & Sons, Inc., Delhi.
4. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
5. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.

Additional Resources:

1. Bahadur, B. Rajam, M.V., Sahijram, L., Krishnamurthy, K.V. (2015). Plant Biology and Biotechnology. Volume 1: Plant Diversity, Organization, Function and Improvement.
2. Crang, R., Lyons-Sobaski, S., Wise, R. (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants 1st ed. Springer
3. Cutler, D.F., Botha, T., Stevenson, D.W. (2007). Plant Anatomy - An Applied Aspect. Blackwell Publishing, USA
4. Evert, R.F. (2017) Esau's Plant Anatomy; Meristems, Cells and Tissues Of The Plant Body- Their Structure, Function And Development. 3rd Edn Wiley India.
5. Moza M. K., Bhatnagar A.K. (2007). Plant reproductive biology studies crucial for conservation. Current Science 92:1907.
6. Shivanna, K.R., Tandon, R. (2014). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London

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

POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVE COURSE – 03 Applied Phycology

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 Phycology BOT-DSE-03	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objective:

- To gain knowledge about diversity, life forms, life cycles, morphology and economic importance of algae.

Learning Outcomes:
On completion of the course the students will be able to understand:

- use of algae for environment, human welfare and industries.
- algal culture techniques and their commercial production

Unit 1: Scope of phycology **01 hour**
In emerging research areas, environment and industries.

Unit 2: Algae as food, feed and fodder **03 hours**
Nutritional value of algae; Common edible algae; Algae as food, feed and fodder with suitable examples.

Unit 3: Algae in industry **06 hours**
Phycocolloids (Agar-agar, Alginic acid and Carrageenan) and secondary metabolites: Sources and Applications; Pharmaceutical and Nutraceutical uses of algae; Algae in cosmetics; Diatomaceous Earth.

Unit 4: Algae in agriculture **03 hours**
Algae as soil conditioners and biofertilizers; Seaweed liquid extract; Seaweed powder; Algal biorefinery residues.

Unit 5:Role ofAlgae in environment **06 hours**
Algae as pollution indicators; wasteland reclamation; Role of algae in wastewater treatment; Ecological importance of Symbiotic associations of algae; Harmful algal blooms; Red tides; Algal toxins.

Unit 6: Algae in biotechnology and research **05 hours**

Gene sequencing and algal systematics; Algae as a model organism (*Chlamydomonas*, *Chlorella*, *Acetabularia*, *Ectocarpus*, *Porphyra*); Bioluminescent forms; Algae in nanotechnology.

Unit 7: Algae as emerging source of bioenergy **02 hours**

Biofuels (Bioethanol, Biodiesel, Biohydrogen); Algal Biorefinery.

Unit 8: Algal culture techniques and commercial production **04 hours**

Isolation, purification and sterilisation of algae; Freshwater and marine culture media (BG-11 and Provasoli ES medium); Photobioreactors and large-scale production of microalgae; Seaweed farming.

Practicals **60 hours**

1. Isolation and identification of algal species (any three) in water samples from polluted and non-polluted sources through temporary mounts.
2. Nutritional analysis (protein and carbohydrates) of *Spirulina/ Chlorella/* anyother available edible algae.
3. Study of algal symbiosis (*Azolla* fronds) through sectioning or tease mount.
4. Phycocolloid (Agar-agar/ Alginates/ Carrageenan) extraction (demonstration/ digital resources).
5. Microalgal culture - maintain cultures of species isolated in Experiment 1(any three).
6. Commercial applications of algae through photographs/products (edible, cosmetics, biofuels, pharmaceutical, nutraceutical, phyco-remediation).
7. Study of algae as a model organism (any 2) through digital resources.
8. Project work on any applied aspect of algae/ Visit to any Institute or Industry (Report to be submitted).

Suggested Readings:

1. Bold, H.C. and Wynne, M.J. (1985) Introduction to the Algae: Structure and Reproduction, 2nd edition. Prentice-Hall International INC.
2. Chapman, D.J. and Chapman, V.J. (1980) Seaweeds and their uses. 3rdedn. British Library.
3. Kumar, H.D. (1999) Introductory Phycology, 2nd edition. Affiliated East-West Press, New Delhi.
4. Lee, R.E. (2008) Phycology, 4th edition: Cambridge University Press, Cambridge.
5. Sahoo, D. (2000) Farming the Ocean*:* Seaweed Cultivation and Utilization. Aravali Book International, New Delhi.

Additional Resources:

1. Andersen, R.A. (2005) Algal Culturing Techniques. Elsevier Academic Press.
2. Chapman, D.J. and Chapman, V.J. (1973) The Algae. 2nd edn. Macmillan, London.
3. Fleurence, J. and Levine, I. (2016) Seaweed in Health and Disease Prevention. Academic Press publications.
4. Sahoo, D (2010). Common seaweeds of India. IK International Pvt Ltd.
5. Sahoo, D. and Seckbach, J. (2015) The Algae World. Vol 26 Cellular Origin, Life in Extreme Habitats and Astrobiology. Springer, Dordrecht.
6. Van den Hoek, C. Mann, D.G. and Jahans H.M. (1995) Algae: An Introduction to Phycology. Cambridge University Press.

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

DISCIPLINE SPECIFICELECTIVE COURSE – 04 Industrial and Environmental Microbiology

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		
Industrial and Environmental Microbiology **BOT-DSE-04**	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To introduce students to the concepts, principles, scope and applications of industrial and environmental microbiology.

Learning Outcomes:

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

- understand how microbiology is applied in manufacturing of industrial products
- know about design of bioreactors
- understand the rationale in medium formulation, design for microbial fermentation, sterilization of medium and air
- comprehend the techniques and the underlying principles in upstream and down-stream processing
- learn the occurrence, abundance and distribution of microorganism in the environment and their role in the environment and also learn different methods for their detection
- understand the basic principles of environment microbiology and application of the same in solving environmental problems - waste water treatment and bioremediation
- comprehend the various methods to determine the quality of water

Unit 1: Microbes and quality of environment **04 hours**

Introduction and scope of microbes in industry and environment; Distribution and isolation of microorganisms from soil, air and water.

Unit 2: Bioreactors/Fermenters and fermentation processes **08 hours**

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous Fermentations; Components of a typical bioreactor, Types of bioreactors: laboratory, pilot

scale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter.

Unit 3: Microbial production of industrial products 10 hours

Microorganisms generally regarded as safe (GRAS); Downstream processing and uses; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization; Production of industrially important products: enzyme (amylase); organic acid (citric acid); alcohol (ethanol); antibiotic (penicillin)

Unit 4: Microbial enzymes of industrial importance 03 hours

Applications of industrially important enzymes (protease, lipase, and penicillin acylase); Methods of immobilisation and its advantages.

Unit 5: Microbial flora of water 05 hours

Water pollution: various sources and control measures; Role of microbes in sewage and domestic wastewater treatment systems. Microorganisms as indicators of water quality: coliforms and faecal coliforms.

Practicals 60 hours

1. Principles and functioning of instruments: autoclave, laminar air flow, incubators, types of fermenters.
2. Preparation of different culture media (Nutrient medium/ Luria Bertani medium/Potato dextrose medium/Czapek Dox medium).
3. Hydrolysis of casein andstarch by microorganisms.
4. Alcohol production by yeast using sugar/ jaggery.
5. Serial dilution method for isolation of microorganisms from water and soil and study of aero-microflora.
6. To determine the BOD of sewage water.
7. To qualitatively check the enzyme activity (phosphatase/amylase/cellulase) in soil samples.
8. To determine the microbial activity in soil by Triphenyltetrazolium chloride (TTC) assay or by measuring the CO_2 evolution.
9. Determination of coliforms in water samples using eosin methylene blue (EMB) medium.
10. Visit to any educational institute/ industry and a report to be submitted

Suggested Readings:

1. Bertrand, Jean-Claude, Caumette, P., Lebaron, P, Matheron, R., Normand, P., Sime• Ngando, T. (2015). Environmental Microbiology: Fundamentals and Applications. Amesterdam, Netherlands, Springer.
2. Joe, S., Sukesh (2010). Industrial Microbiology. S.Chand& Company Pvt. Ltd. New Delhi, Delhi.

3. Mohapatra. P.K. (2008). Textbook of Environmental Microbiology. I.K. International Publishing House Pvt.Ltd. New Delhi, Delhi.
4. Okafer, Nduka (2007). Modern Industrial Microbiology & Biotechnology. Science Pubishers, Enfield, NH, USA.
5. Pelzar, M.J. Jr., Chan E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. New Delhi, Delhi: McGraw Hill Education Pvt. Ltd., Delhi.

Additional Resources:

1. Alef K, and Nannipieri P (1995). Methods in Applied Soil Microbiology and Biochemistry, First Edition Academic Press, USA.
2. Atlas, Bartha. (1997). Microbial Ecology: Fundamentals and Applications. San Fransisco, SF. Pearson.
3. Casida, J.R. (2016). Industrial Microbiology. New Delhi, Delhi, New Age International Publishers.
4. Hurst C.J., Crowford R.L., Garland J.L. and Lipson D.A. (2007). Manual of Environmental Microbiology, American Society of Microbiology, USA.
5. Patel, A.H. (2008). Industrial Microbiology, Bangalore, India: McMillan India Limited.
6. Sharma, P.D. (2005). Environmental Microbiology. Meerut, UP: Alpha Science International, Ltd.
7. Stanbury, P.F., Whitaker, A., Hall, S.J. (2016). Principles of Fermentation Technology. Amesterdam, NDL:Elsevier Publication.
8. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology (9th edition). San Francisco, SF: Pearson Benjamin Cummings.

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Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines
BSc Life Sciences – Botany Component

DISCIPLINE SPECIFIC CORE COURSE – 4: Ecology and Evolution

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		
Ecology and Evolution LS-BOT-DSC-04	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning objectives:

- To understand basic ecological concepts, processes, inter-relation between the living world and abiotic environment.
- To make students understand the basic concept of evolution and natural selection.

Learning outcomes:

- After successful completion of the course the student shall have adequate knowledge about the basic principles of ecology and evolution.

Unit 1:Introduction to fundamental concepts in Ecology 02 hours

Inter-relation between the living world and abiotic environment. Fundamental concepts: Abiotic and biotic components; Levels of ecological organization: species, population, community, ecosystems, biomes.

Unit 2: Ecological factors 04 hours

Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types; Light, Temperature (Thermal stratification in water bodies and atmosphere) and Wind; Ecological amplitude; Leibig's law of minimum; Shelford law of tolerance.

Unit 3: Population Ecology 04 hours

Population Characteristics (dispersion, natality, mortality, survivorship curve, age pyramids); growth rates (density-dependent/independent); Interactions: mutualism, symbiosis, commensalism, competition, parasitism, predation, ammensalism, antibiosis.

Unit 4: Plant communities **05 hours**

Characters; Ecotone and edge effect; Succession; Processes and types (autogenic, allogenic, autotrophic, heterotrophic, primary and secondary)

Unit 5: Ecosystem **05 hours**

Structure; niche and habitats; Food chains and food webs, Ecological pyramids production and productivity; energy flow (single channel and Y-shaped); trophic organisation; Biogeochemical cycling; Cycling of nitrogen and Phosphorous

Unit 6: Introduction to Evolution **03 hours**

Origin and history of life; Macro and microevolution; Phylogeny and the tree of life.

Unit 7: Evolution of Species **04 hours**

Lamarckism and Neo-Lamarckism; Darwinism – selection (natural and artificial), Neo-Darwinism; Species concept and modes of speciation.

Unit 8: Phytogeography **03 hours**

Phytogeographical regions of India; Endemism (definition, factors and types).

Practicals **60 hours**

1. Principle and operation of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.
2. Determination of pH and detection of carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from atleast two soil samples by rapid field tests.
3. Study of ecological adaptations of hydrophytes and xerophytes (four each).
4. Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*), Epiphytes (Orchids), Predation (Insectivorous plants).
5. Determination of minimal quadrat size and number for the study of herbaceous vegetation in the college campus, by species area curve method (species to be listed).
6. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.
7. Study of ecological speciation (allopatric and sympatric) with the help of examples.
8. Study phylogenetic relationships among taxa with the help of exercises.

9. Construct phylogenetic tree using MEGA and interpret evolutionary relationships.

Suggested Readings:

1. Douglas J. Futuyma (1998). Evolutionary Biology (3rd Edition), Sinauer Associates.
2. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
3. Mark Ridley (2003) Evolution (3rd edition), Blackwell.
4. Odum, E.P. (2005). Fundamentals of Ecology. New Delhi, India: Cengage Leaming India Pvt. Ltd., 5th edition.
5. Reece, J. B., Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V., Jackson, R. B. (2014). Campbell biology (Vol. 9). Boston: Pearson.

Additional Resources:

1. Rosenbaum, P.E. (2010). Volpe's Understanding Evolution. McGraw-Hill, New York.
2. Schulze, E. D., Beck, E., Müller-Hohenstein, K. (2005). Plant Ecology. Springer Science & Business Media.
3. Singh, J.S., Singh, S.P., Gupta, S.R. (2014). Ecology, Environmental Science and Conservation. New Delhi, India: S. Chand.
4. Smith, R. L., Smith, T. M., Hickman, G. C., Hickman, S. M. (1998). Elements of ecology.

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

COURSES OFFERED BY DEPARTMENT OF BOTANY
Category III:

B.Sc. programme in Applied Life Sciences with Agrochemicals and Pest Management

DISCIPLINE SPECIFIC CORE COURSE (DSC 04)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Plant Pathology ALS BOT DSC 04	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**NIL**

Learning Objectives:
The learning objectives of this course are as follows:

- to introduce students with various fungi, fungus like organisms, bacteria and viruses.
- to give an understanding of their characteristics, reproduction and ecology.
- to introduce students with the principles and concepts of plant pathology.
- to acquaint with various plant diseases, symptomatology, causal organisms and their control measures.

Learning Outcomes:

By studying this course, students will be able to:

- understand the world of different types of pathogens of plants.
- identify the characteristic symptoms of different groups of plant pathogens in the fields.
- understand the ecological and economical impact of plant diseases.
- identify common plant diseases and their control measures.
- understand the application and significance of integrated disease management.
- explicate the economic and pathological importance of fungi, bacteria and viruses.

Unit 1: Introduction **3 Hours**
Definition, Concepts and Terminology; General symptoms; Classification of diseases.

Unit 2: **Key events of Disease development** **6 Hours**

Disease cycle; Host pathogen relationships; Plant defence mechanism (Structural and biochemical); Epidemiology and Disease forecasting.

Unit 3: Fungal Diseases **5 Hours**

General symptoms; Disease cycle and Control measures - Powdery mildew of Pea. Black stem Rust of Wheat; Smut of Barley (Loose and Covered smut).

Unit 4: Diseases caused by Oomycota **3 Hours**

General symptoms; Disease cycle and Control measures – White rust of Crucifers; Late blight of Potato.

Unit 5: Bacterial Diseases **3 Hours**

General symptoms; Disease cycle and Control measures - Citrus canker; Angular leaf spot of Cotton.

Unit 6: Viral Diseases **3 Hours**

General symptoms; Mode of transmission and Control measures-- Tobacco mosaic disease; Vein clearing of Bhindi.

Unit 7: Plant Disease Control **7 Hours**

Quarantine, Cultural practices, Physical methods, Chemical methods, Biological control (Antibiosis, Hyper-parasitism, Predation, Induced Systemic Resistance).

Practicals **60 Hours**

1. Study of White rust of crucifers, Symptoms on leaves and hypertrophy with the help of live or preserved specimens. Study of causal organism (*Albugocandida*) with the help of temporary tease/section mount. Permanent section mount of somatic and reproductive phases.
2. Study of Late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
3. Study of Powdery mildew of Pea, Symptoms on leaves and stem of Pea with the help of live or preserved specimens. Study of *Erysiphe* asexual stage with the help of temporary tease/ section mount and sexual stage through permanent slides.
4. Study of Black stem Rust of Wheat, Symptoms on both Wheat and Barberry with the help of live or preserved specimens/photographs. Study of *Puccinia graministritici* with the help of temporary tease/section mount of Wheat . Permanent slides of somatic and reproductive phases on both the hosts.
5. Study of Smut of Barley, Symptoms of Loose and Covered smut through live or preserved specimens. Study of teliospores through temporary mount.
6. Study of Bacterial Diseases through the specimens - Citrus canker; Angular leaf spot of Cotton.

7. Study of Viral Diseases through specimens - Tobacco mosaic Disease; Vein clearing of Bhindi.
8. Study of Phylloplane Mycoflora through cellotape method.
9. Study through digital images / photographs – Chlorosis, Tuber rot, Apple scab, Mycoparasite, Predaceous fungi.

Essential/ Recommended readings:

1. Singh, R.S. (2021). Plant Diseases 10th revised edition, Medtech, New Delhi.
2. Schumann, G.L. and D'Arcy C.J. (2009). Essential Plant Pathology 2nd edition, AmericanPhytopathological Society, U.S.A.
3. Agrios, G.N. (2005). Plant Pathology 5th edition, Elsevier Academic Press, Amsterdam.
4. Oliver, R. (2023). Agrios' Plant Pathology 6th edition, Academic Press.
5. Sharma, P.D. (2014). Plant Pathology Rastogi Publications, Meerut, U.P.

Suggestive readings:

1. Gupta, R. and Chugh, G. (2022). *Plant, Microbes and Diseases*. I.K. International Pvt. Ltd., Delhi.
2. Ownley B.H. and Trigiano R.N. (2016. *Plant Pathology Concepts and Laboratory Exercises* 3rd edition, CRC Press.
3. Singh, R.S. (2017). Introduction to Principles of Plant Pathology, 5th edition, Medtech, New Delhi.
4. Tronsmo A.M., Munk L., Anika D., Tronsmo A., Yuen J and Collinge D.B. (2020). Plant Pathology and Plant Diseases. CABI Publishing, U.S.A.

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

POOL OF DISCIPLINE SPECIFIC CORE
FOR B.SC. PROGRAMME IN APPLIED LIFE SCIENCES WITH AGROCHEMICALS AND PEST MANAGEMENT

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 02)

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		
Crop Genetics and Plant Breeding ALS BOT DSE 02	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**NIL**

Learning Objectives:

The Learning Objectives of this course are as follows:

- to develop an understanding of the concepts of plant breeding and its applications.
- to provide adequate knowledge on the natural breeding systems of different agriculturally important plant and strategies employed for crop improvement.
- to impart skills on plant genome analysis and gene mapping using DNA markers and their use in increasing efficiency of plant breeding.
- to understand the genetic basis of hybrid vigour and development of hybrid varieties.
- to make students familiar with the concept of varietal release and rights of a farmer and plant breeder.

Learning Outcome:

By studying this course, the students will be able to:

- gain knowledge on the importance of plant breeding for developing new cultivars and use of breeding strategies for improvement of crop plants.
- understand the concept of gene pool and germplasm resources that are fundamental to crop improvement.

- explicate the breeding methods for commercially important crop plants.

Unit 1: Introduction (2 Hours)

Importance of plant breeding and its history; Breeding systems in crop plants; Self-incompatibility, male sterility and apomixis, Important achievements in plant breeding.

Unit 2: Sources of Variation (4 Hours)

Plant genetic resources- their management and conservation, utilization of gene pools in breeding programs. Chromosome manipulation- induced mutations, haploidy, polyploidy, somatic hybridization, somaclonal variation.

Unit 3: Conventional Breeding Methods (8 Hours)

Selection methods for self-pollinated, cross-pollinated and vegetatively propagated crop plants; Hybridization for self-pollinated, cross-pollinated and vegetatively propagated crop plants-procedure, advantage and limitations.

Unit 4: Heterosis Breeding (3 Hours)

Genetic and molecular basis of heterosis (hybrid vigour); Development of hybrid varieties through exploitation of hybrid vigour. Inbreeding depression.

Unit 5: Molecular Genetics and Plant Breeding (10 Hours)

Molecular markers as tools in plant breeding; Principle of genetic linkage; Concept of genetic distance; Development and choice of mapping populations (F_2, NILs, RILs, BC etc); Linkage map construction; Quantitative traits - Principles and methods of QTL mapping, QTL Introgression; Marker-assisted breeding- Gene tagging; Marker-aided selection (foreground and background selection); Elimination of linkage drags; Marker assisted recurrent selection (MARS). Novel Plant Breeding Tools (TALEN's, CRISPR-Cas9, Base editing).

Unit 6: Intellectual Property Rights and Varietal Release

(3 Hours)

IPR, Patenting; Breeder's Right; Release of New Varities-Trials & their evaluation, Prerelease, Notification and its Release; Plant variety protection; Farmer's Right.

PRACTICAL (60 Hours)

1. Introduction to open/controlled pollinations in field and laboratory (Breeders kit; temporal details of anthesis, anther dehiscence, CMS, stigma receptivity, emasculation, bagging).

2. Analysis of the breeding system of chosen crop species by calculating pollen:ovule ratio.
3. Calculation of Index of self-incompatibility (ISI).
4. Study of dominant/ codominant nature of different molecular markers.
5. Assessment of phenotypic diversity in different accessions of given plant material using morphological markers.
6. Assessment of genetic diversity and construction of dendrogram using molecular markers.
7. Phenotypic screening of a mapping population/ land races for biotic stress resistance and calculating the log of percentage severity and symptom score.
8. Study of floral biology, emasculation and hybridization techniques in self-pollinated and cross-pollinated crops.
9. Estimation of heterosis, inbreeding depression and heritability.
10. Project: Case study based on gene mapping.
11. Field trip to plant breeding station.

Essential/recommended readings

1. Acquaah, G. (2012). *Principles of Plant Genetics & Breeding*. 2nd edition. Hoboken, NJ, Wiley.
2. Allard, R.W. (1999). *Principles of Plant Breeding*. John Wiley, New York.
3. Singh, B.D. (2022). *Plant Breeding: Principles and Methods*, 12th edition. New Delhi, Delhi: Kalyani Publishers.
4. Frey, K. J. (1982). *Plant Breeding II.* Kalyani Publishers, New Delhi.

Suggestive readings:

1. Chopra, V.L. (2023). *Plant Breeding: Theory and Practice* 2nd Restructured Edition, New India Publishing Agency, New Delhi.
2. Poehlman J. M. and Sleper D. A. (1995). *Breeding Field Crops,* 4th Ed. Panima Publishing Corporation, New Delhi.
3. Welsh, J. R. (1981). *Fundamentals of Plant Genetics and Breeding*. John Wiley and Sons, New York.

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

COMMON POOL OF GENERIC ELECTIVES

GENERIC ELECTIVE (BOT-GE-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
		Lecture	Tutorial	Practical/ Practice		
Plant Health & Disease Diagnostics BOT-GE-16	4	2	0	2	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- understand the challenges and importance of plant pathogen diagnosis
- understand methods for reducing/minimizing risk of the spread of pathogens and pests.
- understand principles and tools for early warning systems to protect plant health.

Learning Outcomes:

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

- diagnose the cause of a plant disease and identify the causal agent
- select appropriate methods and strategy for control and mitigate spread.

Unit 1: Introduction to Plant Diseases **04 Hours**

Definition; History of Plant Pathology, Concept and basic components of disease; Causes and classification of diseases; Disease cycle; Significance of plant diseases.

Unit 2: Plant Disease Diagnosis **06 Hours**

Koch's Postulates; Plant disease symptoms and types (Necrosis, Hypertrophy and Hyperplasia, Hypoplasia); General symptoms of viral, bacterial and fungal plant diseases; Methods of plant disease diagnosis- Histochemical, Serological and PCR techniques.

Unit 3: Plant Disease Epidemiology **05 Hours**

Epidemics and factors affecting the development of epidemics; Epidemic assessment and Disease forecasting; Tools of epidemiology geographic information system (GIS), Global Positioning System (GPS), Geostatistics, Remote sensing.

Unit 4: Plant Diseases **11 hours**

Causal organism, symptoms, disease cycle and management of the plant disease caused by bacteria, virus and fungi: Tobacco Mosaic, Yellow Vein mosaic of Bhendi, Citrus Canker, Angular leaf spot of Cotton, White rust of crucifers, Late & early blight of potato, Rust of wheat, Smut of Cereals.

Unit 5: Management of Plant Diseases **04 Hours**

Concept of integrated disease management (IDM); strategies for IDM- regulatory, cultural, physical, chemical and biological.

Practicals **60 hours**

1. Preparation of Fungal Medium (Potato Dextrose Agar | Czapek Dox), Study of Instruments (Laminar Air flow, Autoclave, Incubator) & sterilization techniques.
2. Isolation pathogen from an infected plant sample.
3. Symptoms of Citrus canker and Angular leaf spot of Cotton through specimens / photograph.
4. Powdery mildew of pea: Symptoms and study of asexual and sexual stage of causal organism (*Erysiphe polygoni*) with the help of temporary tease /section/permanent slides.
5. Symptoms of Tobacco Mosaic Virus and Yellow Vein Mosaic of Bhinde through specimens / photographs.
6. White Rust of Crucifers - Symptoms and study of asexual and sexual stages of *Albugo candida* from tease /section/permanent slides.
7. Late blight of potato. Symptoms
8. Early blight of potato - Symptoms and study of asexual stage of *Alternaria solani* through temporary tease mounts
9. Black stem rust of wheat: Symptoms on both wheat and barberry. Types of spores of *Puccinia gormenistritici* wheat and barberry by temporary tease/section mount /permanent slides.
10. Symptoms of Loose and covered smuts of barley.

Suggested Readings:

1. Cooke, B.M., Jones, D.G., Kaye, B. (2007) The Epidemiology of Plant Diseases, 2nd ed. Springer.
2. Madden, L.V., Hughes, G. and Bosch, F van den (2017). The Study of Plant Disease Epidemics, APS Publications.
3. Sethi, I.K. and Walia, S.K. (2018). Text book of Fungi and their Allies. (2nd Edition), Medtech Publishers, Delhi.
4. Sharma, P.D. (2014*).* Plant Pathology. Rastogi Publications, Meerut.
5. Singh R.S. (2018*).* Plant Diseases. 10th Edition Medtech, New De

Additional Resources:

1. Agrios G.N. (2005*).* Plant Pathology. 5th Edition, Elsevier.
2. Gupta, V.K. and Sharma, R.C. (2020) Integrated Disease Management and Plant Health, Scientific Publishers, India
3. Kapoor, A.S. and Banyal, D.K. (2012). Plant Disease Epidemiology and Management, AbeBooks.

GENERIC ELECTIVE (BOT-GE-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
		Lecture	Tutorial	Practical/ Practice		
Environmental Monitoring and Ecosystem Restoration BOT-GE-17	4	2	0	2	Class XII pass with science	**Nil**

Learning Objectives:

- The course will train students on methods for conducting environmental monitoring protocols.
- It will provide experiential learning in conducting quality check experiments on soil, water and air.
- The course will develop understanding on different aspects of ecosystem restoration and processes through monitoring system.

Learning Outcomes:

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

- understand the problem of environmental degradation
- assessment of quantitative and qualitative parameters used in environmental monitoring of air, soil and water.
- understand the strategies and methods for ecosystem restoration, including physico-chemical and biological indicators.
- understand degraded and restored sites through field visits.

Unit 1: Introduction **03 Hours**

Ecosystem degradation, Magnitude/ Scale of degradation (National and Global Scenario); influence of climate change in Ecosystem degradation (extreme and erratic natural events)

Unit 2: Factors of environmental degradation **03 Hours**

Factors responsible for degradation of soil, water, air and loss of biodiversity; natural and anthropogenic-forest fires, landslides, floods, deforestation, overgrazing, soil erosion, mining, landfills, etc.

Unit 3: Ecosystem Restoration **06 Hours**

Definition; UN decade on Ecosystem Restoration; Bradshaw's Concept: Restoration, Rehabilitation and Reclamation (replacement); Role of Sustainable Development Goals (SDGs)., REDD+, Joint Forest Management; Relevance for people, nature and climate.

Unit 4: Environment Monitoring **09 Hours**

Indicators of land degradation: Soil- alkalinity, salinity, organic carbon and soil health; Water- pH, Hardness, BOD, COD and Heavy metals content; Air- PM 10 , PM 2.5 , SO_2 , NOx, ozone), Air Quality Index (AQI); Bioindicators/ Biomonitors (plants, animals and microbes).

Unit 5: Role of Plants and Microbes in Ecosystem Restoration **09 Hours**

Brief account of remediation technologies: bioremediation, phytoremediation (phytoextraction, rhizofiltration, phytovolatilization, phytostabilization etc); Role of associations of Grasses-AMF, Legumes-Rhizobium in restoring degraded land/ mined out areas; Role of macrophytes in wetland restoration; Role of green spaces including parklands and avenue plantations in amelioration of air quality.

Practicals **60 hours**

1. Field visit to degraded ecosystem/ natural ecosystem/restored ecosystem.
2. Analyze the soil and water samples from polluted and unpolluted sites for their pH
3. Analyze carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field tests in soil samples from degraded and healthy sites.
4. Determine the organic matter in soil samples by Walkley and Black's rapid titration method.
5. Determine the dissolved oxygen of water samples of polluted and nonpolluted sites by Winkler's method.
6. Determine the BOD and COD content of water samples of polluted and nonpolluted sites.
7. To collect, collate and analyze Air Quality Index (AQI) data, Water Quality data of various locations from DPCC/CPCB website collected from real-time monitoring stations.
8. Study of bioindicators (plant, animal and microbes).

Suggested Readings:

1. Bagyaraj, D.J. and Jamaluddin (2016) Microbes for Restoration of Degraded Ecosystems, New India Publishing Agency
2. Majumdar R., Kashyap R (2020). Practical Manual of Ecology and Environmental Science, Prestige
3. Ricklefs, R. E., Miller, G. L., (2000). Ecology, 4th edition W.H. Freeman.
4. Sharma, P. D. (2017). Ecology and Environment, 13th Edition. Meerut: Rastogi Publications.
5. Smith, T. M., Smith, R. L. (2012). Elements of Ecology 8th Edition. Pearson.

Additional Resources:

1. Central Pollution Control Board (CPCB) Air and Water: https://cpcb.nic.in/real-time-data/
2. Managing Ecosystems in The Context of Climate Change Mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests https://www.cbd.int/doc/publications/cbd-ts-86-en.pdf
3. National Clean Air Programme (NCAP) 2018. https://moef.gov.in/wp-content/uploads/2019/05/NCAP_Report.pdf
4. Real Time Ambient Air Quality Data (DPCC). https://www.dpccairdata.com/dpccairdata/display/index.php
5. Restoration for People, Nature and Climate, https://wedocs.unep.org/bitstream/handle/20.500.11822/36251/ERPNC.pdf
6. Champion, H. G., and S. K. Seth. A revised classification of forest types of India. Manager Publication, Government of India, Delhi (1968).

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

SEMESTER-V

BSC. (HONS.) BOTANY

DISCIPLINE SPECIFIC CORE COURSE – 13: Molecular Biology of the Cell

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		
Molecular Biology of the Cell – DSC 13	**4**	**2**	0	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objective:

- To gain comprehensive knowledge about of genetic material, central dogma, genetic code, DNA replication, transcription, modification of transcript, translation and regulation of gene expression.

Learning Outcomes: At the end of this course the student will understand:

1. structure and function of nucleic acids at molecular level.
2. the concept of central dogma and genetic code.
3. molecular details of DNA replication and its types.
4. cellular processes of transcription and translation including modification of transcripts and polypeptides/proteins
5. mechanisms regulating gene expression.

Unit 1: Nucleic acids as carriers of genetic information **02 Hours**

Discovery of nucleic acids, Experiments that established nucleic acids (DNA & RNA) as the carrier of genetic information: Griffith's, Hershey & Chase, Avery, McLeod & McCarty, and Fraenkel-Conrat's experiment.

Unit 2: Structure and organisation of the genetic material **03 Hours**

DNA double helix structure (Chargaff's rule; Watson and Crick model); salient features of DNA double helix. Types of DNA: A, B & Z conformations, denaturation and renaturation (only melting profile- Tm), types of RNA (mRNA, rRNA, tRNA, small RNAs). split genes (Phillip Sharp)

Unit 3: Central Dogma and Genetic Code **04 Hours**

Beadle and Tatum's one gene one enzyme hypothesis; The Central Dogma, Genetic code and its salient features, Experiments for deciphering Genetic code (Experiments by Nirenberg &Matthaei, and Har Gobind Khorana). Adaptor hypothesis by Crick; Baltimore and Temin's discovery of reverse transcription

Unit 4: Replication of DNA **06 Hours**

Delbruck's Dispersive mechanism model; Bloch and Butler's conservative replication model; Messelson and Stahl's semi-conservative replication model; Mechanism - initiation, elongation and termination; Enzymes and other proteins involved in DNA replication; General principles – bidirectional, semiconservative and semi-discontinuous replication (Replisome), RNA priming (Primase &Primosome); Various modes of DNA replication, including rolling circle, θ (theta) mode of replication, replication of linear dsDNA. Replication of the 5'end of linear chromosome (end-replication problem & Telomerase).

Unit 5: Mechanism of Transcription **05 Hours**

Transcription process in prokaryotes (Initiation, Elongation and Termination); structure and function of RNA polymerase enzyme; concept of promoters and transcription factors; comparison between prokaryotic and eukaryotic transcription; concept of post-transcriptional modifications (introduction to eukaryotic mRNA processing: 5' capping; Splicing and alternative splicing; 3' poly A tailing).

Unit 6: Mechanism of Translation **05 Hours**

Translation in prokaryotes: Initiation, Elongation and Termination; concept of charging of tRNA and role of aminoacyl synthetases; ribosome structure and assembly (prokaryotes and eukaryotes); comparison between prokaryotic and eukaryotic translation; post-translational modifications (phosphorylation, glycosylation).

Unit 7: Gene Regulation **05 Hours**

Gene regulation in prokaryotes: Operon concept; inducible & repressible systems; regulation of lactose metabolism in *E. coli* (inducible system, positive & negative control); regulation of tryptophan synthesis (Repression-De-repression and concept of Attenuation) in *E. coli.* Gene regulation in eukaryotes: concept of gene silencing by DNA methylation and RNA interference.

Practicals **60 hours**

1. Isolation of plasmid and genomic DNA from *E. coli* and quantification using agarose gel electrophoresis
2. Isolation of genomic DNA from plant samples (atleast two different genera / species) using CTAB method and quantification using agarose gel electrophoresis
3. Quantification of unknown DNA by diphenylamine reagent (colorimetry).

4. To estimate the generation time of *Escherichia coli* (prokaryote) and budding yeast (eukaryote) by spectrophotometric measurement and plotting growth curve as an indirect method to study DNA replication
5. To study control of replication in budding yeast with the help of specific inhibitors (beta-lactams:-Clavulanic acid, Ceftazidime, Piperacillin, Ceftriaxone etc) and studying budding frequency.
6. To study control of transcription in *Escherichia coli* with the help of prokaryotic (Rifampicin) and eukaryotic (Actinomycin-D) transcription inhibitors and plotting growth curve
7. To study control of translation in *Escherichia coli* with the help of prokaryotic (Kanamycin / Streptomycin) inhibitors using an IPTG-inducible system.
8. To understand the regulation of lactose (*lac*) operon (positive & negative regulation) and tryptophan (*trp*) operon (Repression and De-repression & Attenuation) through digital resources/data sets.

Suggestive readings:

1. William S. Klug, Michael R. Cummings, Charlotte A. Spencer, Michael A. Palladino, & Darrell Killian (2019). Concepts of Genetics. Pearson; 12th edition.
2. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
3. Snustad, D.P. and Simmons, M.J. (2019). Principles of Genetics. John Wiley, 7th edition.
4. Russell, P. J. (2010). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.

Additional Resources:

1. Griffiths, A.J.F., John Doebley J., Peichel, C., Wassarman D.A. (2020). Introduction to Genetic Analysis. W H Freeman & Co; 12th edition
2. Micklos D A., Freyer G.A. (2003) DNA Science: A First Course (2nd Edition), Cold Spring Harbor Laboratory; Greg A., CSHL Press, 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 – 14: Reproductive Biology of Angiosperms

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 Biology of Angiosperms – DSC 14	4	**2**	0	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To understand the scope of reproductive biology, development and structure of male and female reproductive units of the flower, organization of male and female gametophytes, pre-fertilization, fertilization and post-fertilization events.
- To understand the processes and significance of pollen--pistil interactions, apomixis and polyembryony.
- Significance of seed as a diaspore.

Learning Outcomes:

Upon completion of the course, the students will become familiar with:

- The significance and scope of reproductive biological studies in crop production and conservation. Structure and function of anther and ovule, male and female gametophyte.
- The significance of associations of MGU, FGU and double fertilization; embryo and endosperm development, genomic imprinting.
- Pollination and seed dispersal mechanisms, apomixis and polyembryony as alternate pathways of angiosperm reproduction.
- Experiential learning through field trips, scientific photography, videography and documentary preparation. The students will also learn to write scientific reports and present scientific data.

Unit 1: Introduction **01 Hour**

Introduction about Reproductive biology and its scope; significant contributors to the field; structure of flower.

Unit 2: Anther and Pollen **05 Hours**

Anther wall: Structure and functions, microsporogenesis, microgametogenesis; Pollen wall: Structure and functions, Number Position Character (NPC), pollen viability and storage, Male Germ Unit (MGU) – structure and significance.

Unit 3: Pistil **04 Hours**

General structure and types of pistil and ovules; megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (details of *Polygonum* type); Organization and ultrastructure of mature embryo sac; cell specification; Female Germ Unit – structure and significance.

Unit 4: Pollination **04 Hours**

Types (Self, cross, geitonogamy, xenogamy), significance; Structure of the stigma and style; Pollen-pistil interactions- capture, adhesion, hydration, pollen tube penetration; Path of pollen tube in the pistil; Role of synergids in pollen tube attraction; Double fertilization; Polytubey block

Unit 5: Self-Incompatibility **04 Hours**

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self-incompatibility (in brief): mixed-pollination, intraovarian and in vitro pollination and fertilization, modification of stigma surface, parasexual hybridization.

Unit 6: Endosperm **02 Hours**

Types (2 examples each), development, structure and functions; Genomic imprinting

Unit 7: Embryo **04 Hours**

General pattern and comparison of development of dicot and monocot embryo (initial apical cell and basal cell polarity, globular embryo with radial polarity, mature embryo); Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo, haustorial systems: Embryo patterning.

Unit 8: Seed **02 Hours**

Structure and importance of seed as diaspore, as storage organ; germination and seedling formation.

Units 9: Polyembryony and apomixis **02 Hours**

Introduction, types, causes and applications.

Unit 10. Applications of Reproductive biology **02 Hours**

Haploid embryos - concept and significance; crop productivity, conservation

Practicals **60 hours**

- Anther: Wall and its ontogeny, tapetum (amoeboid and glandular), Microspore mother cell, spore tetrads, uninucleate, bicelled and dehisced anther; Temporary stained mounts of T.S. anther to study the organization.

- Pollen: General morphology, psuedomonads, polyads, pollinia (slides/digital resources, fresh material); Ultrastructure of pollen wall (micrograph); Pollen viability: tetrazolium test/FDA; Germination: calculation of percentage germination in different media using hanging drop/sitting method.

- Temporary mounts of pollen grains cleared with 1N HCl/KOH to study germ pores; Ultrastructure of male germ unit (MGU) through micrographs.

- Ovule: Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; tenuinucellate and crassinucellate; Special structures: endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/digital resources).
  Female gametophyte: developmental sequence of monosporic embryo sac only; Ultrastructure of Female Germ Unit.

- Pollination: Adaptations; bagging experiment; **project on pollination.

- Intra-ovarian pollination; Test tube pollination (through digital resources).

- Endosperm: Dissections of developing seeds for endosperm with free-nuclear haustoria.
- Embryogenesis: Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

- Seed dispersal mechanisms (adaptations through live specimens), **project on seed dispersal

** The projects can be on pollination/ seed dispersal or on any other topic based on the syllabus. It can be a write-up with visuals. The students can also make a digital project submission in the form of a documentary of 5-10 min.

Suggested Readings:

- Bhojwani S.S., Bhatnagar S.P. & Dantu P.K. (2015). The Embryology of Angiosperms, 6th Edition. By VIKAS PUBLISHING HOUSE. ISBN: 978-93259-8129-4.
- P. Maheshwari, (2004). An introduction to the embryology of Angiosperms. Tata McGraw-Hill Edition, ISBN: 0-07-099434-X.
- Johri, B.M. (1984). Embryology of Angiosperms. Netherlands: Springer-Verlag. ISBN: 13:978-3-642-69304-5
- Raghavan, V. (2000). Developmental Biology of Flowering plants. Netherlands: Springer. ISBN: 978-1-4612-7054-6.
- Shivanna, K.R. (2003). Pollen Biology and Biotechnology. New Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.
- Mangla,Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Methods.Cambridge University Press ISBN 978-1-009-16040-7.
- Tandon R, Shivanna KR, Koul M Reproductive Ecology of Flowering Plants: Patterns and Processes 1st ed. 2020 Edition ISBN 978-9811542091.Springer Verlag
- Kapoor, R., Kaur, I. Koul M.2016. Plant Reproductive Biology and Conservation IK International Publishing House Ltd. India ISBN: 9789382332909

Additional Resources:

- Shivanna, K.R., Tandon, R. (2020). Reproductive Ecology of Flowering Plants: A Manual. Springer (India) Pvt. Ltd. New Delhi, Heidelberg, New York, Dordrecht, London
- Shivanna, K. R., & Rangaswamy, N. S. (2012). *Pollen biology: a laboratory manual*. Springer Science & Business Media.

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

DISCIPLINE SPECIFIC CORE COURSE – 15: Plant Physiology

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		
Plant Physiology – DSC 15	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning objective:

7. To introduce the basic principles of plant structure and function and its application in related fields.

Learning outcomes: On completion of the course the students will be able to:

8. understand the structure and function of plants
9. comprehend and compare various tissue systems in plants and their role
10. realise the importance of water, soil and atmosphere in the life of organisms
11. appreciate the ability of plants to sense the environment and adapt
12. interpret and evaluate the significance of regulator molecules in controlling life forms
13. apply the principles of plant physiology to solve problems in related fields

Unit 1: Plant-water relations **04 Hours**

Water potential and its components, water absorption by roots, water movement via symplast, apoplast and aquaporins, root pressure, guttation, ascent of sap, cohesion-tension theory, transpiration, factors affecting transpiration, anti-transpirants

Unit 2: Mineral nutrition **04 Hours**

Essential and beneficial elements, macro- and micro-elements, criteria for essentiality, roles of essential elements, chelating agents, phytosiderophores, mineral nutrition in hydroponics and aeroponics.

Unit 3: Nutrient uptake **05 Hours**

Transport of ions across cell membrane, passive absorption, simple and facilitated diffusion (carrier and channel proteins), Fick's law, active absorption, proton ATPase pump, electrochemical gradient, ion flux, uniport, co-transport (symport, antiport)

Unit 4: Translocation in the phloem **03 Hours**

Composition of phloem sap, phloem loading and unloading, Pressure-Flow Model, source-sink relationship

Unit 5: Plant growth regulators **08 Hours**

Chemical nature (basic structure, precursor), physiological roles, bioassays and applications of Auxins, Gibberellins, Cytokinins, Abscisic Acid, Ethylene; Other growth regulators - Jasmonic Acid, Brassinosteroids, Nitric Oxide. Mechanism of action of Auxin. Introduction to interactions among plant growth regulators.

Unit 6: Physiology of photo-sensory molecules **03 Hours**

Discovery, chemical nature, mode of action and role of phytochrome, cryptochrome and phototropin in photomorphogenesis

Unit 7: Physiology of flowering **02 Hours**

Concept of florigen, photoperiodism, CO-FT Model of flowering, vernalization.

Unit 8: Seed dormancy **01 hour**

Seed dormancy -causes and methods to induce and/or overcome dormancy

Practicals **60 Hours**

9. Determination of osmotic potential of plant cell sap by plasmolytic method.
10. Determination of water potential of potato tuber cells by weight method.
11. Determination of water potential of potato tuber cells by falling drop method.
12. Study of effect of light on the rate of transpiration in excised leafy twig.
13. Calculation of stomatal index and stomatal frequency from the lower surface of leaves of a mesophyte and a xerophyte.
14. To calculate the area of an open stoma and percentage of leaf area open through stomata in a mesophyte and a xerophyte (lower surface).
15. To study the effect of different concentrations of ABA on stomatal closure.
16. To study the effect of light and dark on seed germination.
17. To study induction of amylase activity in germinating barley grains.
18. To study the effect of ethylene on fruit ripening.
19. To study the effect of auxin on rooting.

Suggested Readings:

6. Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd.
7. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
8. Kochhar, S.L., Gujral, S.K. (2020). Plant Physiology: Theory and Applications. New Delhi, Delhi: Foundation Books, 2nd Edn. Cambridge University Press India Pvt, Ltd.

Additional Resources:

- Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual. New Delhi, Delhi: Narosa Publishing House.
- Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.

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COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVES (BOT-DSE-05)

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
		Lecture	Tutorial	Practical/ Practice		
Plant Pathology **BOT-DSE-05**	4	2	0	2	Class XII pass with Biology/ Biotechnology	

Learning Objectives:

- To introduce students with the phytopathology, its concepts and principles\
- To acquaint with various plant diseases, causal organisms and their control

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

- Understand the economic and pathological importance of fungi, bacteria and viruses
- Identify common plant diseases and their control measures

Unit 1: Introduction **03 Hours**

Definition of disease and its components (disease pyramid); Classification of diseases (on the basis of pathogens; geographical distribution; extent of occurrence); History and significance of Phytopathology (with special reference to India); Eminent plant pathologists and their contributions (Anton de Bary; E.J. Butler; Louis Pasteur; PMA Millardet; E.F. Smith; Adolf Mayer; K.C. Mehta, J.F. Dastur ; B.B. Mundkur; R.N. Tandon).

Unit 2: Basic concepts of Plant Pathology **04 Hours**

Definitions (Pathogenesis; Pathogen; symptoms; etiology); Types of pathogens and their Symptoms (Fungus, Oomycetes, Bacteria, Virus, Nematode, Phytoplasma); Koch's Postulates; Disease cycle (Components) - Epidemiology and forecasting of Plant diseases.

Unit 3: Host- -Pathogen relationship **04 Hours**

How pathogens attack plants (brief concept on mode of penetration; post-penetration and colonization). Plant defence mechanisms (Constitutive and induced, structural and biochemical).

Unit 4: Fungal diseases **05 Hours**

Causal Organism, Symptoms, Disease Cycle and control: Powdery mildew of Pea; Ergot of Rye; Apple scab, Early blight of potato, red rot of sugarcane, Black, Yellow and Brown rust of Wheat; Smut of Barley (Loose and Covered Smut).

Unit 5: Oomycete Diseases **02 Hours**

Causal organism, symptoms, disease cycle and control: Late Blight of Potato; White Rust of Crucifers; Downy mildew of Grapes.

Unit 6: Bacterial Diseases **01 Hours**

General symptoms; Disease cycle and Control measures - Citrus canker; Angular leaf spot of Cotton.

Unit 7: Viral Diseases **01 Hours**

General symptoms; Mode of transmission and Control measures-Tobacco mosaic disease; Vein Clearing of Bhindi

Unit 8: Nematode Diseases **01 Hours**

General symptoms, Disease cycle and Control measures-Root knot disease of Brinjal.

Unit 9: Plant Disease Control **07 Hours**

Plant quarantine and its significance; Methods of disease control: Physical (Heat treatment, drying, radiation and regeneration); Chemical methods (foliar spray; dust, seed treatment; soil treatment; treatment of wounds). Types of fungicides - Inorganic (Bordeaux mixture, Fixed copper; Sulphur, Lime Sulphur); Organic (Dithiocarbamates, quinones); Systemic fungicides and their mode of action (Oxanthin, Strobilurins, Benzimidazole, Pyrimidine). Cultural practices (Host eradication, sanitation, crop rotation, Polythene traps, Mulches) Biological Control (Antibiosis, hyper - parasitism, Hypovirulence, Predation, Induced systemic Resistance).

Unit 8: Plant Disease Control **02 Hours**

Quarantine, Cultural practices, Physical methods, Chemical methods, Biological control (Antibiosis, Hyper-parasitism, Hypovirulence, Predation, Induced Systemic Resistance).

Practicals **60 hours**

4. Study of Late blight of Potato through specimens, temporary mounts (V.S. of leaf showing infection) and permanent slides.
5. Study of Black stem Rust of Wheat: Symptoms on wheat and barberry. Observe uredospores and teleutospores on V.S. wheat leaf/ to study stem spore stages of *Puccinia graministritici* with the help of temporary tease/section mount of wheat. Permanent slides of somatic and reproductive phases on both the hosts.
6. Study of smut of barley, symptoms of loose and covered smut and temporary spore mount.
7. Study of Powdery mildew of pea, Symptoms with the help of live or preserved specimens. Study of *Erysiphe* asexual and sexual stages with the help of temporary tease/section mount/ permanent slides.
8. Study of symptoms of Red rot of sugarcane, W.M. of conidia through temporary tease mount.

9. Study symptoms of bacterial diseases: Citrus canker, Angular leaf spot of Cotton.
10. Study symptoms of viral diseases: Tobacco mosaic Disease, Vein clearing of *Abelmoschus esculentus*/*Ageratum* sp.
11. Study of nematode diseases: Root knot disease of Brinjal.
12. Isolation of seed borne mycoflora by moist chamber method technique.
13. Study of biocontrol agents: Nematophagous fungi; *Trichoderma* sp.
14. The students should submit specimens of any two plant diseases studied by them.

Suggested Readings:

7. Agrios, G.N. (2005) *Plant Pathology* 5 th edition: Elsevier Academic Press, Amesterdam.
8. Sharma, P.D. (2014) *Plant Pathology* Rastogi Publications, Meerut, U.P.
9. Singh, R.S. (2018) *Plant Diseases*. 10th Edition Medtech, New Delhi.

Additional Readings:

- Ownley, Bonnie and Trigiano, Robert N. (2017). Plant Pathology: Concepts and Laboratory Exercises, 3rd Edition, CRC Press.

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DISCIPLINE SPECIFIC ELECTIVES (BOT-DSE-06)

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
		Lecture	Tutorial	Practical/ Practice		
Natural Resource Management **BOT-DSE-06**	4	2	0	2	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- Natural Resources are materials from earth which support life and significantly meet the needs of people. The paper aims to describe the different types of natural resources and their management. Students will study about the importance of each natural resource and how and why they are threatened in current times. They will also be taught about sustainably using our resources

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

13. understand the different resources available in nature
14. learn the importance of each resource along with the threats to these resources
15. gain an in-depth understanding of management of these resources and also restoration of natural ecosystems
16. study the importance of sustainable practices
17. gain an insight into various initiatives taken the world over to save our natural resources.
18. understand the concept of clean energy and management of waste

Unit 1: Natural Resources **01 Hours**
Definition, fundamental concepts and types

Unit 2: Sustainable Utilization **04 Hours**
Concept, goals, approaches (economic, ecological, socio-cultural)

Unit 3: Land Resources **06 Hours**
Forests (definition, threats, management); Agricultural practices and their impact; Soil degradation (causes, management and remediation/restoration strategies)

Unit 4: Water Resources **04 Hours**

Freshwater, Marine, Estuarine, Wetlands – Threats and Management

Unit 5: Biological Resources **03 Hours**
Biodiversity – Levels, Significance, Threats, Management

Unit 6: Energy **02 Hours**
Clean energy strategies – Solar, Wind, Hydro, Tidal, Geo-thermal, Bio-energy

Unit 7: Climate Change **04 Hours**
Impact, adaptation and mitigation (Land, Soil, Water, Biodiversity, Air)

Unit 8: Contemporary practices **04 Hours**
EIA, GIS, Energy Audits, Waste Management, Ecosystem Restoration, Carbon footprint

Unit 9: National and International Initiatives **02 Hours**
International Solar Alliance; Ramsar Convention; Basel Convention; Carbon Neutral Goals; Net-zero Coalition; Clean Development Mechanism; CAMPA (Compensatory Afforestation Fund Management and Planning Authority); Carbon Credits; REDD+ project, Renewable Energy Certificates

Practicals **60 hours**

5. Comparison of pH (pH meter) and salinity (Electrical Conductivity) of various soil samples.
6. Comparison of field capacity of various soil samples.
7. Comparison of pH (pH meter) and TDS (TDS meter) of various water samples.
8. Comparison of salinity (titrimetric method) of various water samples.
9. Calculation and comparison of BOD and COD of various water samples from given data.
10. Comparison of species diversity in various communities by Shannon-Wiener Index.
11. Measurement of dominance of woody species by DBH method in the college campus.
12. Project (any one of the following):
    6. Rainwater harvesting (site visit)
    7. Ecological restoration (site visit)
    8. Energy audit
    9. Seed germination and seedling growth in garden and contaminated soils
    10. Composting
    11. Any other
13. Field visit/s to any degraded ecosystem (landfill, polluted water body, invaded forest) or any ongoing restoration project site.

Suggestive readings:

- Vasudevan, N. (2006). Essentials of Environmental Science. New Delhi, India: Narosa Publishing House.
- Singh, J. S., Singh, S.P. and Gupta, S.R. (2006). Ecology, Environment and Resource

Conservation. New Delhi, India: Anamaya Publications.
- Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. New Delhi, India: Prentice Hall of India Private Limited.

Additional resource:

10. https://moef.gov.in/en/division/forest-divisions-2/campa/compensatory-afforestation-fund-management-and-planning-authority-campa/
11. https://www.un.org/en/climatechange/net-zero-coalition
12. https://www.recregistryindia.nic.in/
13. https://static.investindia.gov.in/National%20Policy%20on%20Biofuels.pdf
14. https://cri.nccf.in/
15. https://www.investindia.gov.in/team-india-blogs/carbon-financing-india
16. https://www.un-redd.org/
17. Ecosystem Restoration for People, Nature and Climate https://wedocs.unep.org/bitstream/handle/20.500.11822/36251/ERPNC.pdf
18. Managing Ecosystems In The Context Of Climate Change Mitigation: A review of current knowledge and recommendations to support ecosystem-based mitigation actions that look beyond terrestrial forests https://www.cbd.int/doc/publications/cbd-ts-86-en.pdf
19. Jordan III, W. R., Gilpin, M. E., Aber, J. D. (1987). Restoration Ecology: a synthetic approach to ecological research. Cambridge, Great Britain: Cambridge University Press.

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

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines

(B.Sc. Life Sciences with Botany as one of the Core discipline)

DISCIPLINE SPECIFIC CORE (LS-BOT-DSC-05)

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
		Lecture	Tutorial	Practical/ Practice		
Plant Physiology and Metabolism **LS-BOT-DSC-05**	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

Learning Objectives:

4. To make students realize how plants function, the importance of water, minerals, phytohormones, and role of light in plant growth and development;
5. To understand mechanisms of carbon assimilation, nitrogen metabolism, phloem transport and translocation.

Learning Outcomes: At the end of this course, students will be able to:

- correlate physiological and metabolic processes with functioning of the plants.
- establish the link between theoretical principles and experimental evidence.

Unit 1: Plant-water relations **03 hours**

Water potential and its components, pathway of water movement, ascent of sap (include root pressure and guttation), transpiration and its significance, stomatal movements – only ion theory.

Unit 2: Mineral nutrition **03 hours**

Classification of mineral elements: Essential elements (macro- and micronutrients) and beneficial elements, General role of essential elements, transport of ions across membrane, active and passive transport (brief account of carriers, channels and pumps).

Unit 3: Translocation in phloem **02 hours**

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 4: Plant growth regulators **04 hours**

Physiological roles and bioassays of auxins, gibberellins, cytokinins, ethylene and ABA.

Unit 5: Plant response to light and temperature **02 hours**

Photoperiodism - discovery (SDP, LDP, day neutral plants), concept of florigen; phytochrome (discovery and physiological role), vernalization.

Unit 6: Enzymes **02 hours**

Classification, Structure and properties, mechanism of enzyme catalysis and enzyme inhibition.

Unit 7: Carbon metabolism **06 hours**

Photosynthetic pigments (chlorophyll *a* and chlorophyll *b*, xanthophyll, carotene); photosystem I and II, Light reactions (electron transport and photophosphorylation), Dark reactions: C3 pathway; C4 and CAM pathways (no chemical structures); photorespiration. Metabolite pool and exchange of metabolites, synthesis and degradation of sucrose and starch.

Unit 8: Respiration **02 hours**

Basic differences in animal and plant respiration, Cyanide resistant respiration.

Unit 9: Nitrogen metabolism **04 hours**

Nitrate assimilation (NR and NiR), biological nitrogen fixation in legumes (nodulation and role of dinitrogenase) Ammonia assimilation: GS-GOGAT, reductive amination and transamination.

Unit 10: Stress physiology in plants **02 hours**

ROS, RNS and anti-oxidative defence strategies.

Practicals **60 hours**

- Determination of osmotic potential of plant cell sap by plasmolytic method.
- To study the effect of the environmental factor light on transpiration by excised twig.
- Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
- To study the activity of catalase and study the effect of pH on the activity of enzyme.
- To Study Hill's reaction.
- To study the effect of light intensity on O_2 evolution in photosynthesis.
- Comparison of the rate of respiration in any two parts of a plant.
- To separate photosynthetic pigments by paper chromatography.
- Bolting / Effect of auxins on rooting.
- To demonstrate the delay of senescence by cytokinins/ effect of ethylene on fruit ripening

20. To study the phenomenon of seed germination (effect of light and darkness).
21. To demonstrate Respiratory Quotient (RQ)

Suggested Readings:

- Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, International 6th edition, Oxford University Press, Sinauer Associates, New York, USA.
- Bajracharya, D. (1999). Experiments in Plant Physiology: A Laboratory Manual, Narosa Publishing House, New Delhi.
- Hopkins, W. G., Huner, N. P. A. (2009). Introduction to Plant Physiology, 4th edition, Wiley India Pvt. Ltd, New Delhi.

Additional Resources:

- Jones, R.,Ougham, H., Thomas,H.,Waaland, S. (2013). *The molecular life of plants.* Chichester, England: Wiley-Blackwell.
- Kochhar, S.L. & Gujral, S.K. 2020. Plant Physiology: Theory and Applications, 2nd Edition. Cambridge University Press, UK.
- Bhatla, S.C., Lal, M.A. (2018). *Plant Physiology, Development and Metabolism.* Singapore: Springer.

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

COURSES OFFERED BY DEPARTMENT OF BOTANY

Category III:

B.Sc. programme in Applied Life Sciences with Agrochemicals and Pest Management

DISCIPLINE SPECIFIC CORE COURSE (DSC 05)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the core course			Eligibility criteria	Pre-requisite of the course (If any)
		Lecture	Tutorial	Practical/ Practice		
Plant Physiology and Metabolism ALS BOT DSC 05	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- to understand the fundamental concepts of plant physiology and metabolism.
- to identify the role of water, minerals, hormones, and light in plant growth and development.
- to understand the basic biochemical mechanisms and mineral nutrition of plants.
- to identify the criteria for the essentiality of elements.
- to understand the role of hormones in plant growth and development.
- to examine the commercial applications of growth regulators.
- to understand the physiology of flowering and senescence.
- to understand the mechanisms of photosynthesis and respiration.
- to examine the biological nitrogen fixation in plants.

Learning Outcomes:

By studying this course, students will be able to:

6. comprehend the physiological processes that occur in plants, including the role of water, minerals, hormones, and light in plant growth and development.
7. acquaint the basic biochemical mechanisms of plants, including photosynthesis, respiration, nitrogen metabolism, and chemical regulation of growth and development.
8. comprehend the process of biological nitrogen fixation, reproductive physiology and senescence of plants.
9. develop practical skills in plant physiology and metabolism.

Unit 1: Plant-water relations **(3 Hours)**

Water potential and its components, pathway of water movement, ascent of sap, transpiration and its significance, factors affecting transpiration, root pressure and guttation.

Unit 2: Mineral Nutrition (3 Hours)

Essential elements, Macro- and micronutrients, Criteria for essentiality of elements, Methods of studying mineral requirement (Hydroponics, Aeroponics)

Unit 3: Translocation in Phloem (3 Hours)

Composition of phloem sap, girdling experiments, Pressure Flow Model, phloem loading and unloading.

Unit 3: Chemical Regulation of Growth and Development (3 Hours)

Role of hormones in plant growth and development, Commercial applications of growth regulators, Growth retardant and its usefulness

Unit 4: Reproductive Physiology and Senescence (3 Hours)

Photo-periodism and flowering response, Photo-perception and critical photoperiod, Phyto-chrome and its role in flowering, Vernalization and senescence.

Unit 5: Photosynthesis (7 Hours)

Historical contributions of Blackman, Emerson, and Hill, Photosynthetic pigments (chlorophyll-a and b, xanthophyll, carotene), Photosystem I and II, reaction center, antenna molecules, Electron transport and mechanism of ATP synthesis, C3 pathway, C4 and CAM plants (in brief, no pathways), Photorespiration.

Unit 6: Respiration (5 Hours)

Glycolysis, Anaerobic respiration, TCA cycle, Oxidative phosphorylation, Glyoxylate cycle, RQ

Unit 7: Nitrogen Metabolism (3 Hours)

Biological nitrogen fixation - nodulation in detail, Nitrate and ammonia assimilation.

PRACTICAL (60 Hours)

2. To determine the osmotic potential of plant cell sap by plasmolytic method.
3. Calculate stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. Study Hill's reaction.
5. To study the effect of the environmental factor light on transpiration by excised twig.
6. Study the effect of light intensity on O_2 evolution in photosynthesis.
7. Compare the rate of respiration in any two parts of a plant.

8. To study the activity of catalase and the effect of pH and heavy metals.
9. Demonstrate the effect of auxin on rooting.
10. Demonstration of Bolting.
11. Demonstration of root respiration.
12. Demonstration of suction due to transpiration
13. A field visit to Hydroponics and Aeroponics facilities.

Essential/ Recommended readings:

6. Hopkins, W. G., Huner, N. P. A. (2009) *Introduction to Plant Physiology*, 4th edition. New Delhi, Delhi: Wiley India Pvt. Ltd
7. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018) *Plant Physiology and Development* International 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
8. Kochhar, S.L., Kaur, S. and Gujral, S.K. (2020) *Plant Physiology: Theory and Applications*. New Delhi, Delhi: Foundation Books, imprint of Cambridge University Press India Pvt, Ltd.

Suggestive readings:

6. Bajracharya, D. (1999) *Experiments in Plant Physiology: A Laboratory Manual.* New Delhi, Delhi: Narosa Publishing House.
7. Bhatla S.C. and Lal, M.A. (2018) *Plant Physiology, Development and Metabolism*, Springer.
8. Salisbury F.B. and Ross C.W. (1992) Plant Physiology, 4th edition, Wadsworth Publishing Company, California.

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

DSE for

B.Sc. programme in Applied Life Sciences with Agrochemicals and Pest Management

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSC 05)

Creditdistribution,EligibilityandPre-requisitesoftheCourse

Coursetitle&Code	Credits	Creditdistributionofthecore Course			Eligibilitycriteria	Pre-requisiteofthecourse (Ifany)
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology of Plants ALS BOT DSE03	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**NIL**

LearningObjectives:

Thelearningobjectivesofthiscoursearefollows:

12. to acquaint the students with internal basic structure and cellular composition of the plant body.
13. to correlate structure with important functions of different plant parts.
14. to study of various tissue systems and their development and functions in plants
15. to have knowledge of the flowering and fruiting, reproduction process, role of pollinators, ovule and seed development.

LearningOutcomes:

By studying this course, students will be able to:

11. gain knowledge of various cells and tissues, meristem, epidermal and vascular tissue system in plants.
12. get an insight of various aspects of growth, development of the tissues and differentiation of various plant organs.
13. gain the knowledge of basic structure and organization of plant parts in angiosperms and its correlation with morphology and functions.
14. get acquainted with pollen development and pollination, ovule development and fertilization, endosperm development and its importance.

Unit1: Meristematic and permanent tissue: (4 Hours)

Meristems and derivatives- structural organization of shoot and root apices; permanent tissue: simple and complex tissues.

Unit 2: Dermal System (2 Hours)

Epidermis, stomata, trichomes and glands

Unit3: Organs (4 Hours)

Structure of dicot and monocot root, stem and leaf

Unit 4: Secondary Growth (4 Hours)

Vascular cambium – structure and function, Secondary growth in root and stem, periderm.

Unit 5: Anther (4 Hours)

Structure and development, microsporogenesis, Pollen Development, structure of pollen and pollen wall (Basic Concepts).

Unit 6: Ovules (4 Hours)

Structure and types, megasporogenesis and mega gametogenesis, mature embryo sac.

Unit 7: Pollination and Fertilization (4 Hours)

Pollination mechanisms and adaptations; double fertilization; sexual incompatibility- basic concepts

Unit 8: Endosperm and Embryo (3 Hours)

Types and function of endosperm, embryogenesis, dicot and monocot embryo

Unit 9: Seed development (1 Hours)

Basic concepts of seed development

PRACTICAL (60 Hours)

1. Study of root and shoot apex through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma, sclerenchyma and their types); Macerated xylary elements, Phloem (Permanent slides/ Photographs/ Digital resources)
3. To cut transverse section of stem: Monocot: *Zea mays*; Dicot: *Helianthus*; Study of secondary growth in *Helianthus* stem.
4. To cut transverse section of root: Monocot: *Zea mays*; Dicot: *Cicer*; Study of secondary growth in *Helianthus* .
5. Study of the structure of Dicot and Monocot leaf.
6. Study of anther structure (young and mature).
7. Calculation of percentage of germinated pollen in a given medium through hanging drop/sitting drop method.
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous.

9. Female gametophyte: Mature embryo sac (photographs). Ultrastructure of mature egg apparatus cells through electron micrographs.
10. Dissection of embryo and endosperm from developing seeds.

Essential/ Recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). *Embryology of Angiosperms*, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Mauseth, J.D. (1988). *Plant Anatomy*. San Francisco, California: The Benjamin/Cummings Publisher.
3. Franklin, E. R. (2006). *Esau's Plant Anatomy: Meristems, Cells, And Tissues of the Plant Body: Their Structure, Function, and Development.* New Jersey, U.S.: John Wiley & Sons, Inc., Hoboken.
4. Shivanna, K.R. (2003). *Pollen Biology and Biotechnology.* Delhi, Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.

Suggestive readings:

1. Raghavan, V. (2000). *Developmental Biology of Flowering plants*. Netherlands, Europe: Springer.
2. Johri, B.M. (1984). *Embryology of Angiosperms.* Netherlands, Europe: Springer-Verlag.
3. Bhojwani S.S., Dantu P.K. and Bhatnagar, S.P. (2015) The Embryology of Angiosperms, 6th edition. Vikas Publication House Pvt. Ltd. New Delhi.
4. Tayal, M.S. (2021). Plant Anatomy, 4th Edition. Meerut, U.P.: Rastogi publications.
5. Crang, R., Lyons-Sobaski, S., and Wise, R., (2018) Plant Anatomy: A Concept-Based Approach to the Structure of Seed Plants, 1st Edition, Springer Nature Switzerland AG.

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

POOL OF GENERIC ELECTIVES

GENERIC ELECTIVE (BOT-GE-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
		Lecture	Tutorial	Practical/ Practice		
Genetic Engineering Technologies & Applications BOT-GE-18	4	2	0	2	Class XII pass with Science	**Nil**

Learning Objectives:

- To illustrate the use of modern techniques for the manipulation and analysis of DNA sequences
9. To understand the applications of recombinant DNA technology for the generation of commercial biotechnological products of diverse usage.
10. To gain knowledge about biosafety and ethical concerns associated with recombinant DNA technology.
11. To train students in strategizing research topics employing genetic engineering techniques.

Learning Outcomes: At the end of this course students would be able to:

- understand methods and techniques involved in manipulation and analysis of nucleic acids, gene cloning and creation of genetically modified organisms (GMOs).
- understand the commercial application of rDNA technology in research, agriculture and human health
- comprehend biosafety and ethical issues associated with rDNA technology

Unit 1: Introduction **01 Hours**

Introduction to rDNA technology and gene cloning.

Unit 2: Enzymes and Vectors in genetic engineering **07 Hours**

Restriction endonucleases, exonucleases, polymerases, RNAses, kinases, ligases; Plasmids (pBR322, pUC18, pUC19); Lambda based vectors and derivatives (Insertion vectors, replacement vectors, cosmids, phagemids); Artificial Chromosomes (YACs, BACs); Bacterial transformation, strategies for selection and screening (α complementation, antibiotic resistance); Plant Transformation vectors (Ti plasmid), Protein Expression Vectors for use in *E. coli*; introduction to marker and reporter genes (GUS, GFP).

Unit 2: Gene transfer methods **04 Hours**

Agrobacterium mediated transformation, Electroporation, Microinjection, Particle Bombardment, PEG mediated

Unit 3: DNA libraries construction and screening **04 Hours**

Procedures for construction of genomic and cDNA libraries, screening methods for locating the desired gene (Replica plating, Complementation screening, heterologous gene probe-based hybridizations)

Unit 4: PCR, nucleic acid hybridization and DNA sequencing **08 Hours**

PCR technique and its applications, RT-PCR, qPCR, Hybridization based assays (Southern and Northern blotting), Sanger's di-deoxy chain termination method of sequencing – gel-based electrophoresis (semi-automated) and capillary-based gel electrophoresis (automated sequencing).

Unit 5: Applications of rDNA technology **06 Hours**

Applications in basic research (identify, map, clone, and sequence genes and to determine their functions); applications in agriculture (biotic and abiotic stress tolerant transgenic plants, improved Nitrogen fixation, and plant growth); applications in human health (Disease diagnosis (heritable diseases and acquired infectious diseases) and therapeutics (production of recombinant vaccines, protein therapies: production of Insulin, Interferons, and human growth hormone). Human genome project and sequencing of plant genomes by taking *Arabidopsis* genome as an example. Safety and Ethical Issues related to rDNA research.

Practicals **60 hours**

- Isolation of genomic/plasmid DNA from bacteria.
- Quantification of extracted DNA by DPA (Diphenylamine) method.
- Restriction digestion and AGE (Agarose gel electrophoresis) of DNA.
- Restricting Mapping of linear and circular DNA.
- Study of direct and indirect gene transfer methods by photographs: Electroporation, Microinjection and Particle Bombardment, Ti-plasmid mediated gene transfer.
- Demonstration of techniques by photographs: PCR, RT-PCR, qPCR, Southern and Northern blotting and hybridization.
- Study of applications of rDNA technology by photographs: recombinant insulin, interferon and human growth hormone, Bt Cotton, Golden rice, and Flavr Savr tomato.
- Demonstration of working of equipments used in rDNA technology: Thermocycler, Laminar air flow cabinet, Autoclave, Incubator shaker, Refrigerated centrifuge.

Suggested Readings:

11. M. R. Green, J. Sambrook. Molecular Cloning: A Laboratory Manual (Cold Spring Harbor, ed. 4, 2012).

12. M. Wink. An Introduction to Molecular Biotechnology: Molecular Fundamentals, Methods and Applications in Modern Biotechnology (Wiley, ed. 2, 2011).
13. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
14. Snustad, D.P.,Simmons, M.J. (2019). Principles of Genetics, 7th edition. Chichester, England: John Wiley and Sons.
15. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
16. Primrose, S. B., Twyman, R. (2009). Principles of gene manipulation and genomics. Wiley. com.
17. Howe, C. J. (2007). Gene cloning and manipulation. Cambridge University Press.

Additional Resources:

1. M. M. Burell. (1993) Enzymes of Molecular Biology, Humana Press.
2. H.M. Eun. (1996) Enzymology: Primer for Recombinant DNA Technology, Academic Press.
3. S. B. Primrose, R. Twyman. (2006) Principles of Gene Manipulation and Genomics (Wiley-Blackwell, ed. 7).

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

GENERIC ELECTIVE (BOT-GE-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
		Lecture	Tutorial	Practical/ Practice		
Fundamentals of Molecular Biology **BOT-GE-19**	4	2	0	2	Class XII pass with Science	**Nil**

Learning Objectives:

5. To gain the knowledge of structure and functions of DNA and RNA

Learning Outcomes:

Students would have understanding of

9. understanding of nucleic acid, organization of DNA in prokaryotes and Eukaryotes, DNA replication mechanism, genetic code and transcription process.
10. Processing and modification of RNA and translation process, function and regulation of expression.

Unit 1: Nucleic Acids as genetic material **02 Hours**

Discovery of Nuclein by Fredrich Miescher; Experiments by Griffith, Hershey and Chase, Avery, McLeod and McCarty and Fraenkel Conrat.

Unit 2: Structure of Nucleic acids- the blueprint of Life **04 Hours**

Building blocks of nucleic acid: Ribose sugar, Purine, Pyrimidine, phosphate; Watson and Crick's model of DNA, DNA types (A,B,Z type), Comparison of RNA structure and types (tRNA, mRNA and rRNA); nucleosome- chromatin structure; Euchromatin and heterochromatin.

Unit 4: Central Dogma of Life **04 Hours**

Concept of Central dogma; Salient features of genetic code, deciphering the genetic code (Contribution of Nirenberg, Matthei and Ochoa, H.G. Khorana).

Unit 3: Replication **05 Hours**

Semi-conservative mode of DNA replication; replication of linear and circular DNA (Theta and Rolling circle model); mechanism and role of key enzymes in replication; role of telomerase enzyme in eukaryotic DNA replication; reverse transcription.

Unit 5: Transcription **05 Hours**

Comparative account of transcription in Prokaryotes and eukaryotes; post-transcriptional processing of pre-mRNA in eukaryotes (3', 5' end modifications and general mechanism of splicing involving spliceosomes).

Unit 6: Translation **05 Hours**

Comparative account of prokaryotic and eukaryotic ribosome structure and translation; inhibitors of protein synthesis (antibiotics).

Unit 7: Gene regulation **05 Hours**

Gene regulation in Prokaryotes- Operon concept: inducible and repressible operon; regulation of lactose (lac) and tryptophan (trp) in *Escherichia coli*; attenuation regulation.

Practicals **60 hours**

6. DNA isolation from cauliflower head by spooling method.
7. Study experiments establishing nucleic acid as genetic material: Griffith's, Avery et al, Hershey & Chase's and Fraenkel Conrat's experiments (through photographs)
8. Study DNA packaging (photographs/paper models).
9. Study modes of DNA replication: Meselson and Stahl's experiment, Rolling circle and Theta model of replication and semi-discontinuous, semi conservative replication (photographs).
10. Study structure of tRNA, prokaryotic RNA polymerase and eukaryotic RNA polymerase II (photographs/paper models).
11. Study RNA modification: Assembly of Spliceosome machinery, Splicing mechanism in group I & group II introns (photographs/paper models).
12. Study gene regulation mechanism in prokaryotes: lactose (lac) operon and tryptophan (trp) operon (photographs).
13. Finding the Tm of different DNA samples from the photographs of DNA melting profile provided. Problem solving for calculating the GC content.

Suggested Readings:

- Cooper, G.M., Hausman, R.E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.
- Karp, G. (2010). Cell Biology, 6th edition. New Jersey, U.S.A.: John Wiley & Sons
- Snustad, D.P., Simmons, M.J. (2012). Principles of Genetics, 6th Edition. New Delhi, Delhi: John Wiley & Sons
- Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics, 10th edition. San Francisco, California: Benjamin Cummings

Additional Resources:

6. Hardin, J. and Lodolce, J.P. (2021). Becker's World of the cell, 10th edition, Pearson

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BSC. (HONS.) BOTANY
SEMESTER - VI
Category-I
Botany (H) Courses for Undergraduate Programme of study with Botany as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE - 16: Plant Biotechnology

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		
Plant Biotechnology **DSC-16**	4	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	Nil

Learning objective:

- to provide knowledge of techniques used in plant biotechnology and their application.

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

14. understand basic concepts, principles and methods in plant biotechnology.
15. explain the use of acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural applications.

Unit 1: Introduction to Biotechnology **02 Hours**

Historical timeline; sectors of Biotechnology, brief overview of techniques and methods in Biotechnology.

Unit 2: Plant Tissue Culture **08 Hours**

Historical perspective (Major contributions of Haberlandt, Laibach, White, Reinert and Steward, Murashige and Skoog, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); types and composition of media: roles of nutrients (major and minor), vitamins, hormones and others (coconut water, activated charcoal); plasticity and totipotency; regeneration: organogenesis (direct and indirect) and embryogenesis (somatic and zygotic); protoplast isolation, culture and fusion; tissue culture applications (micropropagation, androgenesis, haploids, triploids, cybrids, production of virus-free plants).

Unit 3: Recombinant DNA technology **07 Hours**

Restriction Endonucleases (History, Types I - IV, biological roles and applications); modifying enzymes and their applications (nucleases, ligases, alkaline phosphatase, polynucleotide kinase), introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC18, pUC19, BACs, Lambda phage, YACs. Gene Cloning: Restriction digestion of DNA, elution of DNA from agarose gels, ligation, bacterial transformation and selection of

recombinant clones (alpha complementation, antibiotic selection, restriction enzyme based selection)

Unit 4: Genetic transformation of Plants **05 Hours**

Methods of gene transfer to plants: *Agrobacterium*-mediated transformation (Ti plasmids, development of binary vectors), Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; selection of transgenic plants: selectable marker genes (Positive selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP); Introduction to genome editing.

Unit 5: Applications **08 Hours**

Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready™ soybean); Transgenic crops with improved quality traits (Flavr Savr™ tomato. Golden™ rice); Improved horticultural varieties (Moondust carnations); Bioremediation (Superbug); Edible vaccines; Biosafety of transgenic plants.

Practicals **60 hours**

4. Preparation of Murashige & Skoog's (MS) medium.
5. Initiation of axenic cultures- seed sterilisation and inoculation
6. Micropropagation (shoot induction) using leaf and/or nodal explants of tobacco/*Datura*/ *Brassica* etc.
7. Study of anther culture, embryo and endosperm culture, somatic embryogenesis usingdigital resources.
8. Preparation of artificial seeds.
9. Induction of callus and analysis of effects of growth regulators (Auxin and Cytokinin) on *in vitro* regeneration using tobacco leaf explant.
10. Preparation of chemically competent cells of *E. coli*.
11. Transformation of *E. coli* with plasmid DNA by heat shock method.
12. Restriction digestion and gel electrophoresis of plasmid DNA.
13. Construction of restriction map of circular and linear DNA from the data provided.
14. Visit to a research laboratory.

Suggested Readings:

5. Slater, A., Scott, N. W. & Fowler, M. R. (2010) Plant Biotechnology: The Genetic Manipulation of Plants. 2nd edn. New York, USA: Oxford University Press Inc.
6. Snustad, D.P., Simmons, M.J. (2010) Principles of Genetics, 5th edition. Chichester, England: John Wiley and Sons.
7. Brown, T. A. (2020) Gene Cloning & DNA Analysis: An Introduction. 8th edn. UK: Wiley Blackwell.
8. Primrose, S. B. & Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7th edn. Victoria, Australia: Blackwell Publishing.
9. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.

Additional Resources:

9. Bhojwani, S.S. and Dantu, P.K. (2013). Plant Tissue Culture: An Introductory Text. Springer New Delhi Heidelberg New York Dordrecht London

10. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
11. Bhojwani, S.S., Bhatnagar, S.P. (2011). The Embryology of Angiosperms, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
12. Stewart, C.N. Jr. (2008). Plant Biotechnology and Genetics: Principles, Techniques and Applications. New Jersey, U.S.: John Wiley & Sons Inc.
13. Glick, B.R., Pasternak, J. J. & Patten C. (2010). Molecular Biotechnology: Principles and Applications. 4thedn. Washington, U.S.: ASM Press.
14. Glick, B.R., & Patten C. (2017). Molecular Biotechnology: Principles and Applications. 5thedn. Washington, U.S.: ASM Press.

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: Plant Biochemistry and Metabolism

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		
Plant Biochemistry and Metabolism **DSC - 17**	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To understand different pathways of metabolism in plant cells.
- To understand how various metabolic pathways work in a synchronized manner.

Learning Outcomes: At the end of the course the student will:

6. know the details of carbon assimilation, oxidation, synthesis of ATP- the energy currency of the cell, nitrogen fixation and lipid metabolism.
7. understand the role of enzymes in regulating metabolic pathways for molecules like carbohydrates, lipids and proteins.
8. understand the coordination of various biochemical reactions with reference to cell requirement and its economy.

Unit 1:Concepts in Metabolism **01 Hour**

Introduction, anabolic and catabolic pathways, coupled reactions

Unit 2: **Enzymes** **04 Hours**

Structure, classification and mechanism of action, Michaelis-Menten equation (no derivation), enzyme inhibition (competitive, non-competitive and uncompetitive), allosteric regulation and covalent modulation, factors affecting enzyme activity.

Unit 3:Carbon Assimilation **07 Hours**

Concept of light, absorption and action spectra, photosynthetic pigments (no structural details), PSI, PSII antenna molecules and reaction centres, LHC, photochemical reaction, photosynthetic electron transport, photophosphorylation (cyclic and non-cyclic)

Dark reactions: CO_2 reduction in C3, C4 pathways and CAM, photorespiration

Unit 4: Carbohydrate Metabolism **02 Hours**

Metabolite pool and exchange of metabolites, synthesis and degradation of sucrose and starch (no structural details)

Unit 5:Carbon Oxidation **06 Hours**

Glycolysis, fate of pyruvate- aerobic, anaerobic respiration and fermentation, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, Krebs cycle and its regulation, amphibolic role of Krebs cycle, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration

Unit 6: ATP Synthesis **02 Hours**

Mechanism of ATP synthesis-substrate level phosphorylation, oxidative and photophosphorylation, chemiosmosis, ATP synthase

Unit 7: Lipid Metabolism **04 Hours**

Triglycerides: synthesis, degradation through alpha and beta -oxidation, glyoxylate cycle

Unit 8: **Nitrogen Metabolism** **04 Hours**

Nitrate assimilation (NR and NiR), biological nitrogen fixation in legumes (nodulation and role of dinitrogenase) Ammonia assimilation: GS-GOGAT, reductive amination and transamination.

Practicals **60 Hours**

1. Study the activity of urease and the effect of substrate concentration on its activity.
2. Study the effect of pH on the activity of catalase enzyme.
3. Chemical separation of photosynthetic pigments (liquid-liquid partitioning).
15. Study Hill reaction by dye reduction method.
16. Study the law of limiting factors.
17. Compare the rate of respiration in three different parts of a plant.
18. Study the activity of Nitrate reductase in leaves of two different plants.
19. To study the activity of lipases in germinating oil seeds and explain mobilization of lipids during germination.
20. To study the fluorescence in isolated chlorophyll pigments.
21. To study the absorption spectrum of photosynthetic pigments.
22. To study respiratory quotient (RQ).

Suggested Readings:

14. Nelson, D.L., Cox, M.M. (2017). Lehninger Principle of Biochemistry, 7th edition. NewYork, NY: W.H. Freeman, Macmillan learning.
15. Taiz, L., Zeiger, E., Moller, I. M. & Murphy, A. 2018. Plant Physiology and Development, International 6thedn, Oxford University Press, Sinauer Associates, New York, USA.

16. Hopkins, W.G., Huner, N. (2008). Introduction of Plant Physiology, 4th edition. New Jearsey, U.S.: John Wiley and sons.
17. Jones, R., Ougham, H., Thomas, H., Waaland, S. (2013). The molecular life of plants. Chichester, England: Wiley-Blackwell.

Additional Resources:

19. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015). Biochemistry and Molecular Biology of Plants, 2nd edition. New Jearsey, U.S.: Wiley Blackwell.
20. Kochhar, S.L. & Gujral, S.K. 2020. Plant Physiology: Theory and Applications, 2nd Edition. Cambridge University Press, UK.
21. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer.

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: Advanced tools & Analytical Techniques in Plant Biology

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 tools & Analytical Techniques in Plant Biology **DSC- 18**	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To gain the knowledge on various techniques and instruments used for the study of plant biology

Learning Outcomes: At the end of this course, students will be:

- competent in the basic principles of major techniques used in study of plants
- understand principles and uses of light, confocal, transmission and electron microscopy, centrifugation, spectrophotometry, chromatography, x-ray diffraction technique and chromatography techniques

Unit 1: Imaging and related techniques **06 Hours**

Electron microscopy: Transmission and Scanning electron microscopy, cryofixation, negative staining, shadow casting, freeze-fracture, freeze-etching; Chromosome banding, FISH, GISH, chromosome painting.

Unit 2: Fractionation methods **04 Hours**

Centrifugation: types of rotors, differential and density gradient centrifugation, sucrose density gradient, ultracentrifugation, caesium chloride gradient; marker enzymes for analysis of cellular fractions.

Unit 3: Radioisotopes **04 Hours**

Types of radioisotopes; types of emissions (alpha, beta, gamma radiations); half-life; use of radioisotopes in biological research; auto-radiography; pulse-chase experiment; Biosafety measures and disposal of radioactive material

Unit 4: Spectrophotometry **02 Hours**

Principles and applications of UV, Visible and IR spectrophotometry

Unit 5: Chromatography **05 Hours**

Principles and applications of Paper chromatography, Column chromatography, TLC, GLC,

HPLC, Ion-exchange chromatography, Molecular sieve chromatography, Affinity chromatography.

Unit 6: Techniques for detection and analysis of nucleic acids and proteins 09 Hours

PCR – design of PCR primers, enzymes used for PCR, cloning of PCR products; DNA polymorphism and its applications (RFLP, AFLP, SSR, SNPs); RNA isolation and analysis, cDNA synthesis and qRT-PCR; Extraction of proteins, PAGE (Native and denaturing); Blotting and hybridization techniques: Southern (Radioactive and Non-radioactive), Northern and Western; DNA sequencing – Sanger's dideoxy sequencing; ELISA.

Practicals 60 hours

1. Study of microscopic techniques using digital resources (freeze-fracture, freeze-etching, negative staining, FISH, chromosome banding).
2. Isolation of chloroplasts by differential centrifugation.
3. Separation of nitrogenous bases by paper chromatography.
4. Separation of sugars by thin layer chromatography
5. Separation of chloroplast pigments by column chromatography (demonstration)
6. Amplification of DNA by PCR and visualization of PCR products.
7. Detection of DNA polymorphism (SSR based DNA fingerprinting).
8. Gel based and capillary based DNA sequence data analysis.
9. Estimation of protein concentration by Bradford method.
10. PAGE to study overexpression of proteins/ Separation of proteins by PAGE.
11. Blotting techniques: Southern, Northern and Western using digital resources.

Suggested Reading:

18. Hofmann, A., &Clokie, S. (2018) Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology (8th ed.). Cambridge University Press.
19. Gerald Karp, Janet Iwasa, Wallace Marshall (2019).Karp's Cell and Molecular Biology, 9th Edition: Wiley
20. O' Brien, T.P. and Cully M.E (1981). The Study of Plant Structure. Principles and selected Methods, Termarcarphi Pty. Ltd., Melbourne.

Additional Resources:

1. Cooper, G.M., Hausman, R .E. (2009). The Cell: A Molecular Approach, 5th edition. Washington, D.C.: ASM Press & Sunderland, Sinauer Associates, MA.

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POOL OF DISCIPLINE SPECIFIC ELECTIVES

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE -07): Recombinant DNA Technology and Proteomics

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		
Recombinant DNA Technology and Proteomics BOT-DSE-07	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives: This course structure is designed to:

- familiarize the students with the essential knowledge and technical skills/ methodology involved in creating recombinant DNA molecules.
- provide knowledge on generating modified organisms, synthesize a product or modify a biological process by tailoring and/or incorporating DNA from one organism into another.

Learning outcomes:

After completion of the course students will:

7. be able to identify, locate, isolate and functionally characterize DNA sequences/genes.
8. Get familiarized with technologies used to create recombinant DNA.
9. be able to design strategies adopted to generate genetically modified organisms for various applications.
10. be aware of the application of recombinant DNA in pharmaceuticals, agriculture, environment management, etc.

Unit 1: **Enzymes inrecombinant DNA technology** **04 hours**

Nucleases: DNAses, RNAses, Restriction endonucleases (discovery, classification, isoschizomers and cleavage action), exonucleases, polymerases (DNA, RNA, Reverse transcriptase, *Taq* polymerase), ligases, kinases, alkaline phosphatase.

Unit 2: Cloning vectors **04 hours**

Plasmids (basic features and types - pBR322, pUC18, pUC19, TA vectors), lambda vectors (insertion and replacement vectors), M13, cosmids and phagemids, pBluescript II; Artificial chromosomes as vectors (BACs, YACs). Expression vectors and shuttle vectors, YeP; strategies for over-expression of proteins

Unit 3: Isolation and cloning of target DNA **03 hours**

PCR, Strategies: isolation/generation of target sequence (restriction-based and PCR-based), generation of compatible cohesive ends, linkers and adaptors.

Unit 4: **Creating and screening DNA libraries** **03 hours**

Construction of genomic and cDNA libraries, screening and identification of target sequence by DNA hybridization and immunological methods.

Unit 5: **Introduction of DNA into host cell** **06 hours**

Preparation and transformation of competent bacterial cells (heat shock and electroporation). DNA delivery into plant cells and protoplasts: *Agrobacterium* mediated (disarmed Ti plasmid), electroporation, microinjection, liposomes and biolistic methods). Selection and identification of transformants (alpha-complementation, antibiotic resistance and reporter genes (GUS and GFP).

Unit 6: Protein purification and Identification **03 hours**

Chromatography-based methods (ion exchange chromatography and affinity chromatography), antibody-based methods (ELISA and Western blotting).

Unit 7: **Proteomics** **04 hours**

Introduction to proteomics: gel-based methods (Native and SDS PAGE, 2D gel electrophoresis, differential gel electrophoresis), mass spectrometry.

Unit 8: Applications **03 hours**

Application of recombinant DNA technology and Proteomics in medicines (insulin, vaccines), agriculture (insecticide delta endotoxin, golden rice, antisense strategy in tomatoes).

Practicals **60 hours**

15. Plasmid DNA isolation using Bacterial cultures.
16. Agarose Gel electrophoresis of plasmid DNA
17. Quantification of DNA by spectrophotometry
18. Extraction of protein and its Quantification by Lowry’s method

19. Constructing Restriction map of linear and circular DNA using the data provided
20. Study of recombinant DNA techniques through photographs (Biolistic technique, electroporation, microinjection, PCR, western blotting, artificial chromosomes YAC, BAC, Cosmid, Phagemid, Ti plasmid)
21. Demonstration of SDS-PAGE and affinity Chromatography

Suggested reading:

- Brown, T. A. (2016) Gene Cloning an Introduction: Chapman & Hall.
- Zlatanova, J. and Van Holde, K.E. (2016) Molecular Biology Structure and Dynamics of Genomes and Proteomes: Taylor and Francis; .
- Glick, Bernard R, Jack J. Pasternak, Patten Cheryl L. 2018. Molecular Biotechnology; principles and applications of recombinant DNA, ASM Press, Washington.
- Lovric, J., 2011. Introducing Proteomics. Wiley-Blackwell
- S.B. Primrose, R. M. Twyman, R.W.Old. 2001. Principles of Gene manipulation: Blackwell Science; 2001

Additional reading:

- Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
- Kreuzer, H. Massey, A (1996) Recombinant DNA and Biotechnology; A guide for teachers; ASM Press.

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

Category II

Botany Courses for Undergraduate Programme of study with Botany as one of the Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE (DSC-6.): Economic Botany and Biotechnology

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		
Economic Botany and Biotechnology LS-DSC-BOT - 6	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**Nil**

Learning Objectives:

- To understand the economic importance of plants as cash crops - cereals, legumes, spices, non-alcoholic beverages, oils and fibres.
- To understand the concepts and applications of the techniques of Plant Tissue Culture and Recombinant DNA Technology in enhancing economic value of plants

Learning Outcomes: At the end of the course the students will have:

- knowledge of the nutritive and commercial / medicinal value of various plants and plant parts used as sources of carbohydrates, proteins, spices, oil and beverages.
- practice the methods / techniques of Plant Tissue Culture and apply tools of Biotechnology in improvement of crops for economic potential.

Unit 1: Origin of Cultivated Plants **02 hours**

Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2: Cereals and millets **04 hours**

Wheat, Rice and Maize: Origin, description of the part used, economic importance. Major and minor millets (Pearl millet, Sorghum, Kodo millet and Finger millet).

Unit 3: Pulse crops **02 Hours**

General account and economic importance with special reference to chickpea and pigeon pea.

Unit 4: Spices **03 Hours**

General account, part used and economic importance with special reference to cardamom, clove and black pepper.

Unit 5: Beverage **02 Hours**

Tea; morphology, types, processing, uses.

Unit 6: Oils and Fats **02 Hours**

General account; Classification, Difference between essential oils and fatty oils, uses (Sunflower, Soybean, Mint)

Unit 7: Fibre Yielding Plants **02 Hours**

Classification of fibres. Cotton and Jute, description of part used and uses.

Unit 8: Plant Tissue Culture Technology **05 Hours**

Introduction; nutrient media; aseptic and culture conditions, organogenesis (direct and indirect) and somatic embryogenesis; androgenesis, embryo culture, endosperm culture, protoplast culture Applications: micropropagation, generation of somaclonal variants, synthetic seeds and germplasm conservation.

Unit 9: DNA Recombinant Technology **08 Hours**

Introduction, Blotting techniques (Southern and Northern); PCR; Molecular DNA markers (RAPD, RFLP) and DNA fingerprinting in plants. Genetic Engineering Techniques: Gene cloning vectors (pUC18, Ti plasmid); enzymes (nuclease, polymerase, kinase, ligase); screening for gene of interest by DNA probe hybridisation, Insertion of genes into plant (*Agrobacterium* mediated, biolistics); selection of recombinants by selectable marker and reporter genes (GUS). Applications: Bt cotton, Golden rice, Flavr-Savr tomato, Edible vaccines.

Practicals: **60 Hours**

- Study of economically important plants through: specimens (Millets, Pigeon pea, Chickpea, Tea, and Cotton), Sections (Wheat, Maize, Black pepper, Clove), Micro-chemical Tests (Wheat, Soybean, Groundnut and Cotton).
- Principle and working of equipment used in Tissue culture: Laminar air flow cabinet, Autoclave.
- Preparation of culture medium (MS medium), sterilisation and inoculation of explants (Demonstration)
- Study of Micropropagation, Anther culture, Somatic embryogenesis, Endosperm and Embryo culture
- Study of Molecular techniques: PCR, Blotting techniques

22. Extraction and separation of DNA.
23. Visit to any tissue culture/biotechnology laboratory

Suggested reading:

14. Bhojwani, S.S., Razdan, M.K. (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.
15. Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text. Springer

16. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications. Washington, U.S.: ASM Press.
17. Kochhar, S.L. (2011). Economic Botany in the Tropics, 4th edition. New Delhi, Delhi: MacMillan Publishers India Ltd.
18. Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, Springer
19. Wickens,G.E. (2012) Economic Botany: Principles and Practices. Springer

Additional Resources:

11. Park, S. (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition. Elsevier
12. Ranabhatt, H. and Kapor, R. (2018). Plant Biotechnology {Woodhead Publishing}
13. Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition {CBS / Oxford & IBH}
14. Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}.
15. Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 3rd Edition {Wiley-Blackwell}
16. Trigiano, R. N., Dannis, J. Gray (2019). Plant Tissue Culture, Development, and Biotechnology {CRC Press}

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

Category - III

B.Sc. programme in Applied Life Sciences with Agrochemicals and Pest Management

DISCIPLINE SPECIFIC CORE COURSE (DSC 06)

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		
Plant Biotechnology: Concepts and Applications ALS BOT DSC 06	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	NIL

Learning Objectives:

The learning objectives of this course are as follows:

- to give students knowledge of techniques used in plant biotechnology and its applications.
- to explore the use of biotechnology to generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.
- to understand the biotechnological processes such as recombinant DNA technology and its applicative value in pharmaceuticals, food industry, agriculture, horticultural and ecology. This knowledge is central to our ability to modify plant responses and properties for global food security and commercial gains in biotechnology and agriculture.
- to perform the techniques currently used to generate information and detect genetic variation.

Learning Outcomes:

By studying this course, students will be able to:

- comprehend the basic concepts, principles and processes of plant biotechnology.
- apply the acquired knowledge in biotechnological, pharmaceutical, medical, ecological and agricultural fields.
- use the basic biotechnological techniques to explore molecular biology of plants.
- explain the use of biotechnological techniques for plant improvement and biosafety concerns.

Unit 1: Introduction to Biotechnology (2 Hours)

Historical timeline; Brief overview of techniques and methods in Biotechnology, sectors of Biotechnology.

Unit 2: Plant Tissue Culture (8 Hours)

Historical perspective (Haberlandt, Laibach, White, Reinert and Steward, Murashige, Cocking, Guha and Maheshwari, Bhojwani, Morel and Martin); Composition of media; Nutrients (major and minor), vitamins and hormones; Plasticity and Totipotency; Regeneration: Organogenesis (Direct and Indirect) and Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, haploids, triploids, cybrids, production of virus-free plants).

Unit 3: Recombinant DNA Technology and Genetic Transformation (12 Hours)

Restriction Endonucleases (History, Types I - IV, biological role and applications); Modifying enzymes and their applications (nucleases, ligases, alkaline phosphatase, polynucleotide kinase) Introduction to prokaryotic and eukaryotic cloning vectors: pBR322, pUC 18, pUC19, BACs, Lambda phage, YACs. Gene Cloning: Restriction digestion of DNA, ligation, bacterial transformation and selection of recombinant clones; Methods of gene transfer to plants: *Agrobacterium*-mediated transformation (Ti plasmids), Direct gene transfer by Electroporation, Microinjection, Microprojectile

bombardment; Selection of transgenic plants: selectable marker genes (Positive selection markers – antibiotic- and herbicide-resistance conferring genes) and reporter genes (Luciferase, GUS, GFP).

Unit 3: Applications of Transgenic Technology (8 Hours)

Pest resistant (Bt-cotton) and herbicide resistant plants (RoundUp Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato. Golden rice); Improved horticultural varieties (Moondust carnations); Role of transgenics in bioremediation (Superbug); Edible vaccines; Introduction to genome editing; Biosafety of transgenic plants.

PRACTICALS 60 hours

1. Preparation of nutrient media for plant cell cultures- Murashige & Skoog's (MS) medium
and B5 medium.
2. Initiation of axenic cultures (seed sterilisation and inoculation)
3. Micropropagation (shoot induction) using leaf and/or nodal explants of tobacco/*Datura*/ *Brassica* etc.
4. Study of anther culture, embryo and endosperm culture, somatic embryogenesis using digital resources/ photographs.
5. Preparation of artificial seeds.
6. Isolation of plasmid DNA.
7. Induction of callus and analysis of effects of growth regulators on *in vitro* regeneration using
tobacco as a model plant
8. Preparation of competent cells and transformation of *E. coli* by heat shock method.
9. Restriction digestion and gel electrophoresis of plasmid DNA.
10. Construction of restriction map of circular and linear DNA from the data provided.
11. Visit to a Research laboratory.

Essential/recommended readings:

1. Bhojwani, S.S., Bhatnagar, S.P. (2011). The Embryology of Angiosperms, 5th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
2. Bhojwani, S.S., Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Amsterdam, Netherlands: Elsevier Science.

3. Glick, B.R., & Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
4. Brown, T. A. 2020. Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
5. Slater, A., Scott, N. W. & Fowler, M. R.(2010) Plant Biotechnology: The Genetic Manipulation of Plants. 2ndedn. New York, USA: Oxford University Press Inc.
6. Primrose, S. B. and Twyman, R.M. (2013) Principles of Gene Manipulation and Genomics. 7thedn. Wiley-Blackwell Publishing.

SuggestedReadings :

1. Stewart, C.N. Jr. (2008). Plant Biotechnology and Genetics: Principles, Techniques and Applications. New Jersey, U.S.: John Wiley & Sons Inc.
2. Snustad, D.P., Simmons, M.J. (2010). Principles of Genetics, 5th edition. Chichester, England: John Wiley and Sons.
3. Bhojwani, S.S. and Dantu, P.K. (2013). Plant Tissue Culture: An Introductory Text. Springer New Delhi Heidelberg New York Dordrecht London

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

POOL OF DISCIPLINE SPECIFIC CORE
FOR B.SC. PROGRAMME IN APPLIED LIFE SCIENCES WITH AGROCHEMICALS AND PEST MANAGEMENT

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE 04)

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
		Lecture	Tutorial	Practical/ Practice		
Plant Systematics ALS BOT DSE 04	**4**	**2**	**0**	**2**	Class XII pass with Biology/ Biotechnology	**NIL**

Learning Objectives:

The learning objectives of this course are as follows:

- to gain knowledge about the basics of plant systematics.
- to get an insight into the interrelationships of plant systematics and allied subjects.

Learning Outcomes:

By studying this course, students will be able to:

- understand technical terminology used in plant taxonomy.
- apply the terminologies to describe, identify and classify the flowering plants.
- search and analyze taxonomic information from internet-based scientific databases and other resources.
- comprehend and compare various systems of classification.
- recognize diversity in local/regional flora.

Unit 1: Introduction **(1 Hour)**

Plant identification, Classification, Nomenclature, Biosystematics.

Unit 2: Identification **(4 Hours)**

Field inventory, Herbarium Techniques, Functions of Herbarium, Important herbaria and botanical gardens of the world and India, Virtual Herbarium, E-flora: Flora, Monographs, Journals.

Unit 3: Systematics-An Interdisciplinary Science **(5 Hours)**

Evidence from cytology, phytochemistry [Alkaloids, Phenolics, Glycosides, (in brief)] and molecular data (cp.DNA, mt-DNA, nuclear DNA, PCR amplification, sequence data analysis)

Unit 4: Taxonomic Hierarchy **(2 Hours)**

Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological & evolutionary)

Unit 5: Botanical Nomenclature **(7 Hours)**

Principles and rules (ICN); Ranks and names; Typification, Author citation, Valid publication, Rejection of names, Principle of priority and its limitations; Names of hybrids and cultivated plants.

Unit 6: Basic Terms and Concepts of Phylogeny **(4 Hours)**

Cladistics: Terms and concepts (primitive and advanced, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly, clades and grades). Methodology of Cladistics, Methods of illustrating evolutionary relationships (phylogenetic tree, cladogram).

Unit 7: Systems of Classification **(7 Hours)**

Major contributions of Parasara, Charaka, Theophrastus, Bauhin, Tournefort, Linnaeus, Adanson, de Candolle, Bessey, Hutchinson, Takhtajan, Cronquist, Bremer and MW Chase; Classification systems of Benthan and Hooker (up to series) and Engler and Prantl (up to series); Angiosperm Phylogeny Group (APG IV) Classification (major clades).

PRACTICAL (60 Hours)

1. To prepare at least 2 herbarium specimens and identify them using available resources (Literature, herbaria, e-resources, taxonomic keys) and classify up to family level (according to Bentham and Hooker's classification).

2. Description of taxa using semi-technical terms and identification of the families according to Bentham and Hooker's classification.

Note: Any twelve families from the following list to be studied with at least two specimens (or one where limitations exist).

List of Suggested Families (*mandatory)

Acanthaceae, Rubiaceae, *Apiaceae, Apocynaceae, *Asteraceae, *Brassicaceae, *Euphorbiaceae, *Fabaceae, *Lamiaceae, Liliaceae, *Malvaceae, Moraceae, *Poaceae, *Ranunculaceae, *Solanaceae.

Essential/recommended readings:

1. Simpson, M. G. (2019). *Plant systematics*. 3rd Edition, Academic press.
2. Singh, G. (2019). *Plant Systematics- An Integrated Approach.* 4th edition. CRC Press, Taylor and Francis Group.
3. Pandey, A. K., Kasana, S. (2021). *Plant Systematics*. 2nd Edition. CRC Press Taylor and Francis Group
4. *http://www.mobot.org/MOBOT/research/APweb/*
5. Maheshwari, J. K. (1963). *The flora of Delhi.* Council of Scientific & Industrial Research.
6. Maheshwari, J. K. (1966). *Illustrations to the Flora of Delhi.* Council of Scientific & Industrial Research.
7. Harris, J. G., Harris, M. W. (2001). *Plant Identification Terminology: An Illustrated Glossary.* Spring Lake, Utah: Spring Lake Pub. Spring Lake, Utah.

Suggestive Readings:

1. The Angiosperm Phylogeny Group, Chase, M.W., Christenhusz, M.J.M, Fay M.F., Byng, J.W., Judd, W.S., Soltis, D.E., Mabberley, D.J., Sennikov, A.N., Soltis, P.S., Stevens, P.F. (2016). *An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV.* Botanical journal of the Linnean Society 181 (1): 1-20.
2. https://www.mobot.org/MOBOT/research/APweb/treeapweb2s.gif
3. https://www.digitalatlasofancientlife.org
4. http://apps.kew.org/herbcat/navigator.do
5. https://efloraofindia.com/
6. https://powo.science.kew.org/
7. Page, R.D.M., Holmes, E.C. (1998). *Molecular Evolution: A Phylogenetic Approach*. Blackwell Publishing Ltd.

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

COMMON POOL OF GENERIC ELECTIVES

GENERIC ELECTIVE (BOT-GE-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
		Lecture	Tutorial	Practical/ Practice		
Genomics, Proteomics and Metabolomics **BOT-GE-20**	4	2	0	2	Class XII Pass with Science	**Nil**

Learning Objectives:

22. Build the concepts of genomics, proteomics and metabolomics.
23. Understand the role of model organisms in genomics studies
24. Familiarization of tools used in genomics and proteomics.

Learning Outcomes: At the end of this course, students will be able to:

7. understand the implications of genomic, transcriptomic, proteomic and metabolomic studies in an organism.
8. assimilate logic and reasoning behind choice of model organisms for genomics study.

Unit 1: Introduction to genomics **02 Hours**

Recapitulating basics of prokaryotic and eukaryotic genomes; basic concept of structural and functional genomics.

Unit 2: Model organisms in genomics **02 Hours**

Features of important model organisms used in genomics study (*Escherichia coli*, *Saccharomyces cerevisiae*, *Caenorhabditis elegans*, *Arabidopsis thaliana*)

Unit 3: Sequencing strategies **04 Hours**

Sequencing: basic principle-Sanger's method; classical approaches for sequencing large genomes (whole genome shot gun method viz. WGS, clone by clone sequencing); Next generation sequencing (NGS) ; Concept of third generation sequencing

Unit 4: Genome sequencing Projects **04 Hours**

Human genome project (brief history and significance); *Arabidopsis* genome project; rice genome project; applications of genomics in agriculture and human health

Unit 5: Transcriptomics **03 Hours**

Concept: EST sequencing; Gene expression studies by Microarrays and RNAseq.

Unit 6: Introduction to proteins and proteomics **06 Hours**

Proteins as structural and functional unit of life; basics concept of protein structure (primary, secondary, tertiary, and quaternary), peptide bonds; brief introduction of major post-translational modifications (phosphorylation, glycosylation); introduction to enzymes; introduction to proteomics and its applications.

Unit 7: Tools for proteome analysis **05 Hours**

Separation and isolation of proteins from plant tissue; purification of proteins by chromatographic techniques (column chromatography, ion exchange and affinity chromatography); separation of total cellular proteins by electrophoresis: SDS-PAGE, western blotting and ELISA.

Unit 8: Metabolomics **04 Hours**

Concept of metabolomics; classes of metabolites (primary and secondary metabolites in plants); Experimental methods and instruments used in metabolomics- HPLC, GC; applications of metabolomics.

Practicals **60 hours**

- Genomic DNA extraction from cauliflower heads
- Select 10 different organisms (5 prokaryotic and 5 eukaryotic) whose genomes have been completely sequenced and categorize them based on taxonomy, find their genome size and locate the database where their genome sequence is hosted.
- Demonstration of gene expression studies through photographs: microarrays and RNA seq.
- Demonstration of Sanger's DNA sequencing principle.
- Interpretation and reading of DNA sequence chromatograms.
- Experiment to demonstrate activity of Amylase.
- Estimation of protein concentration through Lowry's methods/Bradford assay.
- Demonstration of separation of proteins using SDS-PAGE (demonstration).
- Study of proteins by Western blotting technique (digital resources/demonstration).
- Demonstration of ELISA through kit.

Suggested readings:

15. Brown, T. A. (2020). Gene Cloning & DNA Analysis: An Introduction. 8thedn. UK: Wiley Blackwell.
16. Glick, B.R., Patten C. (2022). Molecular Biotechnology: Principles and Applications. 6thedn. Washington, U.S.: ASM Press.
17. Griffiths, A.J.F., Doebley, J., Peichel, C, Wassarman D. (2020). Introduction to Genetic Analysis, 12th edition. New York, NY: W.H. Freeman and Co.
18. Liebler, D.C. (2002). Introduction to Proteomics: Tools for New Biology, Humana Press.
19. Primrose, S. B. Twyman, R.M. (2006). Principles of Gene Manipulation and Genomics. 7thedn. Victoria, Australia: Blackwell Publishing.
20. Twyman R. (2013) Principles of Proteomics, Taylor & Francis Books.
21. Watson J.D. (2017) Molecular Biology of the Gene. Pearson publishers.

22. Westermeier, R., Naven, T., Hopker, H.R. (2008). Proteomics in Practice: A guide to successful experimental design, 2nd edition, Wiley Blackwell.
23. Wood, P.L., (2021) Metabolomics. Springer Protocols.

Additional resources:

- Banks, K (2022) Introduction to Proteomics. Larsen & Keller Education
- Campbell, A.M. and Heyer, L.J (2006). Discovering Genomics, Proteomics and Bioinformatics, Pearson publishers.
- Bhattacharya, S.K. (2019) Metabolomics: Methods & Protocols. Springer Protocols/Humana Press

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

DEPARTMENT OF GEOLOGY
SEMESTER – IV
BSC (H) Geology
Category - I

DISCIPLINE SPECIFIC CORE COURSE -10 (DSC-10) – : Geomorphology (L3, P1)

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		
(DSC-10) **Geomorphology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

The course on geomorphology is intended to provide students basic scientific knowledge Earth surface process and evolution of the landforms. Students will be aught about the basic and fundamentals of geomorphology to comprehend the process and evolution of landscapes through time.

Learning outcomes

After going through this course, students will develop basic skills and understanding about the key concepts of geomorphology, i.e., systems (morphological, cascading, process-response), threshold, magnitude and frequency, unifying concepts such as conservation of mass and energy in geomorphic systems, sediment routing, equilibrium and steady state. They will be able to use the knowledge to identify various landforms and processes in different environments i.e., glacial, fluvial, aeolian, coastal regions. They will also be able to examine the landforms at primary scale. They will be able to analyse the morphometric parameters of a basin. They will develop skills to prepare a geomorphic map using topographic sheets and Google Earth images.

SYLLABUS OF DSC-10 (Credits: 4)
Theory: 45 hours, Practical: 30 hours

UNIT – I (9 hours)

Detailed content

Introduction to Geomorphology: Concepts in geomorphology, Geosphere-Hydrosphere-Biosphere; Unifying concepts

UNIT – II (9 hours)

Detailed contents

Morphological features of Earth: Geoid, Topography, Hypsometry, Global Hypsometry, Major Morphological features. Large Scale Topography - Ocean basins, Plate tectonics overview, Large scale mountain ranges (with emphasis on Himalaya)

UNIT – III (9 hours)

Detailed contents

Earth Surface Processes: Surficial processes and geomorphology; Weathering and associated landforms, Hill slopes Glacial, Periglacial processes and landforms, Fluvial processes and landforms, Aeolian Processes and landforms, Coastal Processes and landforms, Landforms associated with igneous activities.

UNIT – IV (9 hours))

Detailed contents

Methods and techniques: Dating Methods, measuring rates; Rates of uplift and denudation, Tectonics and drainage development, Sea-level change, Long-term landscape development.

UNIT – V (9 hours)

Detailed contents

Overview of Indian Geomorphology. Introduction to Extra-terrestrial landforms

Practical Component- (30 Hours)

Reading topographic maps, Concept of scale, Preparation of a topographic profile, Preparation of longitudinal profile of a river, Preparing Hack Profile and Calculating Stream length gradient index, Morphometry of a drainage basin - Calculating different morphometric parameters, Preparation of geomorphic maps.

Essential/recommended readings

M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.

Suggestive readings

Robert S. Anderson and Suzzane P. Anderson (2010): Geomorphology - The Mechanics and Chemistry of Landscapes. Cambridge University Press.

Paul R. Bierman and D.R. Montgomery (2014): Key Concepts in Geomorphology. W.H. Freeman and Company Publishers.

M.A. Summerfield (1991) Global Geomorphology. Wiley & Sons.

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

DISCIPLINE SPECIFIC CORE COURSE : DSC-11- Hydrogeology (L3, P1)

Credit distribution, Eligibility and Prerequisites 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		
(DSC-11) Hydrogeology (L3, P1)	4	3	0	1	12th Pass with Science	Studied Stratigraphy, Earth System Science or Equivalent

Learning Objectives
Main objective of the course is to make students comprehend about the nature, occurrence and movement of groundwater in geological context. To develop basic understanding about ground water exploration and management.

Learning Outcomes:
After completing the course, the students will get a basic understanding of aquifers and groundwater systems. The students will be able to comprehend the groundwater flow dynamics and well hydraulics, enhancing their numerical skills for development of groundwater resources. Learners will gain expertise in fundamentals of groundwater exploration helping them to identify groundwater sources in field. The students will be able to analyse and compare the groundwater quality. This would help them to categorise the use of groundwater for various purposes. Learners will be skilled with fundamentals of water balance, groundwater resource estimation and groundwater resource management practices.

SYLLABUS OF DSC- 11
Theory (45 Hours)

UNIT – I (9 hours)
Detailed contents
Introduction and basic concepts: Scope of hydrogeology and its societal relevance. Hydrologic cycle: precipitation, run-off, infiltration and subsurface movement of water. Hydrogeological formations: Aquifer; Aquitard; Aquiclude; Aquifuge. Vertical distribution of subsurface water. Types of aquifers, aquifer properties, anisotropy and heterogeneity of aquifers. Introduction to geologic formation as aquifers.

UNIT – II (9 hours)
Detailed contents
Groundwater flow: Darcy's law and its validity (discussions on laminar and turbulent groundwater flow), intrinsic permeability and hydraulic conductivity, Groundwater flow rates and flow direction.

UNIT – III (9 hours)
Detailed contents
Well hydraulics and Groundwater exploration: Basic Concepts of well hydraulics (drawdown; specific capacity etc). Elementary concepts related to: equilibrium conditions for water flow to a well in confined and unconfined aquifers, estimation of permeability in field and laboratory. Introduction to non-equilibrium groundwater flow condition. Surface-based groundwater exploration methods.

UNIT – IV (9 hours)
Detailed contents
Groundwater chemistry: Physical and chemical properties of water and water quality. Introduction to methods of interpreting groundwater quality data using standard graphical plots. Sea water intrusion in coastal aquifers.

UNIT – V (9 hours)
Detailed contents
Groundwater management: Basic concepts of water balance studies, issues related to groundwater resources development and management. Groundwater level fluctuations. Rainwater harvesting and artificial recharge to groundwater.

Practical Component- (30 Hours)
Preparation and interpretation of water level contour maps and depth to water level maps. Preparation and analysis of hydrographs for differing groundwater conditions. Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams). Simple numerical problems related to: estimation of permeability in field and laboratory, Groundwater flow, Well hydraulics etc.

Essential/recommended readings
Todd, D. K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

Suggested readings
Davis, S. N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
Raghunath, H.M. 2007. Groundwater, Third Edition, New Age International Publishers.
Shekhar Shashank . 2017a. Aquifer Properties. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448
Shekhar Shashank. 2017b. Darcy's law. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448
Shekhar Shashank. 2017c. Assessment of groundwater quality. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448
Syed Tajdarul Hassan. 2017a. Introduction to Hydrology. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448
Syed Tajdarul Hassan. 2017b. Hydraulic Head, Fluid Potential, Reynolds number and Pumping Tests-I. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448
Syed Tajdarul Hassan. 2017c. Hydraulic Head, Fluid Potential, Reynolds number and Pumping Tests-II. E-PG Pathshala, UGC, MHRD, Govt. of India. Available on: https://epgp.inflibnet.ac.in/ahl.php?csrno=448

DISCIPLINE SPECIFIC CORE COURSE– 12 (DSC-12): Geology of India (L3, P1)

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		
DSC-12 Geology of India (L3, P1)	4	3	0	1	12th Pass with Science	Studied Earth System Science, Concepts of Stratigraphy, Structural Geology, and Mineralogy or Equivalent

Learning Objectives

The course on Geology of India is to provide students a comprehensive understanding about the overall geology of the Indian subcontinent through stratigraphic approach. Students will be taught about the geological history of the Indian subcontinent spanning from Archean to Quaternary times. They will be motivated to learn the role of tectonics, climate and sea level in framing the geological history of India through time.

Learning Outcomes:

After completion of the course, students will have understanding of stratigraphic sub-divisions of India from Archaean to Cenozoic times. They will acquaint with depositional environments, paleogeographic setting and tectonic evolution of various Indian sedimentary basins and their fossils and mineral assets. They will understand the major mass extinction events, its effect on various faunas and their recovery after mass extinction.

SYLLABUS OF DSC-12
Theory (45 Hours)

UNIT – I (9 hours)
Detailed contents
Introduction to geology of India: Physical and tectonic subdivisions of Indian subcontinent

UNIT – II (9 hours)
Detailed contents
Major sub-divisions Indian Geology: Distribution of stratigraphic units in the Peninsula and in the Himalayas. Stratigraphy, geographic distribution, lithological characteristics, fossil contents and economic importance.

UNIT – III (9 hours)
Detailed contents
Precambrian and Phanerozoic successions of India: Precambrian basement rocks of Dharwar, Aravalli-Bundelkhand, Bastar, Singhbhum, central provinces of northeastern India; Proterozoic mobile belts in northwestern, central, eastern and southern Indian peninsular regions and in the extra-peninsula; Proterozoic basins including: Vindhyan, Cuddapah, Kurnool, Bhima, and Kaladgi. Marine Paleozoic formations of India: Tethyan regions, Lesser Himalayan region. Marine Mesozoic formations of India: Himalayan and Peninsular region.
Gondwana sequences of India. Cenozoic formations in western, eastern, southern and Himalayan regions. Deccan Traps, Rajmahal Traps.
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UNIT – IV (9 hours)
Detailed contents

Stratigraphic boundary problems: Precambrian-Cambrian boundary; Permian-Triassic boundary; Cretaceous-Tertiary boundary

UNIT – V (9 hours)

Glacial Events: Major glacial events in the Earth's history, stratigraphic implication of the sea-level changes in the Quaternary period and their significance in Indian subcontinent.

Practical Component- (30 Hours)

Study of rocks in hand specimens from the known stratigraphic horizons, Drawing various paleogeographic maps and tectonic maps of sedimentary basins. Study of different Proterozoic supercontinent reconstructions, Interpretation of various stratigraphic logs and their correlation.

Essential/recommended readings

Wadia,D.N. 1957. Geology of India, 3rd Ed., McMillan, London.
Ravindra Kumar, 1985. Fundamentals of historical geology and stratigraphy of India. Wiley Eastern Ltd., Delhi.
Ramakrishnan, M. & Vaidyanathan, R. (2008) Geology of India. Volume 1 & 2, Geological Society of India, Bangalore.

Suggestive readings

Wadia,D.N. 1957. Geology of India, 3rd Ed., McMillan, London.
Naqvi, S.M. and Rogers, J.J. 1986. Precambrian Geology of India. Clarendon Press.
Ravindra Kumar, 1985. Fundamentals of historical geology and stratigraphy of India. Wiley Eastern Ltd., Delhi.

Common Pool of Discipline Specific Electives

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		
DSE-2 **Introduction to Field Geology (L2, P2)**	**4**	**2**	**0**	**2**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

This course on Introduction to Field Geology is intended to provide students of geology about the basic techniques of observation and description of various primary and secondary rock structures and landforms during geological fieldwork. They will learn and develop skills to extract information about an area through the investigation of topographic maps and techniques of field geology.

Learning outcomes

After completion of this course, students will develop the technique of carrying out the field work in different geological terrains. Specifically, they will be able to locate themselves in field Identify sedimentary structures in field, measure grain size in the field, prepare lithologs, identify structures in the field, and prepare and interpret profiles from the topographic maps and how to prepare a field report.

SYLLABUS OF DSE-2

Theory (30 hours)

UNIT – I (6 Hours)

Detailed Content

Rock Particles and Fragments: characters of larger rock fragments, pebbles etc.; Shape and surface markings; Dimensions of Particles and fragments; composition; shape; angular particles; subangular particles; rounded particles;

UNIT – II (6 Hours)

Detailed Content

Sedimentary Structures: process of formation and their interpretation; laminae, bed, ripple marks, wave marks, rill marks, mud cracks, slump marks, cross-stratifications etc. Importance of litholog (theory)

UNIT – III (6 Hours)

Detailed Content

Deformed rocks: Tilted and folded strata; Principal kinds of folds or flexures; Types of folds; Strike, dip, plunge and pitch; Classification of faults; kinds of displacement; principal evidences of faulting; relation of folds and faults; Topographic expression of folds and faults.

UNIT – IV (6 Hours)

Detailed Content

Landforms in various environment: Fluvial landforms, coastal landforms, aeolian landforms, and glacial landforms.

UNIT – V (6 Hours)

Detailed Content

Topographic maps and profile sections: Contours; spacing of contours; scale; direction; requisite data on a completed contour map. Techniques used in examination of outcrops.

Practical Component- (60 Hours)

In the practical class, all components of the field geology and measurement techniques will be demonstrated and practised in the field. The practical classes of this course will be conducted at a go through field visit (10 days) in a suitable geological terrain in India. This will cover- Measuring large grain sizes in the field (Grid method), Identification of sedimentary structures, Preparation of litholog, Identification of landforms (glacial/fluvial/coastal/aeolian), Identification of folds and faults; evidences of faulting, Construction of a profile section; Enlargement of profile section, Measurement of slope from the topographic map, Location in the toposheet thorough GPS/bearing, Measurement of dip, strike, trend, plunge, pitch, Identification of bedding, flow banding, metamorphic foliation.

Essential

Field Geology by F.H. Lahee, CBS Publishers
Basic geological mapping, R. Lisle, Wiley-Blackwell, 2014

Recommended readings

Sedimentary Rocks in the field, M. Tucker, Wiley-Blackwell, 2011

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		
DSE-3 **Paleoseismology** (L3, P1)	**4**	**3**		**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

DSE-3:
Paleoseismology (L3, P1)
Credit: 4
Theory (45 hours), Practical (30 hours)

Learning Objectives

The goal of this course is to provide students an understanding about: Geological techniques to study the pre-instrumental earthquakes and its application to Seismic Hazard Assessment. What do past earthquakes look like in the geologic record in different environments? To estimate the magnitude of past and future earthquakes using trench logs and geochronology as a case study from different seismically active regions of the world, e.g., Himalaya, Japan, New Zealand, etc. Learn the deformation on short- and long-term time scales.

Learning outcomes

After going through this course, students will understand how the Earth deforms from individual earthquakes to systems of faults to the construction of mountain ranges. They can able to map the active faults and their recurrence time of earthquake and seismic hazard in a seismically active area.

SYLLABUS OF DSE-3
Theory (45 hours)

Unit-1 (9 hours)
Detailed Content
Landscape Response to Tectonics: Introduction to Seismicity, its causes and nucleation, Introduction to geodesy and short-term deformation. Earthquakes in the Indian Subcontinent. Tectonic landforms. Climate-Tectonic interaction in landscape evolution. Erosion and uplift in orogenic settings. Active tectonics and rivers.

Unit-2 (9 hours)
Detailed Content
Introduction to Paleoseismology: The Scope of Paleoseismology, Evidences to identify past earthquakes- Primary and Secondary evidences, On-fault and Off-fault structures, Recurrence time of earthquake, Slip-rate Determination and Magnitude Estimation, Development of Paleoseismology. Distinguishing Paleoseismic Features from Non-Seismic or Non-Tectonic Features.

Unit-3 (9 hours)
Detailed Content
Paleoseismic Investigation Techniques: Geomorphic expressions of fault, Surveying and Mapping Paleoseismic Landforms. Trenching, logging and sampling the fault scarps. Stratigraphic and Structural evidences of Paleoearthquakes. Quaternary Dating techniques- ^{14}C, OSL, surface exposures dating.

Unit-4 (9 hours)
Detailed Content
Paleoseismology of different Tectonic Environments: Introduction to paleoseismic investigations in Contractional, Extensional, and Strike-Slip Tectonic Settings. Surface Rupture studies in Himalaya. Interpreting the Paleoseismic History by Retro-deformation. Introduction to Long term deformation study, Quaternary and Neogene Geomorphic Responses to Tectonics- the Himalayan case.

Unit-5 (9 hours)
Detailed Content
Applications on different time scale: Seismic Hazard Assessment, Estimating Paleo-earthquake Magnitude and Recurrence Cycle, Fault Segmentation.

Practical Component- (30 Hours)
Exercises covering various practical based problems on paleoseismology and tectonic events, past earthquakes, and to assess magnitude and recurrence of the seismic events and futures perspectives.

Essential/Recommended readings
James P. McCalpin (editor), 2009, Paleoseismology (2nd edition), Elsevier/Academic Press: Burlington, MA, 629 pp.
Robert S. Yeats, Kerry E. Sieh, and Clarence R. Allen, 1997, Geology of Earthquakes, Seismological Research Letters 68(5).

Recommended readings
Jayangondaperumal, R., Thakur, V. C., Joevivek, V., Rao, P. S., & Gupta, A. K. (2018), Active Tectonics of Kumaun and Garhwal Himalaya. Singapore: Springer.
Douglas W. Burbank and Robert S. Anderson, 2012, Tectonic Geomorphology (2nd edition), Wiley-Blackwell: UK, 454 pp.
William B. Bull, 2008, Tectonic Geomorphology of Mountains: A New Approach to Paleoseismology, Wiley-Blackwell: Malden, MA, 328 pp.
William B. Bull, 2009, Tectonically Active Landscapes, Wiley-Blackwell: Malden, MA, 320 pp.
Edward A. Keller and Nicholas Pinter, 2002, Active Tectonics: Earthquakes, Uplift, and Landscape (2nd edition), Prentice Hall: Upper Saddle River, NJ, 362 pp.

COMMON POOL OF GENERIC ELECTIVES

Credit distribution, Eligibility and Pre-requisites of the Course GE-4

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-4 Natural Hazards and Mitigation (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The main objective of this course is to teach students how to evaluate risks and implement mitigation strategies. This course introduces students to the concept of disaster risk reduction and gives a foundational understanding of natural hazards around the world with a focus on India. This course also lays the foundation for advanced study in climate change impacts, environment science, sustainability, and disaster management.

Learning outcomes

After going through this course, student will know the genesis of major natural hazards of the world, the impact of climate change and understand the disaster management system of India. The students will be able to assess the risk of natural hazards to a specific place and suggest the basic disaster risk reduction measures and emergency plan.

SYLLABUS OF GE-4
Theory (45 hours)

UNIT – I (9 Hours)
Detailed contents
Introduction to natural hazards: Concept of hazards, vulnerability, exposure, risk and disaster. Major natural and manmade hazards and their impact.

UNIT – II (9 hours)
Detailed contents
Hydrometeorological hazards: Floods, storms/cyclone, cloudburst, heat and cold waves, genesis of hydrometeorological hazards, extreme events.

UNIT – III (9 Hours)
Detailed contents
Geological hazards: Geological processes and hazards. Different forms of mass movement: landslide, subsidence, debris flow; Volcanic hazards: major volcanic eruption; Earthquake and secondary hazard: Tsunami, snow avalanche.

UNIT – IV (9 Hours)
Detailed contents
Climate change and pandemic: Climate change, global warming, sea-level rise, impact of climate change on natural resources; Global climate agreements. Pandemics; other natural hazards.

UNIT – V (9 Hours)
Detailed contents
Hazard mitigation: Hazard zonation; Early warning system; Engineering measures. Hazard/disaster profile of India. Disaster management cycle; Different stakeholder in disaster management; Disaster mitigation structure in India; Emergency plan.

Tutorial (30 hours)
Students in small batches or groups will be assigned different exercises about the natural hazards and resolve the key issues to handle and mitigate.

Essential/recommended readings
Edward Bryant (2005). Natural Hazards. Cambridge University Press
Smith, Keith, (2013). Environmental hazards: assessing risk and reducing disaster: Routledge Taylor & Francis Group. London.

Suggestive readings
Edward Bryant (2005). Natural Hazards. Cambridge University Press
Smith, Keith, (2013). Environmental hazards: assessing risk and reducing disaster: Routledge Taylor & Francis Group. London.
Stephen Marshak, (2013). Essential of Geology, W W Norton & Co Inc, New York
Edward A. Keller; Duane E. DeVecchio (2014). Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes. Routledge.
Bell, F.G., 1999. Geological Hazards, Routledge, London.
David C. Alexander (1993). Natural Disasters. CRC Press

DEPARTMENT OF GEOLOGY
SEMESTER – V
BSC (H) Geology
Category - I

DISCIPLINE SPECIFIC CORE COURSE - DSC – 13: Economic Geology (L3, P1)

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		
DSC – 13: Economic Geology (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives
This course on economic geology is provide basic knowledge and leaning to students to about morphology, structure, mineralogy, petrology and geochemistry of various ore deposits, and to help them to develop a basic idea and comprehension of different ore forming processes.

Learning outcomes
After going through this course students will develop basic understanding and skill about the characteristics and distribution of mineral resources and the knowledge on different ore-bearing geological systems. They will learn about the different processes that are responsible for producing different types of ores corresponding to different tectonic settings. They will learn about the different major ore bodies that have been identified in different parts of the India.

SYLLABUS OF DSC-7
Theory (45 hours)

UNIT – I (9 hours)
Detailed content
Introduction to ore geology: Economic and academic definitions/terminologies of ore geological components. Ore minerals and their uses. Morphology and style of ore mineralization. General textures and structures

UNIT – II (9 hours)
Detailed contents
Basic principles of an ore deposit formation: Geochemical behaviour of elements in ore geological systems. Concept of source-transporting agent-driving mechanism-trap

UNIT – III (9 hours)
Detailed contents
Ore forming processes: Magmatic ore forming processes. Hydrothermal ore forming processes. Sedimentary ore forming processes. Surficial and supergene ore forming processes

UNIT – IV (9 hours))
Detailed contents
Basic mineral economics and policies: Introduction to mineral economics related to metal an non-metallic commodities. Application of mineral economics to understand mineral commodity markets. An assessment of the mineral economics for the public and corporate policies.

UNIT – V (9 hours)
Detailed contents
Distribution of major metallic and non-metallic ore deposits in India

Practical Component- (30 Hours)
Identification of common ore minerals by physical and optical properties

Essential/recommended readings
Robb, L., 2020. Introduction to ore-forming processes. John Wiley & Sons.
Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons

Suggestive readings
Robb, L., 2020. Introduction to ore-forming processes. John Wiley & Sons.
Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons.
Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley & Sons.
Misra, K., 2012. Understanding mineral deposits. Springer Science & Business Media.
Ramdohr, P., 2013. The ore minerals and their intergrowths. Elsevier.
Sarkar, S.C. and Gupta, A., 2012. Crustal evolution and metallogeny in India. 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 CORE COURSE – DSC – 14: Engineering Geology ((L3, P1)

Credit distribution, Eligibility and Prerequisites 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		
DSC – 14: Engineering Geology (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Stratigraphy, Earth System Science or Equivalent**

Learning Objectives

The main objective of this course is to provide a basic introduction on the role of geology in slope stability and civil engineering projects. It is aimed to provide various insights of topography, lithology and geological structures to ensure the stability and economy of engineering projects.

Learning outcomes

After going through this course, students will know the basic geological and geotechnical requirements for the site selection of engineering projects. They will be able to characterize the rock-mass strength of the site for various engineering projects and suggest the necessary support system. They will be able to identify the primary causative factors of the slope failure and suggest the preliminary mitigation measures. They will be able to investigate the various geological factors to assess environmental impacts of any engineering project.

SYLLABUS OF DSC- 14
Theory (45 Hours)

UNIT – I (9 hours)
Detailed contents
Introduction to engineering geology: Principles and scope of engineering geology: material, material fabrics and environmental factors. Geological and geotechnical investigations.

UNIT – II (9 hours)
Detailed contents
Engineering properties of geological material: Rock strength; Rock aggregates; Significance of rock as construction material; Rock mass: discontinuities, Rock mass classification; Soil: strength, standard penetration test and engineering bedrock.

UNIT – III (9 hours)
Detailed contents
Engineering structures: dams, tunnels and roads: Engineering structures: Dams, tunnels, road, their types, acting forces, ground conditions; tunnelling methods; geological considerations for site selection.

UNIT – IV (9 hours)
Detailed contents
Slope failure and mitigation measures: Concept of slope failure mechanism; Landslide types and causes, landslide mapping; Engineering treatment of slope and foundations: grouting, retaining walls, rock bolting and other support mechanisms.

UNIT – V (9 hours)
Detailed contents
Site investigation and assessment for engineering structures: Site investigation and characterization; Reconnaissance survey; Environment impact assessment (EIA); Detailed project report (DPR)

Practical Component- (30 Hours)
Merits, demerits & remedial measures based upon geological cross sections of project sites. Computation of Index properties of rocks and soil. Concept, significance and computation of Rock Mass Classification schemes like Rock Structure Rating (RSR), Rock Mass Rating (RMR)/ Tunnelling Quality Index (Q)/Rock Quality Designation (RQD).

Essential/recommended readings
Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.

Suggestive readings (if any)
Krynin, D.P. and Judd, W.R. (1957). Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
Gangopadhyay, S. (2013). Engineering geology. Oxford University Press.
Goodman, R.E. (1993). Engineering Geology: Rock in engineering constructions. Wiley& Sons, N.Y.
Waltham, T. (2009). Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.
Bell, F.G. (2007). Engineering Geology, Butterworth-Heinema.
Anbalagan, R. Singh, B, Chakraborthy, D. and Kohli, A. (2007) "A filed Manual for Landslide investigations". DST, Government of India, New Delhi.
Duncan C. Wyllie and Christopher W. Mah. (2004). Rock Slope Engineering. CRC Press. London.
David George Price (2009). Engineering Geology: Principles and Practice. Springer-Verlag Berlin Heidelberg

DISCIPLINE SPECIFIC CORE COURSE– DSC – 15: Geological Mapping (L2, P2)

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		
DSC – 15: Geological Mapping (L2, P2)	**4**	**2**	**0**	**2**	**12th Pass with science**	**Studied Earth System Science, Structural Geology, and Mineralogy or Equivalent**

Learning Objectives
This course on geological mapping to provide basic skills to carry out geological fieldwork in different terrains and prepare a geological map with all aspects related to lithology, structures, deformation patterns. Which is essential for basic understanding of geoscience and any detailed exploration activity.

Learning Outcomes
After going through this course, students will develop the following skills and knowledge about: How to identify a rock and broadly define its composition? How to identify and measure lithological and/or structural details of rocks at the outcrop/hand-specimen scale? How to plot the data on a base map/toposheet to create a lithological and/or structural map of the terrain? How to appreciate the possible origin of the rock and their genetic process. How to reconstruct the geological history of the terrain?

SYLLABUS OF DSC-15
Theory (30 hours)

UNIT – I (6 hours)
Introduction to toposheets and maps: Concepts of scale, contour density, numbering system. Global Positioning Systems, their types and uses. Choosing a suitable geological traverse.

UNIT – II (6 hours)
Outcrop geology: Pattern of beds in a undulating topography – rule of V. Identification of rock types, and their classification based on field criteria. Textural features of different rocks through field study and microscopy. Preparation of lithologs.

UNIT – III (6 hours)
Basic concept of structural measurements: Measurement of Strike, dip, trend, plunge, pitch etc. at the outcrop in the field. Distinguishing characters of planar and linear structures in the outcrop scale. Overprinting nature of folds/ metamorphic foliations etc.

UNIT – IV (6 hours)
Folds: Identification and structural measurement of a fold in the field. Geometric classification of a fold based on field data. Understanding the outcrop pattern of a fold in non-ideal sections

UNIT – V (6 Hours)
Faults: Distinguishing criteria of a fault in the field. Understanding the slip pattern of faults in an outcrop. Measuring the orientation of different planar and linear structures associated with a fault.

Practical Component- (60 Hours)

In the practical class, all the aforesaid techniques of measurement and identification will be demonstrated and practised in the field. The practical classes of this course will be conducted at a go through field visit (10 days) in a suitable geological terrain

Essential/recommended readings

Lahee F. H. (1962): Field Geology. McGraw Hill
Billings, M. P. (1987). Structural Geology, 4th edition, Prentice-Hall.
Lisle, R.J., Brabham, P., Branes, J. 2011. Basic Geological mapping, Wiley

Suggestive readings

Davis, G. R. (1984) Structural Geology of Rocks and Region. John Wiley
Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.

Common Pool of Discipline Specific Electives

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		
DSE-3 **River Science (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

This course on river science is intended to provide student with basic science and understanding of the life cycle of a river especially in relation to societal development. It is to provide them knowledge and comprehension about the processes of erosion and transportation of sediments and its connection with the landforms.

Learning outcomes

After going through this course, students will be able to gain a thorough understanding of the evolution of a river. They will develop an understanding of stream hydrology concepts such as river hydrographs, river discharge, and flood frequency. Students will be able to comprehend the movement of sediments from source to sink. Students will develop the basic skills to identify different types of drainage networks and the impact of catchment morphometry and shape on the hydrological parameters of the river. Students will be able to analyze river profiles and explain their anomalies. They will be able to calculate the stream power and perform flood frequency analysis.

SYLLABUS OF DSE-3
Theory (45 hours)

UNIT – I (9 Hours)
Detailed Content
Stream hydrology: Basic stream hydrology. Physical properties of water, sediment and channel flow. River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis; Flood frequency analysis

UNIT – II (9 Hours)
Detailed Content
River basin: Sediment source and catchment erosion processes; Sediment load and sediment Yield; Sediment transport processes in rivers; Erosion and sedimentation processes in channel.

UNIT – III (9 Hours)
Detailed Content
Drainage: Drainage network; Quantitative analysis of network organization – morphometry Role of drainage network in flux transfer. Evolution of drainage network in geological time scale.

UNIT – IV (9 Hours)
Detailed Content
Rivers in time and space: River diversity in space, Patterns of alluvial rivers - braided, meandering and anabranching channels, Dynamics of alluvial rivers; Channel patterns in stratigraphic sequences. Different classification approaches in fluvial geomorphology and its applications.

UNIT – V (9 Hours)
Detailed Content

Channels and Landscapes: Bedrock channels, Bedrock incision process; River response to climate, tectonics and human disturbance; Bedrock channel processes and evolution of fluvial landscapes. Fluvial hazards: Integrated approach to stream management. Introduction to river ecology.

Practical Component- (30 Hours)
Exercises based on River visit during weekend, Stream power calculation, Longitudinal profile analysis, Hydrograph analysis, and Flood Analysis

Essential/Recmmended readings
Fryirs and Brierly (2013) Geomorphology and river management. Wiley-Blackwell Pub.
Julien, P.Y. (2002) River Mechanics. Cambridge University Press.

Recommended readings
Bridge, J.S., (2003) Rivers and Floodplain: Forms, Processes and Sedimentary Record. Blackwell Science.
Gibling, M.R., (2021) River Planet. Dunedin Press.
Wohl, E., (2010) Mountain Rivers Revisited. American Geophysical Union.

OR

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-3 **Introduction to Geophysics** (L3, T1)	**4**	**3**	**1**	**0**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

DSE-3:
Introduction to Geophysics (L3, T1)
Credit: 4
Theory (45 hours), Tutorial (30 hours)

Learning Objectives
This course on introduction to geophysics is intended to provide basic scientific knowledge to students to understand the interrelationship of geology and geophysics, which is essential to know the geodynamic behavior of the Earth and its interior. Students will be taught about the basic concepts in geophysics, different types of geophysical exploration methods, and geophysical anomalies to appreciate the geodynamics of the Earth and its resources.

Learning outcomes
After going through this course, students will be able to have an elementary knowledge and comprehension about the geophysical methods and their application to understand and explore Earth and its interior. They will also develop basic skills about the geophysical anomalies and their relation to geological process that are essential for any detailed exploration activity.

Theory (45 hours),

UNIT – I (9 Hours)
Detailed content
Basic concepts of geophysics: Interrelationship between geology and geophysics, Role of geology and geophysics in explaining geodynamical features of the earth.

UNIT – II (9 Hours)
Detailed content
Exploration geophysics: General and Exploration geophysics: Different types of geophysical methods - gravity, magnetic, electrical and seismic; their principles and applications; Concepts and Usage of corrections in geophysical data

UNIT – III (9 Hours)
Detailed content
Geophysical surveys: Geophysical field operations: Different types of surveys, grid and route surveys, profiling and sounding techniques; Scales of survey,

UNIT – IV (9 Hours)
Detailed content
Geophysical Methods: Application of Geophysical methods. Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics, internal structure of the Earth based on major discontinuities in seismic velocities.

UNIT – V (9 Hours)
Detailed content
Geophysical anomalies: Correction to measured quantities, regional and residual (local) anomalies, factors controlling anomaly, and depth of exploration. Integrated geophysical methods: Ambiguities in geophysical interpretation, planning and execution of geophysical surveys

Tutorials (30 Hours)
Students in small batches or groups will be assigned to resolve different types geophysical problems concerning calculating the free air and Bouguer anomalies, determining the gravity anomaly arising due to density contrast in the subsurface, calculating paleolatitude and paleopole, numerical problems on resistivity survey, Problems on seismic survey.

Essential/Recommended readings
Kearey, P., Brooks, M. and Hill, I., 2002. *An Introduction to Geophysical Exploration* . Third Edition. Blackwell Publishing.
Lowrie, W. (2007). Fundamentals of geophysics. Cambridge University Press.
Mussett, A.E. and Khan, M.A., 2000. *Looking into the Earth: An Introduction to Geological Geophysics*. Cambridge University Press.
Bhimasankaram, V.L.S. (1990). Exploration Geophysics - An Outline by, Association of Exploration Geophysicists, Osmania University, Hyderabad.
Dobrin, M.B. (1984) An introduction to Geophysical Prospecting, McGraw-Hill, New Delhi.

Recommended readings
Bhimasankaram, V.L.S. (1990). Exploration Geophysics - An Outline by, Association of Exploration Geophysicists, Osmania University, Hyderabad.
Dobrin, M.B. (1984) An introduction to Geophysical Prospecting, McGraw-Hill, New Delhi.
Telford, W. M., Geldart, L. P., & Sheriff, R. E. (1990). Applied geophysics (Vol. 1), Cambridge University press.

OR

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-2 **Application of thermodynamics in petrology (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology or Equivalent**

Learning Objectives

The course intends to provide the concept of various thermodynamic parameters and application of the laws thermodynamics in different petrological systems. It attempts to demonstrate the effect of pressure temperature and chemical compositions in controlling stability of different mineral associations in open and closed systems. The course intends to demonstrate the application of thermobarometers in natural systems.

Learning Outcome

After completing the course, students will learn to calculate the free energy of the system. Students will learn to construct the stability fields of different mineral associations through Gibb's free energy minimization. Student will be able to apply the thermobarometers and will be able to calculate the pressure temperature conditions of stability of different magmatic, metamorphic and economically valuable mineral associations.

Theory (45 hours)

UNIT 1 (9 hours)

Introduction to thermodynamics, Irreversible and Reversible Processes, Thermodynamic Systems and variables, Energy in the form of heat and work, First law of thermodynamics, enthalpy, entropy, second and third law of thermodynamics, concept of free energy, Gibbs equation: thermodynamic potentials, free energy of formation at any temperature and pressure, equilibrium condition in closed system.

UNIT 2 (9 hours)

Free energy surface in G–T–P space, Clausius–Clapeyron equation, Schreinemakers rules, petrogenetic grid, Concept of stability (phase) diagrams, Phase rule, Free energy of solutions, ideal and non-ideal solutions, fugacity and activity, equilibrium constant,

UNIT3 (9 hours)

Temperature and pressure dependence of equilibrium constant, Geothermometry, geobarometry, mineral reactions among solid solutions, computer-generated phase relations, Introduction to pseudosections.

UNIT 4 (9 hours)

Partial melting and fractional crystallisation in magmatic systems along different geothermal gradients, modelling the role of magmatic processes in controlling the major, trace and REE budget in the crust, modelling the effect of composition on phase stability.

UNIT 5 (9 hours)
Thermodynamics of open system, Mass and heat transfer, effect of fluid ingress and composition of fluid in controlling the stability of different phases.

Practical (30 hours)
Calculation of free energy of formation at any temperature and pressure, Plotting univariant lines in P–T diagrams, Geothermo-barometric calculation, construction of pseudosections, use of mass balancing techniques on natural rocks

Essential/Recommended readings
Philpotts, A.R. and Ague, J.J., 2022. *Principles of igneous and metamorphic petrology*. Cambridge University Press.

Spear, F.S., 1993. Metamorphic phase equilibria and pressure-temperature-time paths. *Mineralogical Society of America Monograph*, *799*.

Ganguly, J., 2008. *Thermodynamics in earth and planetary sciences* (p. 501). Berlin: Springer.

COMMON POOL OF GENERIC ELECTIVES

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-5 Concepts of Sustainability (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The course on concepts of sustainability is aimed at providing students with knowledge-based concepts to understand the challenges of global sustainability and motivate them to think about solutions to these challenges. This course is also intended to encourage students to discuss and propagate issues of sustainability with others and create awareness.

Learning outcomes

After completing this course, students should be able to understand the major challenges and opportunities in the area of global sustainability. Develop an understanding of the system concept and the interconnectivity of humans and nature. They will be able to communicate issues related to sustainability. Critically analyze problems and solutions related to global sustainability.

SYLLABUS OF GE-5

Credits 4
Theory (45 hours)

UNIT – I (12 Hours)
Detailed contents
Basic concept of sustainability: Introduction to Sustainability; basic concepts Human Population – Past and Future trends

UNIT – II (12 hours)
Detailed contents
Ecosystems: Extinctions and Tragedy of Commons; Climate and Energy; Water Resources and Agriculture

UNIT – III (9 Hours)

Detailed contents
National and international issues about sustainability: National Resources Accounting, Environmental Economics and Policy, Measuring Sustainability

UNIT – IV (12 Hours)
Detailed contents
Major challenges about sustainability: Systems interconnectivity among Primary Sustainability challenges Sustainability Solutions: Some examples

Tutorials (30 Hours)
Students leaning the concepts of sustainability will be divided in small batches or groups and assigned critical exercises and problems to resolve major issues of sustainability of national and international importance.

Essential/recommended readings
Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.

Suggestive readings
Rogers, P.P., K. F. Jalal, and J.A. Boyd. 2007. An Introduction to Sustainable Development. Earthscan Publishers, 416 pp.
Brown, L. 2009. Plan B 4.0. Norton Publishers, New York. (The entire book is available in pdf format: http://www.earthpolicy.org/images/uploads/book_files/pb4book.pdf)

DEPARTMENT OF GEOLOGY
SEMESTER – VI
BSC (H) Geology
Category - I

DISCIPLINE SPECIFIC CORE COURSE - DSC – 16: Remote Sensing and GIS (L3, P1)

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		
DSC – 16: Remote Sensing and GIS (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Equivalent**

Learning Objectives

This course is intended to provide basic understanding of remote sensing, geographic information system and photogrammetry. The course also aims to familiarize the students with utilization of geo-processing tools in the field of geosciences.

Learning outcomes

After completing this course, the students will understand the basics of remote sensing and GIS techniques and their applications in various fields of the Earth Sciences. They will be able to utilize open source image processing and GIS software to make basic image correction and thematic maps. They will be able to integrate the GNSS and field-based data with the GIS to create maps for further analysis.

SYLLABUS OF DSC-16
Theory (45 hours)

UNIT – I (12 hours)

Detailed content

Fundamentals of remote sensing: Concept of remote sensing, electromagnetic spectrum, atmospheric windows, remote sensing system, sensors and scanners, remote sensing platforms, image resolution, data procurement, data formats- raster and vector, digital image processing.

UNIT – II (12 hours)

Detailed contents

Photogeology: Types and acquisition of aerial photographs, concept of scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion. Elements of air photo interpretation, identification of the primary and secondary structures of rocks, lithology, landforms and surface processes.

UNIT – III (11 hours)

Detailed contents

Geographic Information System (GIS): Introduction to GIS, datum, coordinate systems and projection systems, spatial data models and data editing. Introduction to digital elevation model (DEM) analysis. Spatial and Temporal interpolation of datasets.

UNIT – IV (10 hours))
Detailed contents
Global navigation satellite systems (GNSS): Introduction to GNSS, GPS, GPS signals. Integrating GNSS data with GIS; GNSS applications in earth system sciences and disaster studies.

Practical Component- (30 Hours)
Introduction to QGIS software, plugins in QGIS, data procurement, creating FCC from raw data, Registration of satellite images, Image enhancement, Classification of images (Visual interpretation), Classification of images (Supervised and Unsupervised), Identification of geological structures, landforms and surface processes. Stereo viewing of images. Vector data editing, Generating slope map, aspect map and drainage network map, Spatial interpolation of datasets, Introduction to GPS.

Essential/recommended readings
Gupta, R.P. Remote Sensing Geology, Springer
Bhatta, B., Remote Sensing and GIS, 2nd Edition, Oxford.
Joseph, G., and Jeganathan, C., Fundamental of Remote Sensing, University Press, Hyderabad.

Suggestive readings
Gupta, R.P. Remote Sensing Geology, Springer
Joseph, G., and Jeganathan, C., Fundamental of Remote Sensing, University Press, Hyderabad.
Demers, M.N., 1997. Fundamentals of Geographic Information System, John Wiley & sons. Inc.
Hoffmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2001. GPS: Theory & Practice, Springer Wien New York.
Jensen, J.R., 1996. Introductory Digital Image Processing: A Remote Sensing Perspective, Springer-Verlag.
Lillesand, T. M. & Kiefer, R.W., 2007. Remote Sensing and Image Interpretation, Wiley.
Richards, J.A. and Jia, X., 1999. Remote Sensing Digital Image Analysis, Springer-Verlag.

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

DISCIPLINE SPECIFIC CORE COURSE – DSC – 17: Fuel Geology ((L3, P1)

Credit distribution, Eligibility and Prerequisites 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		
DSC – 17: Fuel Geology (L3, P1)	4	3	0	1	12th pass with science	Studied Stratigraphy, Earth System Science, Structural Geology or Equivalent

Learning Objectives

The course on fuel geology is intended to provide basic scientific knowledge and understanding about the natural fossil fuels i.e., petroleum and coal to students of geology. Because use of petroleum resources and its exploration is the most powerful driving forces shaping our modern world.

Learning outcomes

After completion of this course students will be able to understand and comprehend the processes involved in generation of hydrocarbons and the formation of coal and the exploration methods. Students will also have a comprehension about the conventional and non-conventional fuels and their demand through time.

SYLLABUS OF DSC- 17

Theory (45 hours)

UNIT – I (9 hours)

Detailed contents

Coal: Definition and origin of Coal; Classification of coal; Fundamentals of Coal Petrology - Introduction to lithotypes, microlithotypes and macerals in coal, Proximate and Ultimate analysis.

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UNIT – II (9 hours)

Detailed contents

Coal as a fuel: Coal Bed Methane (CBM): global and Indian scenario**;** Underground coal Gasification**;** Coal liquefaction

UNIT – III (9 hours)

Detailed contents

Petroleum: Chemical composition and physical properties of crudes in nature; Origin of petroleum; Maturation of kerogen; Biogenic and Thermal effect. Van Krevelen diagram

UNIT – IV (9 hours)

Detailed contents

Oil migration: Primary and secondary. Role of capillary pressure and Buoyancy. Petroleum Reservoirs and Traps: Reservoir rocks: general attributes and petrophysical properties.

UNIT – V (9 hours)

Detailed contents

Classification of reservoir rocks - clastic and chemical. Hydrocarbon traps: definition, Structural, Stratigraphic and Mixed. Time of trap formation and time of Hydrocarbon accumulation. Cap rocks - definition and general properties. Plate tectonics and global distribution of hydrocarbon reservoir.

Practical Component- (30 Hours)

Study of hand specimens of coal. Reserve estimation of coal. Section correlation and identification of hydrocarbon prospect. Panel and Fence diagrams

Essential/recommended readings

Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press.
Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.

Suggestive readings (if any)

Shelly R. C. (2014). Elements of Petroleum geology: Third Edition, Academic Press.
Bjorlykke, K. (1989). Sedimentology and petroleum geology. Springer-Verlag.
Chandra D. (2007). Chandra's Textbook on applied coal petrology. Jinasa Publishing House
North, F.K., 1985 Petroleum Geology
Bastia, R., & Radhakrishna, M. (2012). Basin evolution and petroleum prospectivity of the continental margins of India (Vol. 59). Newnes.

DISCIPLINE SPECIFIC CORE COURSE– DSC – 18: Paleoceanography and Paleoclimate (L3, P1)

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		
DSC – 18: Paleoceanography and Paleoclimate (L3, P1)	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science, Structural Geology, and Mineralogy or Equivalent**

Learning Objectives
The course is intended to make students aware about the climate changes through geological time periods, the chaotic nature of the Climate System, its behaviour at various time scales, and its influence on biotic system. Students will also be introduced to futuristic approaches and projections of the Inter-Governmental Panel of Climate Change, and scientific issues related to climate change. As the Oceans cover 70 percent of the Earth's surface understanding the evolution of oceans through time is essential to understand their role in controlling the earth's climate at various time scales.

Learning Outcomes:
After completing the course, the student will be able to comprehend the role of Oceans in controlling the Earth's climate at various time scales. The students will be able to independently interpret the proxy record generated from various paleoclimate archives. Archives. The student will develop an overall understanding of the Ocean-Climate linkages, Tectonics -climate linkages and modern climate change.

SYLLABUS OF DSC-18
Theory (45 hours)

UNIT – I (9 hours)
Detailed contents
Weather, Climate, Components of climate, Climate classification. Insolation, short and long-term changes in Insolation.

UNIT – II (9 hours)
Detailed contents
Aerosols: Definition, origin, role in climate change. Greenhouse gases: Introduction, causes of changing concentration, role in climate change.

UNIT – III (9 hours)
Detailed contents
Origin and evolution of Oceans. Closing and opening of Ocean Gateways and the resultant effect on climate. Climate of the Arctic and Antarctica through the ages. Bipolar See Saw, Polar Amplifications. Ice core studies and climate change. Oceanic sediments, Terrigenous, biogenic sediments, and their distribution.

UNIT – IV (9 hours)
Detailed contents
Sea-level: factors affecting sea-level changes, Short and long-term sea-level variability, evidence of sea-level change from marine sediments. Ocean-climate linkage. Effect of topography/tectonics on climate. Natural variability in climate. Human influence on climate change.

UNIT – V (9 hours)
Detailed contents
Historical evidence of climate change. Effects of climate change on mankind. Sampling methods for retrieving archives of climate/oceanographic change. Various dating methods of the marine cores., merits and demerits of various dating methods Paleoclimatic/paleoceanographic reconstruction from archives. Elemental and isotopic analysis for paleoclimatic/paleoceanographic reconstruction, Instruments used for paleoclimatic/paleoceanographic studies. Modeling climate change, IPCC climate change projections.

Practical Component- (30 Hours)
Processing of marine core samples for paleoclimatic/ paleoceanographic studies. Exercises in oceanography. Interpretation of various types of paleoceanographic and paleoclimatic data.

Essential/recommended readings
Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
Brasier, M.D. 1980 Microfossils, George Allen and Unwin.

Suggestive readings
Frank J Millero, Chemical Oceanography, CRC Press, Taylor and Francis Group, 2013
Alan Trujillo (Author), Harold Thurman (Author), Essentials of Oceanography 13th Edition, 2023, Pearson Education.
Bradley, R.S., Paleoclimatology: Reconstructing Climates of the Quaternary, Academic. Press.
Brasier, M.D. 1980 Microfossils, George Allen and Unwin.
Cronin, T.M., 1999. Principles of Paleoclimatology, Columbia University Press.
Fischer, G. and Wefer, G 1999 Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.
Kennett, J.P.1982 Marine Geology, Prentice-Hall Inc.
North, G.R. and Crowley, T.J., 1995. Palaeoclimatology, Oxford University Press
Schopf, TJ.M., 1980. Paleoceanography, Harvard University Press.
Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVES

Discipline Specific Elective (DSE-4): Exploration Geology or Geophysics or Application of Hydrogeology in Industries and Mining
(L3, P1)

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		
DSE-4 **Exploration Geology (L3, P1)** or **Research Methods in Geoscience (L3, P1)** or **Application of Hydrogeology in Industries and Mining (L3, P1)**	**4**	**3**	**0**	**1**	**12th pass with science**	**Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent**

DSE-4: Exploration Geology (4 credits)
Theory (45 hours)
Practical (30 hours)

Learning Objectives

The course on exploration geology is intended to provide introductory knowledge of mineral exploration at different stages though geological, geochemical, geophysical, and remote sensing methods. Students will also be provided basic understanding about the estimation of reserves.

Learning outcomes

After going through this course, students will have a clear idea and knowledge about the exploration methods and tools, and their application in mineral resource exploration and exploitation.

SYLLABUS OF DSE-4 (Exploration Geology)
Theory (45 Hours)

UNIT – I (9 Hours)
Detailed content
Introduction to exploration geology: Definitions and different terminologies of exploration components. Basic exploration and exploitation steps or stages. Classification of mineral deposits with respect to exploration strategies. Mineral resources and their uses

UNIT – II (9Hours)

Principles of mineral exploration: Importance of mineralogy, grain size-shape and texture in exploration. Mineral identification and analytical techniques. Sampling techniques, drilling and logging. Estimation of grade in samples.

UNIT – III (9 Hours)
Detailed content
Prospecting and exploration: Surficial survey methods and applications. Geochemical survey methods and applications. Geophysical survey methods and applications. Remote sensing methods and applications

Unit – IV (9 Hours)
Detailed content
Importance of drilling and logging in exploration: Core and non-core drilling. Basic parts of drilling machine. Types of drilling techniques. Planning and location of bore holes on ground.

Unit – V (9 Hours)
Detailed content
Principles of reserve estimation: Reserves estimation methods and models. Critical geological data to be considered. Factors affecting reliability of reserve estimation and types of errors. Evaluation of sampling data: mean, median, mode, standard deviation and variance.

Practical Component- (30 Hours)
Exercises based on Evaluation of data Average grade and reserve estimation techniques. Geological cross-section and borehole problems.

Essential/Recmmended readings
Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.
Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.

Recommended readings
Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.
Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.
Arogyaswami, R.P.N.(1996. Courses in Mining Geology. 4th Ed. Oxford-IBH.
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.

or

DSE-4: Research Methods in Geoscience (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
Main objective of this course to provide an introduction to research methods relevant to geoscience through lectures and practical training about literature review, proper referencing and citation, professional ethics, geoscience hypotheses, analytical techniques, data analysis, preparation of scientific reports and proposals.

Learning outcomes
After successful completion of this course, students will have a basic understanding and skill to develop a research plan related to critical issues in geoscience. The students will also be able to develop skills to synthesise scientific ideas and appreciate the scope of research work in geoscience.

SYLLABUS OF DSE-4

Research Methods in Geoscience (4 credits)

Theory (45 hours)

UNIT – I (9 Hours)

Detailed Content

Fundamentals of research in geoscience: Concept and definitions of research issues in geoscience, types of research in geosciences, testing of hypothesis in geosciences, literature survey of scientific articles relevant to geoscience, critical gaps and key questions to resolve through scientific research in geoscience.

UNIT –II (9 Hours)

Detailed Content

Planning and development of research work: Defining major objective and sub-objectives of geological research in a particular field. Assessment of required methodologies and experimental setups. Types of field and laboratory data, time period and key millstones of the progress, synthesis of acquired data and writing of thesis.

UNIT –III (9 Hours)

Detailed Content

Analytical techniques: Geological fieldwork and collections of representative samples, sample preparation, petrographic techniques, mineralogical and geochemical analytical techniques.

UNIT –IV (9 Hours)

Detailed Content

Data handling and statistical treatments: Basic statistical methods, correlation and regression, principal component analysis, factor analysis, cluster analysis, making of different geological maps and figures using software's.

UNIT –V (9 Hours)

Detailed Content

Writing of thesis and scientific reports: Review of concerned geoscience research articles. Introduction, significance and utility of the concerned geoscience research. Easy to follow stepwise chapters on different aspects of the research work. Synthesis and interpretations, conclusions, referencing, bibliographies, ethics and plagiarism.

Practical: 30 hours

Students will be exposed to basic instrumentation facilities and their working, such as thin section preparation, petrographic analysis, mineralogical and geochemical analytical techniques and writing of project reports.

Essential readings

Lisle, R.J., Brabham, P., Branes, J. 2011. Basic Geological mapping, Wiley

Wilson M. J. 1987. A handbook of determinative methods in clay mineralogy. Blackie

Recommended readings

Lindholm, R.C. 1963. A practical approach to Sedimentology, Allen & Unwin
Faure, G. and Mensing, T.M.2009. Isotopes principles and Applications. Willey.

Jackson M. (1975) Soil Chemical Analysis–Advanced Course: 10th printing, published by author, Dept. Soil Science, University of Wisconsin, Madison, Wisconsin.

Or

Application of Hydrogeology in Industries and Mining (L3, P1)
Credits: 4
Theory: 45 hours
Practical: 30 hours

Learning Objectives
The course introduces the students to the legal and constitutional framework of ground water governance in India. It aims to provide knowledge about the scientific processes and protocols involved in impact assessment and comprehensive hydrogeological studies for developmental projects involving groundwater extraction.

Learning outcomes
After completing the course, students will become familiar with the salient aspects of India's ground water governance framework. They will develop an understanding of the groundwater resources estimation methods, and acquire basic skill to undertake impact assessment, comprehensive hydrogeological and water audit studies for developmental projects involving groundwater extraction. Learners will be trained to write professional grade Impact Assessment Report, Comprehensive Hydrogeological Report and Water Audit Report. They will be skilled with capability of formulating and processing No Objection Certificate (NOC) application for ground water extraction.

SYLLABUS OF DSE-4
Application of Hydrogeology in Industries and Mining (4 credits)

Theory (45 hours)

Unit 1: (9 hours)
Detailed content
Ground water governance: Ground water ownership: The Indian Easement Act 1882. Constitutional provisions regarding ground water. National Water Policy. Environment Protection Act 1986 – Central Ground Water Authority (CGWA) and State Ground Water Regulatory Bodies. National Green Tribunal.

Unit 2: (9 hours)
Detailed content
Guidelines to regulate and control ground water extraction in India: Preamble and background: exemptions from seeking No Objection Certificate, Drinking & Domestic use for Residential apartments/ Group Housing Societies/ Government water supply agencies in urban areas, Agriculture Sector, Commercial Use, Industrial Use, Mining Projects, Infrastructure projects, Ground water abstraction/ restoration charges, Bulk Water Supply, Abstraction of Saline ground water, Protection of Wetland Areas, General compliance conditions in No Objection Certificate, Monitoring of compliance of No Objection Certificate Conditions, Renewal and extension of No Objection Certificate, Delegation of powers against illegal ground water withdrawal, Ground Water Level Monitoring, Environmental Compensation, Provision of penalty and other important conditions. No Objection Certificate Application Portal (NOCAP). Water Audit Report. Accreditation of Ground Water Professional.

Unit 3: (9 hours)
Detailed content
Ground Water Resources Estimation: Dynamic ground water resources of unconfined aquifers for command and non-command areas: assessment unit, estimation of monsoon and non-monsoon recharge from all sources and provision for natural discharges, estimation of monsoon and non-monsoon extraction by different sectors, categorization of assessment blocks and validation. Poor ground water quality area. Waterlogged and shallow water table areas. In-storage ground water resources of unconfined aquifer. INGRES portal.

Unit 4: (9 hours)
Detailed content
Impact Assessment Report (IAR): Buffer zone demarcation, Land Use Land Classification (LULC), Digital Elevation Model (DEM), geomorphology, details of water bodies, geological set up. Hydrogeological set up: aquifer characteristics, depth to water level, water table contours and ground water flow, surface ground water interaction, hydrogeological map, seasonal and long-term water level fluctuation, ground water quality, water quality of nearby water bodies. Assessment of impact of proposed ground water extraction using analytical modelling/numerical solutions, etc. Socio-economic analysis and mitigation measures. Case studies.

Unit 5:
Detailed content
Comprehensive Hydrogeological Report (CHR): Buffer zone demarcation, Land Use Land Classification (LULC), Digital Elevation Model (DEM), geomorphology, details of water bodies, geological set up. Hydrogeological set up: geophysical studies and aquifer characteristics, depth to water level, water table contours and ground water flow, surface - ground water interaction, hydrogeological map, seasonal and long-term water level fluctuation, ground water quality, water quality of nearby water bodies. Mine plan and seepage estimation. Assessment of impact of proposed ground water extraction using analytical modelling/numerical solutions, etc. Socio-economic analysis and mitigation measures. Case studies.

Practicals (30 hours)

Students will be trained to carry out Ground Water Resource estimation, hands on exercises on IAR and CHR, hands on exercises on Water Audit, and exercises based on analytical modelling/numerical solutions for impact assessment, mine seepage estimation analysis.

Essential readings
Todd, D.K., 2004. Ground Water Hydrology, John Wiley & Sons, New York.
Fetter, C.W., 1984. Applied Hydrogeology, McGraw-Hill Book Co., New York
Ministry of Jal Shakti (Department of Water Resources, River Development and Ganga Rejuvenation) (Central Ground Water Authority). Guidelines to regulate and control ground water extraction in India. Notification No. 2941. The Gazette of India: Extraordinary [Part II—Sec. 3(ii)]. 24th September, 2020. Weblink: https://cgwb.gov.in/CGWA/CGWA%20New%20Guidelines%202020.pdf

Recommended Readings
Raghunath, H.M., 1987. Ground Water, Wiley Eastern Ltd., Calcutta.
Ministry of Water Resources, River Development & Ganga Rejuvenation Government of India. 2017. Report of The Ground Water Resource Estimation Committee (GEC-2015) Methodology. Weblink: http://cgwb.gov.in/Documents/GEC2015_Report_Final%2030.10.2017.pdf
Central Ground Water Authority, Ministry of Jal Shakti. 2022. Standard Operating Procedures: Impact Assessment Report and Comprehensive Hydrogeological Report. Weblink: https://cgwa-noc.gov.in/landingpage/UserAssistance/ImpactAssessmentRepMin3.pdf
Central Ground Water Authority, Ministry of Jal Shakti. 2023. Notification of Guidelines dated 24th September 2020 & Amendments dated 29th March 2023: Standard Operating Procedure for Implementation of Guidelines. Weblink: https://cgwa-noc.gov.in/LandingPage/UserAssistance/STANDARDOPERATINGPROCEDUREV-9.1.pdf (SOPs are updated at regular intervals and the updated SOP from CGWA site will be additional reference material)

COMMON POOL OF GENERIC ELECTIVES

One GE from GE pool (GE-6): Evolution of life trough time (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-6 Evolution of life through time (L3, T1)	**4**	**3**	**1**	**0**	**12th Pass**	**Nil**

Learning Objectives

The main objective of the course is to make the student aware about the evolution of life through geological time from simple prokaryotic to complex multicellular life forms, and the role of geological processes and climatic events in shaping the evolution of life on the Earth.

Learning outcomes

On completion of the course, the student will be able to learn how fossilization processes operate in nature and what early planetary conditions led to the origin and evolution of early life. The student will also be able to understand mass extinction events in the Phanerozoic Era and their causes, and how various geological and climatic events influenced the evolution of life and how life itself has influenced the geological processes.

SYLLABUS OF GE-6

Theory (45 hours)

UNIT – I (9 Hours)

Detailed contents

Life through ages: Fossilization processes and modes of fossil preservation, exceptional preservation; Geological Time Scale with emphasis on major bio-events.

UNIT – II (9 hours)

Detailed contents

Geobiology: Biosphere as a system, processes and products; Biogeochemical cycles; Abundance and diversity of microbes, extremophiles; Microbes-mineral interactions, microbial mats.

Origin of life; possible life sustaining sites in the solar system.

UNIT – III (9 Hours)

Detailed contents

Archean life: Earth's oldest life, the oxygen revolution and radiation of life.

Proterozoic life: The Garden of Ediacara and the evolution of metazoan life.

UNIT – IV (9 Hours)

Detailed contents

Palaeozoic Life: The Cambrian Explosion of Life; Biomineralisation and the fossil record. Palaeozoic Marine Life; Origin and progression of vertebrates; Early adaptations of plants to terrestrial life.

Mesozoic Life: Life after the largest (P/T) mass extinction, life in the Jurassic seas; Origin of mammals; Rise and fall of dinosaurs; Origin of birds; and spread of flowering plants.

UNIT – V (9 Hours)
Detailed contents
Cenozoic Life: Radiation of placental mammals following K/Pg mass extinction; Evolution of modern grasslands and co-evolution of hoofed grazers; Palaeocene-Eocene Thermal Maximum (PETM) deep time analogue for modern greenhouse state; Back to water – Evolution of Whales; The age of humans; Hominid dispersals and climate setting

Tutorial (30 hours)
Students in different batches or groups will be given exercises to prepare shorts reports about the life evolution and extinction through different geological times on Earth.

Essential/recommended readings

Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition), W.H.Freeman (Macmillan)
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley

Suggestive readings

Stanley, S.M. & Luczaj, J.A. (2014). Earth System History (4th Edition), W.H.Freeman (Macmillan)
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Benton, M.J. & Harper, D.A.T. (2016). Introduction to Paleobiology and the fossil record. Wiley
Canfield, D.E. & Konhauser, K.O. (2012). Fundamentals of Geobiology, Blackwell.
Suggested Reading:
Cowen, R. (2000). History of Life. Wiley-Blackwell.
Lumine, J.I. (1999). Earth-Evolution of a Habitable World, Cambridge University Press.
Lieberman, B.S. & Kaesler, R. (2010). Prehitoric Life-Evolution and the Fossil Record, Wiley-Blackwell.
Lieberman, B.S. & Kaesler, R. (2010). Prehitoric Life-Evolution and the Fossil Record. Wiley-Blackwell.
Cockell, C., Corfield, R., Edwards, N. & Harris, N. (2007). An Introduction to the Earth-Life System Cambridge University Press.

Department of Zoology

SEMESTER-IV
BSc (Hons.) Zoology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC CORE COURSE -10 – :
Comparative Anatomy of Vertebrates
Zoo-DSC-10

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Comparative Anatomy of Vertebrates Zoo-DSC-10	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Vertebrates

Learning Objectives

The learning objectives of this course are as follows:

- to impart in-depth knowledge about the structural patterns and a comparative account of the different organ systems of vertebrates.
- to understand the account of the functional and comparative morphology provides a deepunderstanding of animal diversity and the adaptive changes the vertebrates have gone throughduring evolution from common ancestors
- to help students identify the body plan types of complex chordates and their systematic organization based on evolutionary relationships, structural and functional affinities.
- to apprise the students about the correlation of comparative development to evolutionary biology and phylogeny, and how it helps in classifying animals.
- to enable students to establish the evolutionary links based on fossil records.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the evolutionary significance of comparative anatomy.
- understand the importance of morphology and anatomy of organisms in relation to evolution.
- appreciate the comparative anatomy among vertebrates that provides evolutionary evidences.
- enhance collaborative learning and communication skills through practical sessions, teamwork, group discussions, assignments, and projects.

SYLLABUS OF DSC-10

UNIT 1: Integumentary System **4 hrs**

Structure and derivatives of integument.

UNIT 2: Digestive System **4 hrs**

Alimentary canal and associated glands; Dentition.

UNIT 3: Circulatory System **4 hrs**

General plan of circulation; Evolution of heart and aortic arches.

UNIT 4: Respiratory System **4 hrs**

Skin, gills, lungs, accessory respiratory organs in fishes, air sacs.

UNIT 5: Skeletal System **5 hrs**

Outline of axial and appendicular skeleton; Concept of neurocranium, dermatocranium and splanchnocranium; Structure of a typical vertebra and its classification based on centrum; Jaw suspensorium; General plan of girdles and limbs.

UNIT 6: Nervous System **3 hrs**

Comparative account of brain; Cranial nerves in mammals.

UNIT 7: Sense Organs **3 hrs**

Classification of receptors; Structure and function of mammalian eye and ear.

UNIT 8: Urinogenital System **3 hrs**

Succession of kidney; Evolution of urinogenital ducts; Types of uteri in mammals.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of different types of feathers of birds.
2. Study of the disarticulated skeleton of Frog, Varanus, Fowl, Rabbit (Vertebral Column, Sternum,Girdles, Ribs, Limb bones).
3. Study of the vertebrate Skull (i) one herbivorous and one carnivorous animal skull; (ii) one monocondylic and one dicondylic skull.
4. Study of carapace and plastron of turtle/tortoise.
5. Study of the digestive, circulatory and urinogenital system of frog/rat through videos ondissection or through virtual dissections.
6. Project related to topics covered in theory.
7. Field trips/Documentary film show on vertebrates/Visit to Zoological Park, Biodiversity Park or Sanctuary.

8. Student Presentation: Power point presentation on any two animals from two different classes.

Essential/recommended readings

1. Kardong, K.V. (2005) Vertebrate's Comparative Anatomy, Function and Evolution. IV Edition. McGraw-Hill Higher Education.

2. Kent, G.C. and Carr R.K. (2000). Comparative Anatomy of the Vertebrates. IX Edition. The McGraw-Hill Companies.

Suggestive readings

1. Leiem C.F., Bermis W.E, Walker, W.F, Grande, L. (2001) Functional anatomy of the vertebrates, An evolutionary perspective. III Edition, Brookes/Cole, Cengage Learning.

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

DISCIPLINE SPECIFIC CORE COURSE -11 – : Developmental Biology Zoo-DSC-11

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		
Developmental Biology Zoo-DSC-11	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Chordates

Learning Objectives

The learning objectives of this course are as follows:

- to provide an in-depth knowledge on the embryonic and post embryonic developmental processes.
- to apprise the students of the fascinating aspect of the development of a single fertilized egg to mature into a fully developed complex organism.
- to explain the basic principles and concepts the developmental processes from a single cell system to a multi-cellular system.
- to understand morphogenesis in Sea urchin, Drosophila, Frog and Chick.
- to provide the undergraduate students an in-depth knowledge on the embryonic

and post embryonic developmental processes.

- by understanding the developmental processes, the students can relate to errors occurring during development leading to congenital disorders and human diseases.
- to familiarize the students with the technique of IVF and pre-diagnostic methods to identify any abnormality arising during development.
- To make the students aware of the areas of great interest including stem cell therapy, tissue engineering and regenerative medicine.

Learning Outcomes

By studying this course, students will be able to

- appreciate the events that lead to the formation of a multicellular organism from a single fertilized egg.
- better understand the general patterns and sequential developmental stages during embryogenesis.
- gain knowledge of the general mechanisms involved in morphogenesis.
- comprehend the processes of ageing to improve the overall health and quality of life in aged people.
- acquire basic knowledge and importance of latest techniques like stem cell therapy, *in vitro* fertilization and amniocentesis etc.
- develop the skill to raise and maintain culture of model system- *Drosophila* in the laboratory.

Syllabus of DSC-11

UNIT- 1: Introduction **2 hrs**

Historical perspectives and basic concepts: Phases of development, Pattern formation, Differentiation and growth, Cytoplasmic determinants.

UNIT- 2: Early Embryonic Development **12 hrs**

Gametogenesis: oogenesis, spermatogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal), Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula; Fate maps; Gastrulation in frog and chick, Embryonic induction and organizers.

UNIT- 3: Late Embryonic Development **6 hrs**

Fate of Germ Layers; Extra-embryonic membranes in birds; Implantation of embryo in humans, structure, types, and functions of placenta.

UNIT- 4: Post Embryonic Development **6 hrs**

Metamorphosis and its hormonal regulation in amphibians and insects;Regeneration: Modes of regeneration, epimorphosis, morphallaxis and compensatory regeneration (with one example each); Ageing: concepts and theories.

UNIT- 5: Implications of Developmental Biology **4 hrs**

Teratogenesis: Teratogenic agents and their effects on embryonic development; *in-vitro* fertilization, Embryonic stem cell (ESC), Amniocentesis.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula (Neural plate, Neural fold and Neural tube stages), 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. *in vivo* study of chick embryo development by windowing and candling methods. (Demonstration only)
4. Study of indirect development and metamorphosis by rearing any one insect.
5. Study of different sections of placenta (photomicrographs/ slides).
6. Project report on *Drosophila* or any insect culture/Visit to Poultry Farm/IVF Centre
7. Student Presentation: Power point presentation on any topic related to developmental biology.

Essential/recommended readings

1. Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley- Blackwell.
2. Gilbert, S. F. (2010) Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
3. Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.
4. Balinsky B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.

Suggestive readings

1. Baweja, V. and Misra, M. (2021) E-book on Practical Manual of developmental Biology.
2. Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company.
3. Wolpert, L. (2002) Principles of Development. II Edition, Oxford University Press.
4. Kalthoff, K. (2001) Analysis of Biological Development. II Edition, McGraw Hill Publishers.

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

DISCIPLINE SPECIFIC CORE COURSE– 12:
Animal Behaviour Zoo-DSC-12

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		
Animal Behaviour Zoo-DSC- 12	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

Learning Objectives

The learning objectives of this course are as follows:

- To provide an overview of animal behaviour in a scientific study of the wild and the wonderful ways in which animals interact with each other, with other living beings, and with the environment.
- to understand and appreciate different types of animal behaviour, their adaptive and evolutionary significance.
- to equip the students with an ability to pursue career in behavioural ecology other related areas.
- to apprise the students of the versatility of Animal behaviour and its crosstalk among conservation biology, molecular biology, behavioural ecology and integrated pest management.

Learning Outcomes

By studying this course, students will be able to:

- comprehend various types of animal behaviour and their importance.
- observe, analyse, interpret and document the different types of behaviour.
- enhance their skills by taking short projects pertaining to Animal behaviour.
- appreciate and develop passion to biodiversity; and respect the nature and environment.
- better understand and relate the fundamentals and advanced concepts so as to develop a strong foundation that will enable them to acquire skills and knowledge.

SYLLABUS OF DSC-12

UNIT- I Introduction to Animal Behaviour **4 hrs**

Origin and history of ethology; Pioneers of modern ethology: Karl *von* Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen; Proximate and ultimate causes of behavior.

UNIT- 2 Mechanisms of Behaviour **5 hrs**

Innate behaviour, Instinct, Stimulus filtering, Sign stimuli, Code breakers.

UNIT- 3: Patterns of Behaviour **5 hrs**

Orientation: Primary and secondary orientation; Kinesis - orthokinesis, klinokinesis; **Taxis**: tropotaxis and klinotaxis, menotaxis (light compass orientation).

Learning: Associative learning, Classical and operant conditioning, Habituation, Imprinting;

Reasoning: Intelligence and artificial intelligence.

UNIT- 4: Communication **3 hrs**

Importance of communication; Role of Tactile, Chemical, Auditory, Visual stimuli in communication.

UNIT- 5: Social Behaviour **4 hrs**

Concept of Society; Insects' society; Honey bee: Society organization, polyphenism and polyethism; Foraging in honey bee, round dance, waggle dance; Experiments to prove distance and direction component of dance; Formation of new hive/queen.

UNIT- 6: Altruism **3 hrs**

Altruism, Inclusive fitness, Hamilton's rule

UNIT 7: Sexual Behaviour **6 hrs**

Asymmetry of sex; Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter- sexual selection (female choice); Courtship behaviour, Courtship behavior in 3-spine stickleback; Infanticide; Parental care, sexual conflict in parental care.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Tools, techniques and methods used in studying animal behavior.
2. To study nests and nesting behaviour of the birds and social insects.
3. To study the behavioural responses of wood lice to dry and humid conditions.
4. To study geotaxis behaviour in earthworm.
5. To study the phototaxis behaviour in insect larvae.
6. To study different types of animal behaviour such as habituation, social life, courtship behaviour in insects and birds, and parental care from short videos/movies. At least two videos for each behaviour.
7. Construction of ethogram using suitable data to study animal behaviour.
8. Visit to Forest/Wild life Sanctuary/Biodiversity Park/Zoological Park to study and record the behavioural activities of animals and prepare a short report.

Essential/recommended readings

1. John Alcock, (2013) Animal Behaviour, Xth Edition, Sinauer Associates Inc., USA.
2. Manning, A. and Dawkins, M. S, (2012) An Introduction to Animal Behaviour, VI th Edition, Cambridge University Press, UK.
3. McFarland, D. (1985) Animal Behaviour, Pitman Publishing Limited, London, UK.

Suggestive readings

1. Rubenstein, D. (2022) Animal Behavior, XIIth Edition, Sinauer Associates, Oxford University Press, UK.
2. Gadagkar, R. (2021) Experiments in Animal Behaviour: Cutting-Edge Research at Trifling Cost, Indian Academy of Sciences. David McFarland, Animal Behaviour, Pitman Publishing Limited, London, UK.

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

POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

SEM IV

DISCIPLINE SPECIFIC ELECTIVES (DSE-5): Bioenergetics and Enzymology
Zoo-DSE-5

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			
Bioenergetics and Enzymology Zoo-DSE-5	04	03	Nil	01	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Biochemistry	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- to develop a holistic understanding of the complex enzymatic reactions occurring within body through lectures, practical and laboratory exercises, assignments, seminars and visit to research Institutes.
- to appreciate the basic laws of thermodynamics; free energy, and equilibrium to acquire the knowledge to introspect and understand the core concepts of biochemistry
- to build upon undergraduate-level knowledge of biochemical principles with specific emphasis on concepts of transfer of energy in different metabolic pathways.
- to learn about the basic tools used over and over in biological reactions.

Learning Outcomes

By studying this course, students will be able to

- differentiate between the "high energy" biomolecules with respect to their hydrolysis and group transfers.
- appreciate the energy stored in reduced organic compounds that can be used to reduce cofactors such as NAD^+ and FAD, which serve as universal electron carriers.
- Increase the understanding of the function of electron-transport chain in mitochondria and the chemi-osmotic theory involved in ATP synthesis.
- explain the thermodynamic basic principles for energy transformation in biological membranes.

- use spectroscopic and other physical analytical methods to use membrane proteins and biological redox processes.

SYLLABUS OF DSE-5

UNIT- 1: Principles of Biophysical Chemistry **5 hrs**

Concept of pH, buffers, Principles of thermodynamics: free-energy, entropy, enthalpy, chemical bonds and stabilizing interactions: van der Waals, electrostatic, hydrogen bonding and hydrophobic interactions.

UNIT- 2: Bioenergetics: **9 hrs**

Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials and free energy change.

High energy phosphate compounds- introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG.

Transfer of energy: Electron Transport Chain, Bioenergetics of the liver.

UNIT- 3: Kinetics of enzyme action **10 hrs**

Concept of ES complex, Derivation of Michaelis-Menten equation for uni-substrate reactions. Different plots for the determination of Km and V_{max} and their physiological significances. Importance of K_{cat}/K_m. Kinetics of zero and first order reactions.

Classification of multi substrate reactions with example of each class. Ping Pong random and ordered BiBi mechanisms. Use of initial velocity, inhibition and exchange studies to differentiate between multi substrate reaction mechanisms.

Reversible (glutamine synthase and phosphorylase) and irreversible (proteases) inhibition. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, Suicide inhibitor.

UNIT- 4: Mechanism of Enzyme Action **8 hrs**

Cofactor dependency, pH, temperature and ionic strength dependency; Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory. Chemical modification of active site groups. Mechanism of action of chymotrypsin.

UNIT V: Enzyme Regulation **7 hrs**

Feedback inhibition and feed forward stimulation; Allosteric enzymes: qualitative description of "concerted" & "sequential" models for allosteric enzymes;
Half site reactivity, Flip-flop mechanism, positive and negative co-operativity.

UNIT VI: Multi-enzyme system: **6 hrs**

Occurrence, isolation and their properties: Mechanism of action and regulation of pyruvate dehydrogenase & fatty acid synthase complexes. Enzyme-enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Titration of a weak acid using a pH meter, preparation of buffers
2. Verification of Beer-Lambert's law and determination of absorption coefficients.
3. Preparation of cytochrome C from goat/chicken heart and distinguish between different cytochromes in ETC using absorbance spectra.
4. Isolation of NAD from brewer's yeast. Calculate Gibbs' Free Energy for electron flowfrom reduced NADH to Oxygen.
5. Assay of enzyme activity and specific activity, e.g. acid phosphatase, alkaline phosphates, SGOT, SGPT.
6. Determination of K_m and V_{max} using Lineweaver-Burk graph. (Dry experiment).
7. Enzyme inhibition - calculation of Ki for competitive inhibition. (Dry experiment)
8. Perform complex energy calculations that can be applied to biological systems. (Dryexperiment)

Essential/recommended readings

1. Lehninger by D. Nelson, and M. Cox, (2017) "The principles of Biochemistry", 7 th edition, M.W.H. Freeman and Company, New York.
2. D. M. Greenberg, (2014) "Metabolic Pathways", 3rd edition, Academic Press, Elsevier Science & Technology Books,
3. David G. Nicholls and Stuart J. Ferguson (2013) "Bioenergetics 4", Academic Press.
4. L. Stryer, (2012) "Biochemistry", 7 th edition, W.H. Freeman and Company, New York.

Suggestive readings

1 J. M. Berg, J. L. Tymoczko, L. Stryer (2007) "Biochemistry", 6th edition, W. H. Freeman andCompany, New York, NY, 2007.

2 D.J. Voet, J.G. Voet, C.W. Pratt, (2008) "Principles of Biochemistry" 3rd edition, John Wiley & Sons, Inc.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-6): Cell Growth and Regulation
Zoo-DSE-6

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			
Cell Growth and Regulation Zoo-DSE- 6	04	03	Nil	01	Passed Class XII with Biology/ Biotechnology	Basic knowledge of Cell Biology	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- to enable students to learn biological phenomenon at cellular level
- to develop an understanding of cell function and its regulatory mechanisms.
- to understand cell division, cell cycle and its regulation, growth factors, survival factors; cell cycle control systems and checkpoints.
- to provide in-depth knowledge on various experimental skills and histo-pathological studies used in clinical and research laboratories
- to acquire knowledge in the areas of cellular malfunctioning causing serious health conditions such as autoimmune disorders, cancers etc.

Learning Outcomes

By studying this course, students will be able to:

- appreciate the diverse cellular processes, cell signaling, and cellular interactions.
- Know more about the defects in cellular functioning and molecular mechanisms that can lead to diseases and disturb the homeostasis of the body.
- to elucidate the roles of cell signalling in gene regulation
- appreciate differences in normal and cancer cell, apoptosis vs. necrosis; cell death and cell renewal
- observe stem cells and their applications in therapeutic cloning and regenerative medicine.
- Know the fundamentals of targeted cancer therapies and molecular approaches to cancer treatment.

SYLLABUS OF DSE- 2

UNIT 1: Cell division, Cell Cycle, and its Regulation **10 hrs**

A brief study of stages and events during mitosis and meiosis; overview of cell cycle; mitogens, growth factors, and survival factors; cell cycle control system: components and mechanisms; cell cycle checkpoints.

UNIT- 2: Cell Signalling **7 hrs**

Types of cell-cell signalling, signalling molecules, and cell receptors; components of a generalized signalling pathway; examples of two pathways: GPCR/ cAMP/ PKA/ CREB/ target gene and a nuclear receptor pathway (to elucidate roles in gene regulation).

UNIT 3: Gene Regulation **9 hrs**

Concepts of positive and negative gene regulation; principles of eukaryotic transcriptional regulation of genes; concepts of activators, repressors, silencers, and enhancers.

UNIT- 4: Cell Death and Cell Renewal **9 hrs**

Apoptosis *vs*. necrosis; intrinsic and extrinsic pathways of programmed cell death; stem cells and maintenance of adult tissues; cells in culture and cell lines; embryonic and induced pluripotent stem cells and their applications in therapeutic cloning and regenerative medicine.

UNIT 5: Cancer Biology **10 hrs**

Hallmarks of a cancer cell; types and causes of cancer; oncogenes and tumour suppressor genes; tumour viruses; correlation of cell signaling, gene regulation, cell cycle control, and cell death in cancer development (any one example); targeted cancer therapies/molecular approaches to cancer treatment.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Principles of Microscopy.
2. Preparation of a temporary slide of onion root tip to study various stages of mitosis.
3. Study of various stages of meiosis through permanent slides.
4. Cell culture techniques: preparation of media, seeding, thawing and maintenance of cell culture, trypsinization and cryopreservation
5. Measurement of cell growth: Direct count by Trypan blue and Indirect count by Spectrophotometer.
6. Calculation of Doubling Time based on given data.
7. Assessment of metabolic activity by MTT.
8. Study of monolayer (in Roux Bottle, Roller bottle, Plastic film, Optical culture system, Bread Bed reactors, Heterogenous reactors). Suspensions (stirred bioreactors, continuous flow cultures, air lift fermenter) and immobilized cultures.

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

Essential/recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.
2. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

Suggested readings

1. Alberts et. al., (2008) Molecular Biology of the Cell, Garland Science, Taylor & Francis Group, New York, USA.

2. Lodish et. al., (2007) Molecular Cell Biology, W.H. Freeman and Company, New York, USA

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-7):
Fish and Fisheries Zoo-DSE-7

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			
Fish and Fisheries Zoo-DSE- 7	04	03	Nil	01	Passed Class XII with Biology/ Biotechnology	Nil	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To offer an insight about the climatic conditions that favours fish growth and reproduction.
- to understand the importance of fish as a rich source of animal protein.
- To learn the basic concepts and knowledge of fish biology and its applications.
- to equip the student with a balanced and complete scientific understanding of fisheries.
- to enable students to learn more technical skills to generate entrepreneurial skills and suitable employment opportunities.
- to acquire knowledge of the pathogenic and pathological basis of fish diseases including infectious diseases caused by viruses, prokaryotes, protozoans, helminthes, vector borne and zoonotic diseases.
- To learn about nutritional deficiencies and lifestyle diseases, endocrine diseases and cancer.

Learning Outcomes

By studying this course, students will be able to:

- acquire basic knowledge of physiology and reproduction in fishes.
- analyse different kinds of water and identify/differentiate among various kinds of fishes.
- equip the students with the knowledge on the procedures for artificial and induced breeding which can be learnt by visiting any fish farm or demonstrated in research labs in college/Departments.
- have more knowledge of the in-land and marine Fisheries in India and to explore ways in which it can contribute to the Indian economy.
- know more about the different methods of fishing and fish preservation

which can be employed for export and storage of commercial fishes.

- develop skills for entrepreneurship or self-employment in fisheries-related business.

SYLLABUS OF DSE- 7

UNIT– 1 Introduction and Classification **6 hrs**

General description of fish; Account of systematic classification of fishes (upto classes); Classification based on feeding habit, habitat and manner of reproduction. Brief introduction to transgenic fishes.

UNIT– 2 Morphology, Physiology and Behavior **14 hrs**

Types of fins and their modifications; Locomotion in fishes; Hydrodynamics; Types of Scales,Gills and gas exchange; Swim Bladder: Types and role in Respiration, buoyancy;Osmoregulation in Elasmobranchs, Schooling; Parental care; Migration.

UNIT– 3 Fisheries **8 hrs**

Inland Fisheries; Estuarine Fisheries, Marine Fisheries; Fishing crafts and Gears; Depletion of fisheries resources; Application of remote sensing and GIS in fisheries; Fisheries law and regulations.

UNIT – 4 Aquaculture **17 hrs**

Sustainable Aquaculture; Extensive, semi-intensive and intensive culture of fish; Pen and cage culture; Polyculture; Composite fish culture; Brood stock management; Induced breeding of fish;Management of finfish hatcheries; Preparation of compound diets for fish; Role of water quality in aquaculture; Post harvest handling techniques and Fishery by-products.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of specimens- *Petromyzon*, *Myxine*, *Pristis*, *Chimaera, Exocoetus*, *Hippocampus*, *Gambusia, Labeo, Heteropneustes, Anabas* (at least one fish from each class).
2. Study of different types of scales by preparing a temporary/permanent mount.
3. Study of air breathing organs in *Channa, Heteropneustes, Anabas* and *Clarias.*
4. Demonstration of induced breeding in Fishes and hatchery management (video/visit tofisheries institute/fish farm).

Demonstration of the setting up of a fish aquarium, and its management/maintenance.

5. Study of parental care in fishes through visual media and resources.
6. Study of different methods of fish tagging.
7. Determination of fish density in a pond by Peterson's mark recapture method.
8. Project Report on a visit to any fish farm/pisciculture unit.

Essential/recommended readings

1. Pandey, K. and Shukla, J.P. (2013) Fish and Fisheries. Rastogi publication,India
2. Chakrabarti, R. and Sharma, J. G. (2008). Aquahouse: New Dimension of Sustainable Aquaculture. DIPAS, Indian Council of Agricultural Research, New Delhi, India.
3. Norman, J.R. A History of Fishes. Hill and Wang Publishers. Khanna, S.S.and Singh, H.R. (2014) A text book of Fish Biology and Fisheries. Narendra, Publishing House.
4. Bone, Q. and Moore, R. (2008) Biology of Fishes. Talyor and Francis Group, CRC Press, U.K.

Essential/recommended readings

1. Srivastava, C.B.L. (2008) Fish Biology. Narendra Publishing House.
2. Jhingran, V.G. (1982) Fish and Fisheries in India. Hindustan Publication Cooperation. India.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-8):
Parasitology Zoo-DSE-8

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			
Parasitology Zoo-DSE- 8	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic under-standing of parasitic animals**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- To enable the students to see, appreciate and understand the diversity of parasites
- to learn about Parasitology that will enable students to diagnose parasites correctly, understand their life cycle and control them effectively and use some of them as bio control agents
- to acquire understanding of study of life cycles of parasites, that can help in defying the stigmas and religious taboos for many societies making free many of the people from superstition and ill health.
- to make the students aware about the possible scope of the subject which includes research and applied aspects including entrepreneurial skill

Learning Outcomes

By studying this course, students will be able to:

- better understand the variation amongst parasites, parasitic invasion in animals; applicable to medical and agriculture aspects
- Identify the stages of the life cycles of parasites and their respective infective stages. develop ecological model, on the base knowledge of population dynamics of parasites.
- comprehend the different methods adopted by parasites to combat with the host immune system.
- develop skills and realize significance of diagnosis of parasitic attack and treatment of patient or host.

- analyse and interpret the case studies to highlight innovative researches, serendipities towards the advancement and enrichment of knowledge in the field of Parasitology.

SYLLABUS OF DSE- 8

UNIT- 1: Introduction to Parasitology **3 hrs**

Brief introduction of Parasitism, Parasite, Parasitoid and Vectors; Host parasite relationship

UNIT- 2: Parasitic Protists **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Entamoeba histolytica, Trypanosoma gambiense and Plasmodium vivax.*

UNIT- 3: Parasitic Platyhelminthes **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Fasciolopsis buski, Schistosoma haematobium* and *Taenia solium*

UNIT- 4: Parasitic Nematodes **10 hrs**

Study of Morphology, Life Cycle, Epidemiology, Pathogenicity, Diagnosis, Prophylaxis and Treatment of *Ascaris lumbricoides*, *Ancylostoma duodenale*, *Wuchereria bancrofti* and *Trichinella spiralis*.

UNIT- 5: Parasitic Arthropoda **8 hrs**

Biology, importance and control of ticks, mites, *Pediculus humanus* (Head and Body louse), *Xenopsylla cheopis* and *Cimex lectularius*

UNIT- 6: Parasitic Vertebrates **4 hrs**

A brief account of parasitic vertebrates; Cookicutter Shark, Hood Mockingbird and Vampire bat.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of life stages of *Entamoeba histolytica, Trypanosoma gambiense*, and *Plasmodium vivax* through permanent slides/micro photographs.
2. Study of adult and life stages of *Fasciolopsis buski, Schistosoma haematobium* and *Taenia solium* through permanent slides/microphotographs.
3. Study of adult and life stages of *Ascaris lumbricoides, Ancylostoma duodenale* and *Wuchereria bancrofti* through permanent slides/microphotographs.
4. Study of *Pediculus humanus* and *Xenopsylla cheopis* and *Cimex lectularius* through permanent slides/ photographs.

5. Study of monogenea from the gills of fresh/marine fish [Gills can be procured from fish market as by-product of the industry]
6. Submission of a brief report on parasites (anyone phylum).
7. Visit to rural area/hospital near rural area/NCDC/NIMR/NICD to study the natural history and diagnostics of parasites.

Essential/recommended readings:

1. Parija, S. C. (2013) Textbook of Medical Parasitology, Protozoology & Helminthology (Text and colour Atlas), IV Edition, All India Publishers & Distributers, New Delhi.
2. Ichhpujani, R.L. and Bhatia, R. (2009) Medical Parasitology. III Edition, Jaypee BrothersMedical Publishers (P) Ltd., New Delhi
3. Ahmed, N., Dawson, M., Smith, C. and Wood, Ed. (2007) Biology of Disease. Taylor andFrancis Group.

Suggested readings:

1. Chatterjee, K. D. (2009). Parasitology: Protozoology and Helminthology. XIII Edition, CBSPublishers & Distributors (P) Ltd.
2. Arora, D. R and Arora, B. (2001) Medical Parasitology. II Edition. CBS Publications andDistributors
3. Noble, E.R. and Noble, G.A. (1989) Parasitology: The Biology of Animal Parasites. VIEdition, Lea and Febiger

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

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

GENERIC ELECTIVES (GE-8): Exploring Animal World
Zoo-GE-8

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
Exploring the Animal world Zoo-GE-8	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- to overview the concepts of invertebrate and vertebrate animals, including sponges, cnidarians, comb jellies, flatworms, nematodes, annelids, molluscs, arthropods, echinoderms, invertebrate chordates, fishes, amphibians, reptiles, birds, and mammals.
- to enable students to understand the diversity within different groups, and interrelationship among different species and genera within each group of animals.
- to learn the hierarchy, body plan and their role in ecological development of animals.

Learning Outcomes

By studying this course, students will be able to

- Learn about the importance of systematics, taxonomy, and structural organization of non-chordates and chordata.
- Appreciate the diversity of animals living in varied habits and habitats.
- Understand evolutionary history and relationships of different animals through functional and structural affinities.
- better understand coelom formation, different levels of organization, role of macronutrients and micronutrients, their nutritional requirements for different age groups during various health conditions.

SYLLABUS OF GE-8

UNIT- 1: An Introduction to the Animal Kingdom **2 hrs**

Non-chordates *vs.* Chordates; Outline of Coelom, Body symmetry, Levels of organization

UNIT-2: Kingdom Protista **2 hrs**

General characters of Protozoa; Locomotory organelles

UNIT- 3: Porifera **2 hrs**

General characters of Phylum Porifera, Canal system in Porifera

UNIT- 4: Radiata **2 hrs**

General characters of Phylum Cnidaria & Ctenophora; Polymorphism

UNIT- 5: Helminthes **3 hrs**

General characters of helminths (Platyhelminthes and Nemathelminths); Parasitic Adaptations

UNIT- 6: Coelomates (Non-chordates) **6 hrs**

General characters of Phylum Annelida; Metamerism
General characters of Phylum Arthropoda; Vision in insects
General characters of Phylum Mollusca; Pearl Formation
General characters of Phylum Echinodermata, water vascular system in starfish

UNIT- 7: Lower chordates (Protochordata) **1 hr**

Salient features of Protochordates (Hemichordates, Urochordates and Cephalochordates)

Unit 8: Higher chordates **12 hr**

General characters of Vertebrates:

- Cyclostomes; Cartilaginous and Bony fishes; Catadromous and Anadromous migration.
- Amphibians; Adaptations for Terrestrial Life
- Reptiles; Poisonous and Non-poisonous Snakes
- Aves; Flight Adaptations in birds
- Mammals - Prototheria, Metatheria and Eutheria.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of specimens- Non-chordates:

Euglena, Noctiluca, Paramecium; Sycon; Physalia, Tubipora, Meandrina; Taenia, Ascaris; Nereis, Heteronereis, Aphrodite, Hirudinaria, Peripatus; Limulus, Cancer, Daphnia, Julus, Scolopendra, Apis, Termite; Chiton, Dentalium, Octopus; Asterias and *Antedon*

2. Study of specimens- Chordates:
Balanoglossus, Herdmania, Amphioxus; Petromyzon; Sphyrna, *Pristis, Hippocampus, Exocoetus, Diodon/ Tetradon; Icthyophis/ Uraeotyphlus, Bufo, Hyla, Salamandra; Rhacophorus, Draco, Uromastix, Naja, Viper*;
Any three common birds (Crow, duck, Owl); Funambulus, Loris and Bat

3. Study through Permanent Slides:
i) Cross Section of *Sycon*, and *Ascaris* (male and female).
ii) T. S. of Earthworm passing through Pharynx, Gizzard, and Typhlosole region of intestine.
iii) Septal and Pharyngeal Nephridia of Earthworm.
iv) Placoid and Cycloid Scales in Fishes.

4. Study of Organ Systems (through videos/animations/photographs/dissections*:
i) Digestive System of Cockroach;
ii) Urinogenital System of Rat
* subject to UGC guidelines

Essential/recommended readings

1. Young, J.Z. (2004) The Life of Vertebrates. III Edition, Oxford University Press.
2. Ruppert, Fox and Barnes (2003) Invertebrate Zoology. A Functional Evolutionary Approach, VII Edition, Thomson Books/Cole.
3. Parker T.J. and Haswell W.A. (1972). Textbook of Zoology Vertebrates. VII Edition, Volume II. Blackwell, Hoboken

**Note: Refer Ruppert, Fox and Barnes (VII Ed.) for the classification of invertebrates;*

Suggestive reading

1. Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd.
2. Campbell and Reece (2005). Biology, Pearson Education, (Singapore) Pvt. Ltd.
3. Mann Raven, P.H. and Johnson, G.B. (2004). Biology, VI Edition, Tata McGraw Hill Publications. New Delhi.

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

GENERIC ELECTIVES (GE-9): Microbiota: Importance in Health and Disease Zoo-GE-9

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			
Microbiota: Importance in Health and Disease Zoo-GE-9	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL	Zoology

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint students with the basic concepts of microbiota that coexist with the human being both in health and in different pathologies.
- To enable students to understand how microbiota undergoes changes as a consequence of the influence of multiple factors, diet, lifestyle, pharmacological treatments generating alterations in this bacterial ecosystem.
- To compare the role of our microbiota in behavior, mood, and development.
- to make the students aware of the microbial communities that reside within or upon us, and how they impact our health.
- To acquire knowledge about the interactions between the different types of microbiota and their host in different pathophysiological situations.

Learning Outcomes

By studying this course, students will be able to

- Identify the components of the human microbiota and their major characteristics.
- Learn the key approaches and techniques used to identify and quantify the bacterial, fungal, archaeal, protozoan, and viral components of the microbiota.
- Identify the common members of the microbiota and their influence on various body systems including the skin, upper and lower respiratory system, oral and the lower digestive system, urinary and reproductive systems, the immune system, and the nervous system in healthy and diseased states.
- Compare the role of our microbiota in behavior, mood, and development.
- Appreciate the emerging treatment approaches for microbiota-associated illnesses.

SYLLABUS OF GE-9

UNIT- 1: Microbes **4 hrs**

Introduction to microbes, general approaches and techniques used for studying microbiota, the nature of microbiological problems, Prokaryotic and eukaryotic organisms.

UNIT- 2: Introduction to the Human Microbiome **16 hrs**

Importance of human body environment for growth of a variety of microorganisms, concept of contamination, infection and disease, septicaemia, Acute and subacute bacterial endocarditis.

a) Microbial Diseases of the Respiratory System: Tuberculosis; Common cold,

b) Microbial Diseases of the Eyes: Conjunctivitis, Trachoma; Viral Diseases of the Eye.

c) Microbial Diseases of skin: Bacterial diseases of the skin: Acne, folliculitis, boils, cellulitis, Infections of burns and surgical wounds, gangrene, Leprosy. Viral Diseases of the Skin: Chicken pox;

Fungal Diseases of the Skin: Candidiasis.

d) Microbial Diseases of the Nervous System: Bacterial diseases: Tetanus, Viral diseases: Polio/Rabies; Protozoan diseases: Trypanasomiasis

e) Microbial Diseases of the Oral Cavity and Digestive System: Bacterial diseases: Dental caries; Cholera, Gastroenteritis; Fungal diseases: Aflatoxin poisoning, Ergot poisoning; Viral diseases: Mumps; Protozoan diseases: Amoebic dysentery, Giardiasis

f) Microbial Diseases of the Urinary/Reproductive Systems: Bacterial diseases: Syphilis; Viral diseases: genital warts; Protozoan diseases: Trichomoniasis; Fungal diseases: Vaginitis

UNIT- 3: Microbiota and the Immune System Development **5 hrs**

Normal flora, transient flora opportunistic microbes, Pathogenicity, virulence, and factors that increase virulence (enzymes, toxins), Factors that affect the spread of disease, Nonspecific immune responses, Specific immune responses: humoral and cell mediated immunity

UNIT- 4: Human Microbiota in Health and Disease **5 hrs**

Basic concept of Gut microbiota in the mother-child environment, Gut microbiota and cancer; Microbiota and viral diseases- An opportunity for COVID-19. Relationship between diet and the intestinal microbiota, Probiotics, prebiotics and other "biotics".

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Bacterial shapes and arrangements Cell wall, Cell membrane, Glycocalyx, Endospores, Flagella, Cytoplasmic inclusions, Cytoplasmic structures/organelles, Bacterial growth curve, Physical factors affecting microbial growth.
2. To understand Good Lab practise: The effectiveness of hand washing and sterilization.
3. To understand microbial morphology by Gram Staining.
4. To appreciate bacterial anatomy by Acid-fast Staining.
5. Environmental Factors affecting growth of microorganisms: Temperature, pH and Osmotic Pressure.
6. Bacterial growth curve and evaluation of factors affecting microbial growth.
7. Isolation of normal microbiota from the human Body (Nose, Throat, or Skin).
8. Effects of chemical agents on bacteria growth (Kirby-Bauer method).

Essential/recommended readings

1. Leboffe, M. J and Pierce; B. E. (2014) A Photographic Atlas for the Microbiology Laboratory, 5th Edition, Morton Publishing Company.
2. Michael Wilson (2005) "Microbial Inhabitants of Humans-Their Ecology and Role in Health and Disease"; Oxford University Press, UK.

Suggestive readings

1. Nina Parker, Mark Schneegurt, Anh-Hue-Thi Tu and Brian M. Forster; (2016) "Microbiology"; 1st Edition, OpenStax Resource.

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

GENERIC ELECTIVES (GE-10): Insect Vector and Disease
Zoo-GE-10

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			
Insect Vector and Disease Zoo-GE-10	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to familiarize the students with a variety of diseases caused by insects.
- to learn the complex interactions between the transmission by Insect-borne pathogens affecting human health.
- to acquire knowledge of how the insects can only be controlled and prevented by studying their biology, modalities of pathogen transmission
- to enable students to evaluate the associated risk factors and devising new efficient techniques to control these insects.
- to help understand the environmental pressures caused by stagnant water.
- to motivate students to pursue a career in Health Management.

Learning Outcomes

By studying this course, students will be able to

- identify different insects and classify them based on their morphology and behaviour.
- describe the host-pathogen relationships and the role of the host reservoir on transmission of parasite.
- explain various modes of transmission of parasite by insect vectors.
- recognize various possible modern tools and methodologies for laboratory diagnosis, surveillance and treatment of diseases.
- develop a critical understanding of insect transmitted diseases such as Zoonotic, Vertical and Horizontal transmission, host specificity etc.
- spread awareness on public health programs about insect borne diseases and their control.

- To use advanced management strategies in disease control with respect to parasite evolution

SYLLABUS OF GE-10

UNIT- 1: Introduction to Insects **8 hrs**

General Features of Insects, Classification of insects up to Orders- General features of orders, Morphological features: Head, legs and types of antennae. Types of Insects mouth parts w.r.t. feeding habits: siphoning type (butterfly), sponging type (housefly), biting and chewing type (cockroach), piercing and sucking type (mosquito), chewing and lapping type (honey bee).

UNIT- 2: Concept of Vectors **5 hrs**

Brief introduction to carriers and vectors (mechanical and biological vector); Insect reservoirs; Host-vector relationship; Vectorial capacity; Host Specificity; Modes of disease transmission - vertical and horizontal transmission. Insects as vectors: General adaptations in insects to act as vectors.

UNIT- 3: Dipterans as disease Vectors-I **7 hrs**

Dipterans as important insect vectors–Mosquitoes. Study of mosquito borne diseases– Malaria, Dengue, Chikungunya, Filariasis, Viral encephalitis. Control and prevention/cure of diseases caused by mosquitoes. Study of sand fly-borne diseases- Visceral Leishmaniasis, Cutaneous Leishmaniasis; Control of Sand fly; Study of house fly as important mechanical vector, Control of house fly.

UNIT- 4: Siphonapterans as disease vectors **5 hrs**

Fleas as insect vectors; Study of flea borne diseases – Plague, typhus fever; Control and prevention/cure of diseases caused by fleas.

UNIT- 5: Siphunculata as disease vectors **5 hrs**

Human louse (head, body and pubic louse) as disease vectors; study of louse borne diseases – Typhus fever, relapsing fever, vagabond's disease, phthiriasis; Control of human louse and prevention/cure of diseases caused by them.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of different kinds of mouth parts and legs of insects through slides/specimens
2. Study of insect vectors through permanent slides or photographs: Mosquitoes (*Aedes, Culex, Anopheles*), lice [head, body (*Pediculus*), pubic (*Pthirus*)], Flea (*Xenopsylla cheopis*), sand fly (*Phlebotomus*), house fly (*Musca domestica*)

3. Study of different diseases transmitted by above insect vectors using photographs.
4. Project report on any one disease transmitted by insect vector.
5. Optional field trip/Lab. visit to institutes such as NIMR, NCDC.

Essential/recommended readings

1. Mullen and Darden (2009) Medical and Veterinary Entomology, 3rd Edition, Academic Press.
2. Service, M.W. (1980) A Guide to Medical Entomology, Macmillan Press.

Suggestive readings

1. Burgess, N.R.H and Cowan, G.O. (1993) A colour atlas of medical entomology. Springer Science and Business Media, B. V. House.

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DEPARTMENT OF ZOOLOGY
SEMESTER - V
Category I

(B.Sc. Honours in Zoology in three years)

DISCIPLINE SPECIFIC CORE COURSE -13 –:
Principles of Immunology
Zoo-DSC-13

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		
Principles of Immunology Zoo-DSC-13	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

Learning Objectives

The learning objectives of this course are as follows:

- to impart an in-depth knowledge on how our immune system fights with infection and foreign substances that can harm our body
- to understand and design new therapeutics against a wide range of diseases and infections.
- to assist in comprehending the quick response to pandemics in the form of vaccines
- to apprise the students on the development of therapies targeting different components of the immune system that can alter the progression of human inflammatory diseases and cancers.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the concepts of innate and acquired immunity.
- acquire knowledge of the immunogenicity of biomolecules
- comprehend and analyze the different cellular and humoral components of the immune system
- appreciate the contribution of various components of immune system in health and disease including basis of vaccination, autoimmunity, immunodeficiency and hypersensitivity

SYLLABUS OF DSC-13

UNIT 1: Overview of the Immune System **6 hrs**

Early theories (Selective and Instructional) and Clonal Selection theory; Innate immunity: components and defensive barriers of innate immunity. Adaptive immune system: Components and attributes of acquired immunity, humoral and cell mediated immunity, active and passive immunity, primary and secondary immune response,

UNIT 2: Antigens and Immunoglobulins **10 hrs**

Antigens and immunogens; antigenicity and immunogenicity; factors affecting immunogenicity; antigenic determinants and its properties (B- and T-cell epitopes); Haptens and Adjuvants.

Structure and functions of different classes of antibodies; antigenic determinants on immunoglobulin; Production and applications of monoclonal antibodies.

UNIT 3: MHC and Antigen Presentation **4 hrs**

Structure and functions of MHC (MHC-I & MHC-II); endogenous and exogenous pathways of antigen processing and presentation.

UNIT 4: Complement System and Cytokines **3 hrs**

Pathways of complement activation and biological consequences of complement activation; properties and functions of cytokines

UNIT 5: Immune System in Health and Diseases **7 hrs**

Vaccines and their types; Gell and Coombs classification of hypersensitivity; autoimmunity and immunodeficiency with suitable examples.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of lymphoid cells and organs in rat/mouse*.
2. Histological study of spleen, thymus and lymph nodes through slides/photomicrographs.
3. To study various types of white blood cells using Leishman's/Giemsa/Crystal violet stained blood smear.
4. To understand the antigen and antibody interactions by

i) Ouchterlony's double immunodiffusion method.

ii) ABO Blood group antigen determination by heamagglutination test.

iii) Demonstration of ELISA.

iv) Demonstration of Immunoelectrophoresis.

v) FACS

vi) RIA

vii) Elispot

5. Cell counting and viability test (trypan blue dye exclusion test) from splenocytes* from rat/mouse/any other species.
6. Project on any topic/ Project report on visit to any research institute/laboratory to study the immunological techniques.

*depending on availability of animals or sample.

Essential/recommended readings

Punt, J., Stranford, S., Jones, P., Owen, J.A. (2018) Kuby Immunology, VIII Edition, WH Freeman and Company
Abul Abbas, Andrew Lichtman, Shiv Pillai (2017) Cellular and Molecular Immunology; Elsevier
Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006) Immunology, VI; Edition, W.H. Freeman and Company
David, M., Jonathan, B., David, R. B. and Ivan, R. (2006) Immunology, VII Edition, Mosby, Elsevier Publication.

Suggestive readings

1. Singh, I. K. and Sharma, P. [Eds.] (2022) An Interplay of Cellular and Molecular Components of Immunology. Taylor & Francis group, CRC Press.
2. Kaur, H., Toteja, R., and Makhija, S. (2021) Textbook of Immunology, I.K International Publishing House and Wiley India Ltd
3. Singh, I. K. and Sharma, P. [Eds.] (2022) Essentials of Immunology, Laboratory Manual; Prestige Publishers.
4. Kenneth Murphy, Casey Weaver (2016) Janeway's Immunobiology; 9th Edition, Garland Science

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

DISCIPLINE SPECIFIC CORE COURSE -14 –:
Cell and Molecular Biology
Zoo-DSC-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 (if any)
		Lecture	Tutorial	Practical		
Cell and Molecular Biology Zoo-DSC-14	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	Basic knowledge of cell biology

Learning Objectives

The learning objectives of this course are as follows:

- to provide an understanding of structure-function relationships of nucleic acids and protein and the regulatory processes.
- to demonstrate practical knowledge of raising, handling, maintenance and special features such as antibiotic resistance of a simple prokaryotic model organism, *Escherichia coli*.
- to empower the students with a broad range of research and development related to cell signalling, cell culture and cell lines.
- to elucidate the molecular machinery and mechanism of information transfer processes- transcription and translation-in prokaryotes and eukaryotes;

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the diverse cellular processes and cellular interactions.
- have an in-depth knowledge of the defects in cellular functioning and the molecular mechanisms that can lead to various diseases.
- appreciate the importance of homeostasis of the body and the adversities of disturbing it.
- acquire the basic information of cell signalling pathways and to elucidate its roles in gene expression and its regulation in eukaryotes.
- interpret the differences between cellular deaths; stem cells and their applications in therapeutic cloning and regenerative medicine.
- explain post-transcriptional modification mechanisms for the processing of eukaryotic mRNA.
- impart experimental skills used in clinical and research laboratories giving the students an extra edge for taking up higher studies.

Syllabus of DSC-14

UNIT- 1: Cell Signalling **3 hrs**

Introduction to cell signalling pathways GPCR, cAMP, PKA, CREB, target gene and a nuclear receptor pathway.

UNIT-2: Cell Death and Cell Renewal **4 hrs**

Apoptosis vs. necrosis; intrinsic and extrinsic pathways of programmed cell death; stem cells and maintenance of adult tissues; embryonic and induced pluripotent stem cells.

UNIT-3: DNA and its Replication **7 hrs**

DNA replication in prokaryotes and eukaryotes-replication machinery and mechanisms, semi-conservative, bidirectional and semi-discontinuous replication, Replication of circular and linear double stranded DNA, Replication of telomeres.

UNIT 4: Transcription **5 hrs**

Machinery and mechanism of transcription in prokaryotes and eukaryotes-RNA polymerases, Transcription unit, Transcription factors, Synthesis of rRNA.

UNIT 5: Translation **5 hrs**

Genetic code, Process of protein synthesis in prokaryotes: fidelity of protein synthesis, aminoacyl-tRNA synthetases and charging of tRNA; Proteins involved in initiation, elongation and termination of polypeptide chain; Difference between prokaryotic and eukaryotic translation.

UNIT 6: Post Transcriptional Modifications **2 hrs**

Split genes: concept of introns and exons, splicing mechanism, alternative splicing, and RNA editing.

UNIT 7: Gene Regulation **4 hrs**

Transcription regulation in prokaryotes: Lac operon; Overview of transcription regulation in eukaryotes: Activators, repressors, enhancers, silencer elements.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Requirement of a Tissue culture laboratory, its equipment and its layout. Concept of cell culture and cell lines; Media preparation for mammalian tissue culture.
2. Preparation of permanent slides of mitosis/meiosis*.
3. Study of Polytene chromosomes from *Chironomous*/*Drosophila* larva.
4. Inoculation and culture of *E. coli* in liquid culture medium (LB).
5. Preparation of solid culture medium (LB) and growth of *E. coli* by spreading and streaking.
6. Estimation of the growth kinetics of *E. coli* from the data provided.
7. Quantitative estimation of salmon sperm/calf thymus DNA using colorimeter.

(Diphenylamine reagent) or spectrophotometer (A_{260} measurement).

8. Study and interpretation of electron micrographs/photographs showing: DNA replication, Transcription, and Split genes.
9. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

*Subject to UGC guidelines

Essential/recommended readings

1. Karp, G. (2010) Cell and Molecular Biology: Concepts and Experiments. VI Edition. John Wiley and Sons. Inc.
2. R. Ian Freshney (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell.
3. Lodish et. al., (2007), Molecular Cell Biology, W.H. Freeman and Company, New York, USA
4. Alberts et. al., (2008), Molecular Biology of the Cell Garland Science, Taylor & Francis Group, New York, USA.
5. Cooper G. M. and Robert E. Hausman R. E. The Cell: A Molecular Approach, V Edition, ASM Press and Sinauer Associates.
6. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell. VII Edition. Pearson Benjamin Cummings Publishing, San Francisco.

Suggestive readings

1. Watson, J. D. Baker T.A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2008) Molecular Biology of the Gene.VI edition. Cold Spring Harbour Lab. Press, Pearson Pub.
2. Lewin B. (2008). Gene XI. Jones and Bartlett.
3. Gupta, R., Makhija, S. and Toteja, R. (2018). Cell Biology Practical Manual, Prestige Publishers, New Delhi-110003.
4. Sharma, V. K. (1991). Techniques in Microscopy and Cell Biology, Tata McGraw Hill Publishing Company Limited, New Delhi.

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

DISCIPLINE SPECIFIC CORE COURSE 15–:
Fundamentals of Genetics
Zoo-DSC-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 (if any)
		Lecture	Tutorial	Practical		
Fundamentals of Genetics Zoo-DSC-15	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL

Learning Objectives

The learning objectives of this course are as follows:

- to be able to list some of the distinguishing features of prokaryotes versus eukaryotes.
- to provide an understanding of the basic patterns of inheritance.
- to explain how genotype is related to phenotype?
- to describe how a mutation can change the phenotype.

Learning Outcomes

By studying this course, students will be able to

- Enhance knowledge of the basic principles of inheritance.
- Develop analytical skills and critical thinking through pedigree analysis.
- Understand the mechanism of gene transfer and mapping in both prokaryotes and eukaryotes.
- Learn the mechanisms of mutations and harmful and beneficial effects of mutagens, which help evolve new species over time.
- Be able to grasp basic concepts of human chromosomal disorders.

SYLLABUS OF DSC-15

UNIT- 1: Mendelian Genetics and its Extensions **7 hrs**

Principles of inheritance, Incomplete dominance and co-dominance, Multiple alleles, Lethal alleles, penetrance and expressivity, Epistasis, Phenocopy, Pleiotropy, Polygenic Inheritance, Sex-linked, Sex-influenced, and Sex-limited characters inheritance.

UNIT- 2: Linkage, Crossing Over and Chromosome Mapping **6 hrs**

Linkage and crossing over, Cytological basis of crossing over, Recombination frequency

as ameasure of linkage intensity, two-factor and three-factor crosses, Linkage map, Coefficient of Coincidence and Interference, Gene mapping by Somatic cell hybridization.

UNIT- 3: Mutations **8 hrs**

Types of gene mutations, Detection of mutations in *Drosophila*: CLB method, Mutagens: Physical and chemical, molecular basis of spontaneous and induced mutations, Chromosomal aberrations: Structural Variations in chromosomes, Aneuploidy & Polyploidy.

UNIT- 4: sex Determination **3 hrs**

Basis of sex determination: Genetic and environmental; Sex determination in *Drosophila* and human; Mechanism of dosage compensation.

UNIT- 5: Extra-chromosomal Inheritance **3 hrs**

Comparison of nuclear and extranuclear inheritance; Organelle inheritance: Antibiotic resistance in *Chlamydomonas*, Infective heredity in *Paramecium*. Maternal effects: Shell coiling in *Limnaea*, pigmentations in *Ephestia.*

UNIT- 6: Transposable Genetic Elements **3 hrs**

Transposons in bacteria, Ty elements in yeast, Ac-Ds elements in maize, P elements in *Drosophila*, Transposons in humans, Significance of Transposons.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Simulation exercises using beads or seeds to study the gene interactions: 9:3:4; 12:3:1; 9:7; 9:3:3:1 (comb shapes in roosters) and verification of ratios by usingChi-square analysis.
2. Pedigree analysis of Autosomal Dominant trait, Autosomal recessive trait, X-linked Dominant traits, X-linked recessive traits, Y-linked traits and mitochondrial traits.
3. Use of probability in solving problems of genetics (Sum rule, Multiplication rule & Binomial expansion).
4. Gene mapping (order and distance) using data from interrupted mating experiments in bacteria.
5. Linkage maps based on data (two - point and three - point crossing over) from *Drosophila*.
6. Human Karyotypes, Human chromosomal disorders & single gene disorders.
7. Project on Epigenetic, Eugenics, Euthenics and Euphenics.

*Subject to UGC guidelines

Essential/recommended readings

1. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons In.

2. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics. X Edition. Benjamin Cumming

3. Pierce, B. A. (2012). Genetics-A Conceptual Approach. IV Edition. W. H. Freeman and Company

Suggestive readings

1. Peter, J. Russell. (2009), iGenetics: A molecular approach. 3rd Edition. Benjamin Cumming

2. Anthony J.F. Griffiths, Susan R. Wessler, Richard C. Lewontin, Sean B. Carroll (2007). Introduction to Genetic Analysis. 9th Edition. W H Freeman.

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

SEMESTER-V

POOL OF DISCIPLINE SPECIFIC ELECTIVES (DSE) COURSES

DISCIPLINE SPECIFIC ELECTIVES (DSE-9): Chronobiology
Zoo-DSE-9

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			
Chronobiology Zoo-DSE-9	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of animal behavior**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to understand and appreciate the cyclic physiological phenomena.
- to acquaint the students to the concept of generation of internal time.
- to learn about the fascinating phenomena of seasonal migration and hibernation.
- to expose the students to clock dysfunctions
- to make the students aware of the various aspects of chronobiology and how it can be applied to therapeutics and medicine?
- to facilitate the students to learn about their very own rhythms of sleep and body temperature
- to familiarize the students to actograms and their interpretation and analysis.

Learning Outcomes

By studying this course, students will be able to

- better understand the concept and biological significance chronobiology.
- acquire knowledge about the various types of biological rhythms and their adaptive role.
- appreciate the importance of circadian rhythms in human mental and physical health.
- better understand physiological and molecular mechanisms controlling circadian rhythms.
- know the genetic components comprising the biological clocks.
- gain knowledge about the importance of photoperiodism and its association with circannual rhythms.
- learn about the applications of chronobiology in medicine, pharmacology and

therapeutics.

SYLLABUS OF DSE-9

UNIT- 1: Introduction to Chronobiology **8 hrs**

Historical developments in chronobiology; Biological oscillation: the concept of average, amplitude, phase and period; Types of Rhythms – Ultradian rhythms, Circadian rhythms, Infradian rhythms; Lunar rhythm; Circannual rhythm; Adaptive significance of biological rhythms.

UNIT- 2: Circadian rhythms **8 hrs**

Characteristics of circadian rhythms, Free-running rhythm; Temperature compensation; Masking and synchronization; Zeitgebers- Photic and non-photic Zeitgebers; Effect of light, Intensity- Aschoff's rule.

UNIT- 3: Biological clock system **9 hrs**

Input, time generation and output components; Central and peripheral clocks; Suprachiasmatic nucleus; Molecular mechanisms underlying the generation of circadian time in Drosophila and Mammals.

UNIT- 4: Circannual rhythm and Photoperiodism **9 hrs**

Circannual rhythms; Photoperiodism and regulation of seasonal reproduction in vertebrates; Migration in birds; Hibernation in mammals.

UNIT- 5: Circadian clock, diseases and therapeutics **11 hrs**

Circadian clock and sleep-wake cycle; Jet Lag, Shift work ; Sleep and Chronotypes; Consequence of clock dysfunction- Sleep Disorders, Depression, Anxiety, Stress, Cancer; Obesity, Immune Disorders; Chronopharmacology, Chronomedicine and Chronotherapy.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Study of basic characteristics of biological rhythms from a given dataset.
2. Study and actogram construction of locomotor activity of suitable animal models.
3. Study of body temperature rhythm using periodically assembled data.
4. Study of the alertness rhythm using periodically assembled data.
5. Study of phase shift in circadian rhythm using given data.
6. Research plan presentation/ project on circadian (daily) rhythm functions, like eating, sleep or body temperature.
7. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Binkley, S. (2020). Biological clocks: Your owner's manual. CRC Press.
2. Vinod Kumar (2017): Biological Timekeeping: Clocks, Rhythms and Behaviour.
3. Wirz-Justice, A., Benedetti, F., & Terman, M. (2013). Chronotherapeutics for Affective Disorders: A Clinician's Manual for Light and Wake Therapy. Karger Medical andScientific Publishers

4. Koukkari, W. L., & Sothern, R. B. (2007). Introducing biological rhythms: A primer on the temporal organization of life, with implications for health, society, reproduction, and the natural environment. Springer Science & Business Media.

Suggestive readings

1. Dunlap J. C, Loros J. J, DeCoursey P. J. (2004) Chronobiology Biological Timekeeping.Sinauer Associates, Inc. Publishers, Sunderland, MA, USA.
2. Palmer, J. D. (2002). The living clock: The orchestrator of biological rhythms. OxfordUniversity Press.
3. Vinod Kumar (2002) Biological Rhythms. Narosa Publishing House, Delhi/ Springer-Verlag, Germany.
4. Saunders D. S. (2002). Insect Clocks. III Edition, Barens and Noble Inc. New York, USA
5. Weiner, J. (2000). Time, love, memory: a great biologist and his quest for the origins ofbehavior. Vintage.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-10):
Integrative Systems Biology and Bioinformatics

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			
Integrative Systems Biology and Bioinformatics Zoo-DSE- 10	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Basic knowledge of computer and biology**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to give an overview of the key principles of Systems Biology and Bioinformatics.
- to introduce students to a variety of *in silico* solution for biological problems and systems data by analysing biological databases, gene sequence alignments, gene annotation, structure predictions, and drug development, among other areas.
- to encourage undergraduate students to pursue higher education in this field as Bioinformatics has been identified as a critical area of study and development

Learning Outcomes

By studying this course, students will be able to:

- know more about the basic of systems biology and bioinformatics
- better understand about the availability of experimental data through biological databases, usage of small molecules, nucleic acids, protein sequences, in a variety of biological sciences domains
- gain more knowledge about the gene sequence annotation, protein structure prediction and gene enrichment prediction
- acquire skills to perform and understand pair-wise and multiple sequence alignment
- better understand a variety of computational tools and approaches, as well as their use in *in silico* drug discovery, structural bioinformatics, and functional genomics etc.

SYLLABUS OF DSE- 10

UNIT- 1: Introduction to Systems Biology and Bioinformatics **5 hrs**

Introduction to Systems Biology, Bioinformatics, Genomics, Proteomics, Transcriptomics, Metabolomics, Scope and their applications.

UNIT- 2: Systems Biology **10 hrs**

Computational models, modelling and their basic notions, networks (feed forwardgene circuit,transcription regulatory networks and protein-protein interaction networks)

UNIT- 3: Biological Databases **8 hrs**

Introduction to biological databases; Primary, Secondary and Composite databases; Nucleic acid databases (GenBank, DDBJ, EMBL and NDB); Protein databases (PIR, SWISS-PROT, TrEMBL, PDB); Metabolic pathway database (KEGG, Reactome, EcoCyc, and MetaCyc); Small molecule databases (PubChem, Drug Bank, ZINC, CSD)

UNIT- 4: Sequence Alignment and Phylogeny **10 hrs**

Scoring Matrices (PAM, BLOSUM), Methods of Alignment (Dot matrix, Dynamic Programming, BLAST and FASTA); HMM model, Local and global alignment, pair wise and multiple sequence alignments, Molecular Phylogeny.

UNIT- 5: Structural Biology and Drug Discovery **12 hrs**

Protein secondary structure prediction (Chou-Fasman & GOR methods), Protein tertiary structure prediction and its validation (Homology modelling, Threading and *Ab-initio* methods); Lipinski rule, Molecular docking (rigid and flexible docking), ADMET properties, Molecular Dynamics, Drug-DNA interactions.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Retrieval of DNA, RNA, protein sequences and structures from the biological databases and to create various datasets.
2. Perform pairwise and multiple sequence alignments from the generated datasets in Experiment 1, using online/offline tool.
3. Retrieval and analysis of any one disease network from KEGG pathway database.
4. Gene functional enrichment analysis using DAVID tool.
5. Protein structure prediction through homology modelling using Swiss Modeller.
6. Molecular docking (Protein-ligand) using AutodockVina/ SwissDock/ PatchDock/ZDock (anyone).
7. Project related to topics covered in theory/ project report based on visit to labs/institutions/industry etc.

Essential/recommended readings

1. Pevsner, J. (2015) Bioinformatics and Functional Genomics, 3rd edition, Wiley and Blackwell.
2. Xiong, J. (2012) Essential Bioinformatics, Cambridge University Press.
3. Claverie, JM and Notredame, C. (2006) Bioinformatics for Dummies 2nd edition, Wiley Publishing Inc.
4. Klipp, E., Liebermeister, W., Wierling, C. and Kowald, (2016) A. System Biology 2nd edition, Wiley-VCH.

Suggestive readings

1. Alon, U. (2019) An Introduction to Systems Biology 2nd edition, CRC, Taylor & Francis.
2. Jenny Gu, J. and Bourne, P.E.(2011) Structural Bioinformatics 2nd edition, Wiley Blackwell.
3. Harren Jhoti, H. & Leach, A. (2007) Structure-based Drug Discovery, Springer.
4. Kitano, H. (2001) Foundations of Systems Biology, MIT press Cambridge.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-11): Basics of Neuroscience

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	Dept offering the course
		Lecture	Tutorial	Practical			
Basics of Neuroscience Zoo-DSE- 11	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**Concept of functioning of nervous system**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to understand the structure and function of the nervous system at the molecular, cellular, and systems levels.
- to provide an in-depth understanding of neuronal excitability, signal generation and propagation, synaptic transmission, post-synaptic mechanisms of signal integration, and neural plasticity.
- to gain an insight into how membrane excitability elicits functional effects in individual neurons and neuronal networks and how different parts of the brain control various behavioural patterns by releasing neurohormones/neuropeptides.
- to have a thorough knowledge of neuroimaging techniques and a comprehensive understanding of the kinds of information each technique provides about the brain.
- to gain knowledge about the neural mechanism and pathogenesis of common neurodegenerative disorders such as Alzheimer's, Parkinson's disease etc.

Learning Outcomes

By studying this course, students will be able to:

- understand the fundamentals of neuroscience, key concepts, and the relationship between the nervous system and behaviour/cognition.
- comprehend the neural basis of sleep, emotions, learning and memory and related aspects of cognition.
- have a detailed understanding of how different neuroimaging techniques are used to assess brain function and explore questions in clinical and behavioural neuroscience.
- explore potential developments to current research, design, execute and communicate a substantive research project in the field of neuroscience or its application.

SYLLABUS OF DSE- 11

UNIT- 1 Introduction to Nervous System **6 hrs**

Origins of Neuroscience; Neuron doctrine; Classification of the nervous system.

UNIT- 2 Structure of the Brain **5 hrs**

Gross anatomy of the human brain, Meninges, ventricular System, Blood-brain Barrier, Cranial nerves.

UNIT-3 Cellular and Molecular Neurobiology **10 hrs**

Classification of neurons; Structure of prototypical neuron; Electrophysiology of membrane potentials-resting and action potentials, generation, and propagation; Ion Channels and Membrane Ion Currents; Types of Synapses, synaptic transmission and integration; Post synaptic potentials - EPSPs and IPSPs; tripartite synapse.

UNIT- 4 Neurotransmitters **4 hrs**

Types of neurotransmitters; transmitter-gated channels; neurotransmitter receptors Ionotropic and metabotropic receptors; G-protein coupled receptors and effectors.

UNIT- 5 Cognitive and Behavioural Neuroscience **10 hrs**

Neurobiology of visual perception; Molecular basis of learning and memory: Classification ofmemory, amnesia, case of H.M. (Henry Malaison); Synaptic plasticity, Long-term potentiation (LTP), Long-term depression (LTD); Memory consolidation.

UNIT-6 Neurophysiology of Sleep **4 hrs**

Neurophysiology of sleep and wakefulness, electroencephalogram rhythms (EEG).

UNIT- 7 Neuroimaging and Neuropathology **6 hrs**

Computed Tomography Scan (CT), Magnetic Resonance Imaging (MRI), functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET); Neurological disorders (in brief)- Epilepsy, Schizophrenia; Aetiology and Molecular pathogenesis - Parkinson's, Alzheimer's.

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

1. Study of brain coordinates using stereotaxis instrument (video demonstration).
2. Study of *Drosophila* nervous system using GFP reporter system.
3. Study of anatomy of mammalian brain (from slaughter house or) using brain models (Medical anatomical teaching models, graphics, videos etc., can be used).
4. Histological study of neurons and myelin sheath (Nissl and Luxol Fast Blue staining).
5. Study of novelty, anxiety, and spatial learning in mice.
6. Histological study of the cerebellum and spinal cord by H&E stain and cerebral cortex by Nissl stain.

7. Study of neurodegenerative diseases (Parkinson's and Alzheimer's) with the help of brainscan images or brain tissue images.

Essential/recommended readings

1. Purves, D. et al., (2017) Neuroscience, VI Edition. Oxford University Press.
2. Bear, M. F., Connors, B. W. and Paradiso, M. A. (2016). Neuroscience: Exploring the Brain. IV Edition. Philadelphia: Wolters Kluwer.
3. Squire, L., Berg, D., Bloom, F. E., du-Lac, S., Ghosh, A., Spitzer, N. C. (2012) Fundamental Neuroscience, IV Edition, Academic Press Publications.
4. Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000) Principles of Neural Science. IVEdition, McGraw-Hill Companies.

Suggestive readings

1. Carter, R. (2014). The Human Brain Book. D. K. Publishers.
2. Stephan M. Stahl (2000) Essential Psychopharmacology- Neuroscientific Basis and Practical Applications. II Edition. Cambridge University Press.
3. Ramachandran, V. S. and Blakeslee, S. (1998). Phantoms in the Brain: Probing the Mysteries of the Human Mind. William Morrow, New York.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-12): Biology of Insecta
Zoo-DSE-12

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			
Biology of Insecta Zoo-DSE-12	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint the students about biology of class Insecta.
- to acquire knowledge of the morphology and physiology of Insects.
- to enable the students to see, appreciate and understand the diversity of insects.

Learning Outcomes

By studying this course, students will be able to:

- better appreciate the diversity of insects.
- better understand the physiology of Insects which has made them the most successful animalsin terms of numbers and variety of species.
- get acquainted with the highly organized social life of insects.
- to make the students aware about the possible scope of the subject which includes research and applied aspects including entrepreneurial skill.

SYLLABUS OF DSE- 12

UNIT-1 Introduction **4 hrs**

General features of Insects and their diversity; Classification of insects up to orders.

UNIT- 2: General Morphology of Insects **12 hrs**

Head: Eyes, Types of antennae, Mouth parts w.r.t. feeding habits; Thorax: wings- Typical structure of insect wing and its modifications, Types of Legs; Abdomen: Typical structure.

UNIT- 3: Physiology of Insects **18 hrs**

General aspects of the Integumentary (structure of integument and process of moulting), digestive, excretory, circulatory, respiratory, reproductive, and nervous system (using cockroach as the type representative); Metamorphosis: Types & hormonal control.

UNIT- 4: Insect behaviour **6 hrs**

Insect-Plant Interactions: Host-plant selection by phytophagous insects.

UNIT- 5: Insects as plant pests **5 hrs**

Bionomics and control of any two phytophagous insect pests of fruits, vegetables, cash crops and stored grains.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Methodology of collection, preservation and taxonomic identification of insects (classification up to order with the help of taxonomic keys).
2. Study of different kinds of antennae, legs and mouth parts of insects with the help of slides/specimens/ photographs
3. Study of morphological features of insects using pictures/slides/museum specimen (cockroach): head, sclerites, antennae, mouthparts, wing venation, and legs.
4. Preparation of temporary/permanent mount of any stored grain pest and its life stages.
5. Study of biology of any insect pest of agricultural crops (Fruit/vegetable).
6. Field study of insects and submission of a project report showcasing insect diversity.

Essential/recommended readings

1. Chapman, R. F. (1998) The Insects: Structure and Function. Cambridge University Press, UK.
2. Richards, O. W., Davies, R. G. (1977) Imms' General Text Book of Entomology. Vol I & Vol II; Chapman & Hall, UK.

Suggestive readings

1. Snodgrass, R. E. Principles of Insect Morphology. Cornell Univ. Press, USA.
2. Borror, D. J., Triplehorn, C. A., and Johnson, N. F. Introduction to the Study of Insects. M Saunders College Publication, USA.

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

DISCIPLINE SPECIFIC ELECTIVES (DSE-13):
Reproductive Biology and Assisted Reproductive Technologies (ART)
Zoo-DSE-13

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			
Reproductive Biology and Assisted Reproductive Technology (ART) Zoo-DSE-13	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint the students about the various aspects of reproduction in humans.
- to acquire in-depth knowledge of male and female reproductive systems as well as factors that are important in maintaining reproductive health.
- to enable the students to see, appreciate and understand the new technologies in assisted reproduction as well as contraceptive methods.
- to familiarize the students about the social and public health issues related to family planning.
- to make the students aware of the possible scope of the subject which includes research and applied aspects including entrepreneurial skills.

Learning Outcomes

By studying this course, students will be able to:

- get an in-depth understanding of morphology, anatomy, and histology of male and female reproductive organs.
- know different processes in reproduction starting from germ cell formation to fertilization and consequent pregnancy, parturition, and lactation.
- compare estrous and menstrual cycles and their hormonal regulation.
- comprehend the interplay of various hormones in the functioning and regulation of the male and female reproductive systems.
- know about the diagnosis and management of infertility, including the latest methods, technologies, and infrastructure in assisted reproduction.
- better understand the modern methods of contraception and their use in family planning strategies.
- translate their understanding into the development of products like non-hormonal contraceptives; contribute to drug discovery programs as well as neonatal and

maternal health programmes and work with family planning teams to understand the needs and preferences of individuals belonging to lower socioeconomic groups.

SYLLABUS OF DSE-13

UNIT-1: Reproductive Endocrinology **8 hrs**

Hypothalamo–hypophyseal–gonadal axis; Regulation of gonadotropins and gonadal steroids secretion in male and female; Steroidogenesis; Mechanism of action of hormones related to reproduction.

UNIT- 2: Male Reproductive System **9 hrs**

Anatomy of the male reproductive system: Testis, epididymis, vas deferens, prostate gland, seminal vesicle; Spermatogenesis and its regulation; Sperm transport and maturation in the male genital tract.

UNIT- 3: Female Reproductive System **12 hrs**

Anatomy of the female reproductive system: Ovary, fallopian tubes/oviducts, uterus, cervix, and vagina; Folliculogenesis; Oocyte maturation and ovulation; Menstrual cycle and its hormonal regulation. Lactation and its regulation.

UNIT- 4: Fertilization **8 hrs**

Fertilization; Implantation; Feto-placental unit; Hormonal regulation of gestation; Parturition and its hormonal regulation;

UNIT- 5 Reproduction **8 hrs**

Modern contraceptive methods; Infertility in males and females- causes and diagnosis
Assisted Reproductive Technologies (ART): sperm banks, IVF, frozen embryos, ET, EFT, IUT, ZIFT, GIFT, ICSI, PROST. Ethical issues in ART.

Practical **(30 hrs)**

(Laboratory periods: 15 classes of 2 hours each)

1. Examination of histological sections from photomicrographs/permanent slides of rat/human: testis, epididymis, and accessory glands of male reproductive systems.
2. Sections of the ovary, fallopian tube, uterus (proliferative and secretory stages), cervix, and vagina.
3. Study the estrous cycle by examination of the vaginal smear of rats (from live animals)
4. Study of ovariectomy and castration.
5. Study of sperm count and sperm motility in rats.
6. Study of modern contraceptive devices.
7. Submission of project report on the reproductive health of a small human community involving survey, data collection, statistical analysis

OR

Report on the visit to animal culture facility including details about setting up and maintenance of the animal house, breeding techniques, care of normal and experimental animals.

*All exercises requiring live animals should be performed with the help of photomicrographs/pictures/videos.

Essential/recommended readings

1. Johnson, M.H. and Everitt, B.J. (2018) Essential reproduction. IV Edition, London, Blackwell Science.
2. Jones, R.E. and Lopez, K.H. (2014) Human Reproductive Biology. IV Edition, Elsevier.
3. Franklyn F. Bolander (2012) Molecular Endocrinology. III Edition, USA, Academic Press.
4. De-Groot, L.J. and Jameson, J.L. (eds) (2001) Endocrinology. W.B. Saunders and Company.

Suggestive readings

1. Knobil, E. and Neil, JD (eds) (2014) The Physiology of Reproduction. IV Edition, Elsevier.
2. Robert Martin (2013) How We Do It: The Evolution and Future of Human Reproduction. Basic Books.
3. Austin, C.R. and Short R.V. (Eds) (2012) Reproduction in Mammals. Cambridge University Press.

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

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

GENERIC ELECTIVES (GE-11): Animal Cell Biotechnology
Zoo-GE-11

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical			
Animal Cell Biotechnology Zoo-GE-11	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to give the students a fundamental understanding of the field of biotechnology.
- to provide a tool kit in the form of a number of techniques and processes developed over time to solve problems involving primarily human welfare with focus on health and medicine.
- to make the students aware of the scope of biotechnology which encompasses almost every field of science like engineering, research, commercialization and academics.
- to empower the students to face research and industrial outlets by nurturing independent thinking, initiating scientific enquiry and developing their entrepreneurship skills.
- to equip the students with basic understanding of the tools and techniques of biotechnology which are a must for anyone interested in pursuing a career in biotechnology.

Learning Outcomes

By studying this course, students will be able to

- have a better understanding of the basic principles and applications of biotechnology.
- appreciate the basic techniques used in genetic manipulation helping them continue with higher studies in this field.
- acquire knowledge of the basic principles, preparations and handling required for animal cell culture.
- have an in-depth understanding of the principles underlying the design of fermenter and fermentation process and its immense use in the industry.

- enable students to design small experiments for successful implementation of the ideas and develop solutions to solve problems related to biotechnology keeping in mind safety factor for environment and society.
- apply knowledge and skills gained in the course to develop new diagnostic kits and to innovate new technologies further in their career.
- enhance their understanding of the various aspects and applications of biotechnology as well as the importance of bio-safety and ethical issues related to it.

SYLLABUS OF GE-11

UNIT- 1: Introduction **2 hrs**

Concept and Scope of Biotechnology.

UNIT- 2: **Techniques in Gene Manipulation** **9 hrs**

Outline process of genetic engineering and recombinant DNA technology, Restriction endonucleases, DNA modifying enzymes, Cloning Vectors: Plasmids, Phage vectors, Cosmids, Phagemids (lambda & M13). Shuttle and Expression Vectors. Genomic and cDNA libraries. Transformation techniques: Electroporation and Calcium Chloride method.

UNIT- 3: Fermentation **9 hrs**

Different types of Fermentation: Submerged & Solid state; batch, Fed batch and Continuous; Stirred tank, Air Lift, Downstream Processing: Filtration, centrifugation, extraction, chromatography (Only Principles: Adsorption, Ion exchange, gel filtration, hydrophobic, affinity and size exclusion and lyophilization.

UNIT- 4: Transgenic Animal Technology **5 hrs**

Production of transgenic animals: Retroviral method, DNA microinjection method, Nuclear Transplantation: Dolly and Polly.

UNIT- 5: rDNA Application in Health **5 hrs**

Recombinant vaccines, gene therapy (*in-vivo and ex-vivo*). Production of recombinant Proteins: Monoclonal Antibodies, Insulin and growth hormones, Bio safety: Physical and Biological containment.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. Packing and sterilization of glass and plastic wares for microbial culture.
2. Preparation and sterilization of culture media.
3. Preparation of genomic DNA from *E. coli*.
4. Calculation of transformation efficiency from the data provided.
5. Restriction digestion of lambda (λ) DNA using EcoR1 and Hind III.

6. Techniques:
   a. Western Blot
   b. Southern Hybridization
   c. DNA Finger printing
   d. Polymerase chain reaction,
   e. DNA Microarrays
   f. Polyacrylamide gel Electrophoresis
   g. DNA sequencing: Sanger method

Essential/recommended readings

1. Glick, B.R. and Pasternak, J.J. (2009). Molecular Biotechnology- Principles and Applications of Recombinant DNA. IV Edition, ASM press, Washington, USA.
2. Brown, T.A. (1998). Gene Cloning and DNA Analysis: An Introduction. II Edition, Academic Press, California, USA.
3. R. Ian Freshney (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; Wiley-Blackwell.

Suggestive readings

1. Griffiths, A.J.F., J.H. Miller, Suzuki, D.T., Lewontin, R.C. and Gelbart, W.M. (2009). An Introduction to Genetic Analysis. IX Edition. Freeman and Co., N.Y., USA.
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.
3. Mathur, J.P. and Barnes, D. (1998) Methods in Cell Biology: Animal Cell Culture Methods. Academic Press.

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

GENERIC ELECTIVES (GE-12): Introduction to Public Health and Epidemiology

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			
Introduction to Public Health and Epidemiology Zoo-GE-12	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to acquaint students with the basic concepts and importance of epidemiology and its contribution in the public health research.
- to acquire knowledge about the descriptive, analytic, and experimental aspects that can be applied for assessing the epidemiological studies of health status in the Indian population-based registers.
- to understand the relevance of statistics for the analysis of health-related data and its implications in the health sector
- To enable students to interpret results of data analysis for public health research, policy or practice.

Learning Outcomes

By studying this course, students will be able to

- better understand the fundamental components of epidemiology and data analysis.
- gain an understanding of the unique resources that Indian health registers represent for epidemiological research.
- comprehend various types of epidemiological studies, and understand their 'hierarchy' with respect to research.
- evaluate and interpret basic measures of occurrence and association and interpret the results
- appreciate and analytically assess the collection, analysis of data, and evaluate the relevant hypotheses.
- evaluate the strengths and limitations of epidemiologic reports
- apply epidemiological thinking to critically read and appraise articles in medical literature.

SYLLABUS OF GE-12

UNIT- 1: Epidemiology of Infectious Diseases **12 hrs**

Modes of infections with suitable examples. Overview of cause, extent, prevention, treatment and control of the diseases: Respiratory infections, Intestinal infections, Arthropod-borne infections, Zoonosis and Surface infections.

UNIT- 2: Understanding Epidemiological Data **8 hrs**

Understanding incidence, mortality (rates, ratios and proportions); Components of epidemiology: disease frequency, distribution and determinants of diseases. Epidemiological approach and measurements- vital statistics, health indicator parameters (morbidity, mortality and fertility rates); Analysis of data from National Cancer Registry Program (NCRP) and Covid-19 data.

UNIT- 3: Epidemiologic Methods and Survey **6 hrs**

Outlining the parameters for ethical issues in a study. Determining the target and control populations; Designing of questionnaires; Data collection: Strength of observation (descriptive and analytical) and experimental studies. Epidemiology study designs- case control and cohort studies (prospective and retrospective), procedures of sampling and matching, sources of bias.

UNIT- 4: Collection, Tabulation and Representation of Data **4 hrs**

Analysis of data from NCRP data and survey conducted by the students. Basic principles of "R" software for tabulation and graphical representations (bar diagrams, histograms, pie charts, box plot, etc.), measures of central tendency (mean, mode, median and partition values), dispersion (range, standard deviation, coefficient of variance and covariance) and skewness.

Practical **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Designing a questionnaire for survey of prevalence diabetes/ hypertension/ allergy/ respiratory disorders/covid 19.
2. To conduct a population survey for the year for the any one of the disease- diabetes/ hypertension/ allergy/ respiratory disorders/covid 19.
3. Design an epidemiology study: case control and cohort study (prospective and retrospective), including techniques of sampling and matching, sources of bias.
4. Perform correlation and regression studies on the data collected.
5. Analyze the probabilistic distribution studies.
6. Comparison of groups and ascertaining statistical significance of differences.
8. Research and presentation on current trends in infectious diseases.

Essential/recommended readings

1. Glantz, S. (2011) Primer of Biostatistics, 7th edition, McGraw-Hill Medical. ISBN-13: 978-0071781503.
2. Park, K.(2011) Park's Textbook of Preventive and Social Medicine, 21st edition, M/s Banarsi Das Bhanot Publishers.
3. Bonita, R., Beaglehole, R., TordKjellstrèom, (2006) Basic epidemiology, 2nd edition (2006), Contributor; World Health Organization, illustrated, Publisher: World Health Organization.
4. Pagano, M. and Gauvrean, K. (2000) Principles of Biostatistics, 2nd edition, Thompson learning.

Suggestive readings

1. Wayne W Daniel and Chad L. Cross (2013), Biostatistics: A Foundation for Analysis in the Health Sciences, 10th edition, Wiley. ISBN-13: 978-1118302798.
2. Jerrold H. Zar (2009) Biostatistical Analysis, 5th edition, Pearson. ISBN-13: 978-0131008465.

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

GENERIC ELECTIVES (GE-13): Concept of Animal Behaviour
Zoo-GE-13

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			
Concept of Animal Behaviour Zoo-GE-13	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**NIL**	**Zoology**

Learning Objectives

The learning objectives of this course are as follows:

- to familiarize the students with the scientific study of the behaviour of animals.
- to enable students to link behaviour patterns to the brain, genes, and hormones, as well as to the surrounding ecological and social environments.
- to acquire knowledge of aggression, the chase of the hunter and the flight of the hunted, the spinning of webs, the digging of burrows, and the building of nests or remaining motionless and concealed.
- to provide a good understanding of various concepts in animal behaviour.
- to motivate students to pursue a career in animal behaviour.

Learning Outcomes

By studying this course, students will be able to

- better understand the various types of animal behaviour and their importance.
- enhance their observation skills, analytical skills, scientific interpretation and documentation skills.
- enable students to evaluate the characteristic features of animal life including static postures, active movements, noises, smells, changes in colour and shape.
- realise, appreciate and develop passion to biodiversity and respect the nature and its surroundings.

SYLLABUS OF GE-13

UNIT- 1: Introduction to Animal Behaviour **4 hrs**

Origin and history of ethology, Pioneers of modern ethology: Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Four Questions for Ethology.

UNIT- 2: Patterns of Behaviour **7 hrs**

Innate behaviour, Instinct, Sign stimuli, Code breakers, Learning: associative learning and non-associative learning, Classical and operant conditioning, Habituation, Imprinting.

UNIT- 3: Communication **3 hrs**

Importance of communication; Role of Chemical, Tactile, Auditory, Visual stimuli in communication.

UNIT- 4: Social Behaviour **7 hrs**

Concept of Society, Social insects (Honeybee as example), Bee communication, Altruism & Reciprocal altruism, Inclusive fitness, Hamilton's rule.

UNIT- 5: Sexual Behaviour **9 hrs**

Sexual dimorphism, mate choice; Intra-sexual selection (male rivalry); Inter-sexual selection (female choice); Courtship behaviour, Parental care, sexual conflict in parental care, Infanticide.

Practical **(60 hrs)**

(Laboratory periods: 15 classes of 4 hours each)

1. To study nests and nesting behaviour of the birds and social insects.
2. To study the behavioural responses of wood lice to dry and humid conditions.
3. To study geotaxis behaviour in earthworm.
4. To study the phototaxis behaviour in insect larvae.
5. Study of different tools, techniques and methods used in preparing ethogram.
6. To study courtship behaviour in insects and birds from short videos/movies.

Essential/recommended readings

1. Alcock, J. (2013) Animal Behaviour, Xth Edition, Sinauer Associates Inc., USA.
2. Manning, A. and Dawkins, M. S, (2012) An Introduction to Animal Behaviour, VIth Edition, Cambridge University Press, UK
3. McFarland, D. (1985) Animal Behaviour, Pitman Publishing Limited, London, UK

Suggestive readings

1. Rubenstein, D. (2022) Animal Behavior, XIIth Edition, Sinauer Associates, Oxford University Press, UK.
2. Gadagkar, R. (2021) Experiments in Animal Behaviour: Cutting-Edge Research at Trifling Cost, Indian Academy of Sciences.

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

BSc. (H) Zoology
DSC-Animal Biotechnology
Zoo-DSC-16

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of thecourse			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Animal Biotechnology Zoo-DSC-16	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	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 ofthe course (if any)
		Lecture	Tutorial	Practical/ Practice		
Methods in Biostatistics Zoo-DSC-17	**04**	**02**	**Nil**	**02**	**Passed Class XII with Biology/ Biotechnology**	**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**	**Passed Class XII with Biology/ Biotechnology**	**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
		Lecture	Tutorial	Practical/ Practice		
Nano-biotechnology Zoo-DSE-14	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

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
		Lecture	Tutorial	Practical/ Practice		
Human Endocrinology Zoo-DSE- 15	04	03	Nil	01	Passed Class XII with Biology/ Biotechnology	NIL

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			Eligibilitycriteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Toxicology Zoo-DSE- 16	**04**	**03**	**Nil**	**01**	**Passed Class XII with Biology/ Biotechnology**	**NIL**

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.

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

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
		Lecture	Tutorial	Practical/ Practice		
Model Organisms in Research Zoo-GE-14	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL

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
		Lecture	Tutorial	Practical/ Practice		
Nanobiology Zoo-GE-15	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL

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
		Lecture	Tutorial	Practical/ Practice		
Forensic Biology Zoo-GE-16	04	02	Nil	02	Passed Class XII with Biology/ Biotechnology	NIL

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 includessample 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.

BSc. (Life Science) -
Zoology Component (Semester - IV)

DISCIPLINE SPECIFIC CORE COURSE-12 (Zoo-LS-DSC-12):– Fundamentals of Human Physiology

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		
Fundamentals of Human Physiology Zoo-LS-DSC-12	04	02	Nil	02	Passed Class XII with Chemistry/ Biology/ Biotechnology	NIL

Learning Objectives

The learning objectives of this course are as follows:

- to learn the fundamentals that underpins the health and well-being of living organisms.
- to study the internal working of organs and organ systems.
- to expand their knowledge with respect to functioning of various organ systems such as muscular, nervous, digestive, circulatory, respiratory, excretory, reproductive and endocrine in humans.

Learning Outcomes

By studying this course, students will be able to

- Have an enhanced knowledge and appreciation of human physiology
- Recognize and identify principal tissue structures and functions
- Better understand the functions of important physiological systems including the nervous system, muscular system, endocrine and reproductive system
- Learn an integrative approach to understand how these separate systems interact to yield integrated physiological responses to maintain homeostasis in the body along with feedback mechanism.

SYLLABUS OF DSC- 12

UNIT- 1: Nerve and Muscle **7 hrs**

Structure of a neuron, Resting membrane potential, Graded potential, Origin of action potential and its propagation in myelinated and non-myelinated nerve fibres, Ultrastructure of skeletal muscle, Molecular and chemical basis of muscle contraction.

UNIT- 2: Digestion **4 hrs**

Physiology of digestion in the alimentary canal; Absorption of carbohydrates, proteins, lipids.

UNIT- 3: Respiration **4 hrs**

Pulmonary ventilation, Respiratory volumes and capacities, Transport of Oxygen and carbon dioxide in blood.

UNIT- 4: Excretion **4 hrs**

Structure of nephron, Mechanism of urine formation, Counter-current Mechanism.

UNIT- 5: Cardiovascular system **5 hrs**

Structure of Heart, Origin and conduction of the cardiac impulse, Cardiac cycle.

UNIT- 6: Reproduction and Endocrine Glands **6 hrs**

Physiology of male reproduction: hormonal control of spermatogenesis; Physiology of female reproduction: hormonal control of menstrual cycle. Structure and function of pituitary, thyroid, Parathyroid, pancreas and adrenal gland.

Practical: **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Preparation of haemin and haemochromogen crystals.
2. Estimation of WBC and RBC count of blood.
3. Estimation of haemoglobin using Sahli's haemoglobinometer.
4. Determination of Blood Pressure by Auscultatory method.
5. Lung function tests using Spirometry (Determination of Vital Capacity, Peak Expiratory Flow Rate. Lung Volumes and Capacities).
6. Measurement of oxygen saturation by pulse oximetry before and after exercise.
7. Experiments on superficial (plantar) and deep (knee jerk) reflex.
8. Study of permanent histological sections of mammalian pituitary, thyroid, pancreas, adrenal gland, duodenum, liver, lung, kidney, bone, cartilage.
9. Project on Family planning devices.

Essential/recommended readings

1. Tortora, G.J. and Derrickson, B.H. (2009) Principles of Anatomy and Physiology, XIVth Edition, John Wiley & Sons, Inc.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2008) Vander's Human Physiology, XI Edition., McGraw Hill.
3. Guyton, A.C. and Hall, J.E. (2011) Textbook of Medical Physiology. XII Edition, Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
4. Victor P. Eroschenko. (2008). Di Fiore's Atlas of Histology with Functional correlations. XII Edition.

Suggestive readings

1. Kesar, S. and Vashisht, N. (2007) Experimental Physiology. Heritage Publishers.
2. Prakash, G. (2012) Lab Manual on Blood Analysis and Medical Diagnostics. S. Chand and Company Ltd.

BSc. (Life Science) -
Zoology Component (Semester - V)

DISCIPLINE SPECIFIC CORE COURSE-15 (Zoo-LS-DSC-15):– Evolutionary Ecology

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		
Evolutionary Ecology Zoo-LS-DSC-15	04	02	Nil	02	Passed Class XII with Chemistry/ Biology/ Biotechnology	Basic concept of Ecology

Learning Objectives

The learning objectives of this course are as follows:

- to explore the interface of ecological and evolutionary forces that leads to the diversity of the form.
- to understand the function, and behaviour among animals.
- to impart an understanding of the evolutionary origin and drivers of biological variation and diversity, including the significance of genetic variation, natural selection, and genetic drift.
- to unravel the evolution of animals, sexual selection, the evolution of mating systems, animal interactions, reaction norms and plasticity.
- to learn about co-evolution between species and ecology from a phylogenetic perspective and compares evolutionary processes behind reproductive and ecological adaptations.
- to understand how communities and species interact with their environment at large spatial and temporal scales.

Learning Outcomes

By studying this course, students will be able to

- better understand the diverse relationships that the organisms have in the environment.
- analyze the patterns of distribution of animals in different regions and ecosystems.
- gain insight to the major events in history of life and major theories of evolution.
- know the fundamental concepts of natural selection, speciation, mass extinction and macro-evolution.
- explain the characteristics, dynamics, and growth of populations.
- appreciate the characteristics of the community, ecosystem development and climax theories.
- gain knowledge about the relationship of the evolution of various species and the environment they live in.

SYLLABUS OF DSC- 15

UNIT- 1: Introduction to Evolutionary Ecology **3 hrs**

Introduction to the concepts of evolution and ecology and the relationship, evolutionary theories and origin of life, Levels of ecological hierarchy, heritability, natural selection, fitness and adaptation; Types of selection, Ecological adaptations of animals to their environment.

UNIT- 2: **Population Ecology** **7 hrs**

Group attributes- Density, natality, mortality, dispersal and dispersion, life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal and dispersion. Population growth- Exponential and logistic growth, Life history traits - r and K selection. Population regulation - Density dependent and independent. Population interactions: Positive and negative interactions.

UNIT- 3: Community Interactions **6 hrs**

Characteristics of community- species richness, dominance, diversity and abundance. Community organisation – habitat, niche, guilds, and dominant species. Interspecific interactions with examples. Species diversity indices. Types of ecological succession. Characteristics of climax community, Concept of keystone, flagship, umbrella species with examples.

UNIT- 4: Processes of Evolutionary Change and Species Concept **7 hrs**

Natural selection and its types, Genetic drift, Artificial selection. Species concept, Isolating mechanisms, Modes of speciation (Allopatric, Sympatric, Parapatric and Peripatric), Adaptive radiation/macroevolution (Darwin finches).

UNIT- 5: Coevolution **4 hrs**

Introduction to coevolution; types of coevolution (pairwise coevolution, diffuse coevolution, and gene-for-gene coevolution); Co-evolutionary interactions (Coevolution of competitors, Predator-prey coevolution, Host-parasite coevolution, Coevolution of mutualists); Evolutionary equilibria. Approaches to examine coevolution; Co-speciation and diversification.

UNIT- 6: Macroecology **3 hrs**

Introduction to macroecology: patterns and constraints; macroecological datasets; statistical patterns of abundance, distribution and diversity; Allometry: metabolism, body size and temperature; Macroecology of humans; Conservation macroecology: assessing, prioritizing, and quantifying biodiversity at large scales; Extinction dynamics.

Practical: **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of the phytoplankton and zooplankton: Collection of specimens from an ecosystem (pond/river/lake/forest/garden) to study its biotic and abiotic components.
2. Measurement of temperature, turbidity/penetration of light, determination of pH, Dissolved Oxygen content (Winkler's method), chlorides, hardness, Chemical Oxygen Demand, free CO_2.
3. Gause's Principle with laboratory and field examples, Lotka-Volterra equation-significance in competition; Lotka-Volterra equation, functional and numerical responses in Predation.
4. Determination of population density in a natural/hypothetical community by quadrate method and calculation of Shannon-Weiner diversity index for the same community.
5. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.
6. Catch, mark and recapture technique for finding the population size.
7. Study of homology, analogy and homoplasy from suitable specimens.
8. Construction of cladograms based on morphological characters.
9. Study and verification of Hardy-Weinberg Law by Chi-square analysis
10. Project report based on the visit to natural history museum/National Park/Biodiversity Park/Wildlife Sanctuary.

Essential/recommended readings

1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press
2. Zimmer C. and Emlen D. J., (2013) 1st Ed. Evolution: Making Sense of Life, Roberts & Co.
3. Hall, B.K. and Hallgrimson, B. (2013) Evolution; 5th Edition, Jones and Barlett Publishers.
4. Chapman, J., and Reiss, M. (2012). Ecology Principles and Applications; Cambridge University Press.
5. Miller, T., and Spoolman, S. (2008) 12th Edition Environmental Science- Problems, Concepts and Solutions; Thomson Brooks/Cole.
6. Odum, E. P. and Barrette, G. W. (2008) Fundamentals of Ecology; 5th Indian edition; Brooks/Cole

Suggestive readings

1. Smith T. M. and Smith R. L. (2015). Elements of Ecology. 9th International Edition. Publisher: Benjamin Cummings.
2. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.
3. Southwood, T. R. E., & Henderson, P. a. (2000). Ecological Methods, 3rd Edition; Blackwell Science Ltd. (Vol. 278, Issue 5705).

BSc. (Life Science) -
Zoology Component (Semester - VI)

DISCIPLINE SPECIFIC CORE COURSE-18 (Zoo-LS-DSC-18):– Basics of Immunology

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		
Basics of Immunology Zoo-LS-DSC-18	04	02	Nil	02	Passed Class XII with Chemistry/ Biology/ Biotechnology	NIL

Learning Objectives

The learning objectives of this course are as follows:

- to understand the components and functions of immune system of the body.
- to learn how the immune system responds to various infections and foreign substances that adversely affect our body.
- to help comprehend the concept of hypersensitivity and vaccines.
- to acquaint the students on the role of immune system in prevention and altered response to diseases.

Learning Outcomes

By studying this course, students will be able to

- acquire knowledge of immunogenicity and antigenicity.
- better understand innate and acquired immunity.
- appreciate and analyze the various humoral and cellular components of the immune system.
- comprehend the role of immune system in health and disease.
- gain knowledge of autoimmunity, immunodeficiency and hypersensitivity.
- have an enhanced understanding of vaccine and vaccination.

SYLLABUS OF DSC- 18

UNIT-1: Immune System and its components **6 hrs**

Instructional and clonal selection theory; Innate immunity: components and defensive barriers of innate immunity. Adaptive immune system: Components and attributes of acquired immunity, humoral and cell mediated immunity, active and passive immunity, primary and secondary immune response.

UNIT- 2: Antigens, Immunogens and Antibodies **8 hrs**

Antigens and immunogens; antigenicity and immunogenicity; factors affecting immunogenicity; antigenic determinants (B- and T-cell epitopes); concepts of

antigen recognition by B- and T-cells. Structure and function of different classes of antibodies.

UNIT- 3: Antigen Processing and Presentation 4 hrs

Structure and functions of MHC (MHC I & MHC II); endogenous and exogenous pathways of antigen processing and presentation.

UNIT- 4: Cytokines & Complement System 4 hrs

Properties and functions of cytokines; Pathways of complement activation and its biological consequences.

UNIT- 5: Role of immune system in Prevention of Diseases 8 hrs

Gell and Coomb's classification of hypersensitivity; autoimmunity; immune dysfunctions and immunodeficiency with suitable examples. Vaccines and their types.

Practical: 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. To study the structure and function of lymphoid organs of the immune system.
2. Histological study of spleen, thymus and lymph nodes through slides/ photomicrographs.
3. To study haematopoiesis and role of cells in immune response through flowchart.
4. To study various types of blood cells using Leishman's/Giemsa/Crystal violet stained blood smear.
5. Cell counting and viability test (trypan blue dye exclusion test) from splenocytes* from rat/mouse/any other species.
6. To understand the antigen and antibody interactions by
   i) ABO Blood group antigen determination by heamagglutination test.
   ii) Ouchterlony's double immunodiffusion method.
   iii) Production of monoclonal antibodies by HAT selection.
   iv) Demonstration of ELISA.
   v) Demonstration of Immunoelectrophoresis.
   vi) FACS
   vii) RIA
7. Project on any topic/ Project report on visit to any research institute/laboratory to study the immunological techniques

Essential/recommended readings

1. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006) Immunology, VI Edition, W.H. Freeman and Company
2. David, M., Jonathan, B., David, R. B. and Ivan, R. (2006) Immunology, VII Edition, Mosby, Elsevier Publication.

3. Janeway's Immunobiology 9th Edition, by Kenneth Murphy, Casey Weaver, Garland Science
4. Kenneth Murphy, Casey Weaver (2016) Janeway's Immunobiology; 9th Edition, Garland Science
5. Abbas, K. Abul and Lechtman H. Andrew (2003) Cellular and Molecular Immunology, V Edition, Saunders Publication.

Suggestive readings

1. Punt, J., Stranford, S., Jones, P., Owen, J.A. (2018) Kuby Immunology, VIII Edition, WH Freeman and Company
2. 1. Singh, I. K. and Sharma, P. [Eds.] (2022) An Interplay of Cellular and Molecular Components of Immunology. Taylor & Francis group, CRC Press.
3. Kaur, H., Toteja, R., and Makhija, S. (2021) Textbook of Immunology, I.K International Publishing House and Wiley India Ltd
4. Singh, I. K. and Sharma, P. [Eds.] (2022) Essentials of Immunology, Laboratory Manual; Prestige Publishers.
5. Hay, F.C., Westwood, O.M.R (2005) Practical Immunology– Fifth Edition. John Wiley and Sons Ltd.

Sd/-

REGISTRAR