INDEX
SRI VENKATESWARA COLLEGE
BIOLOGICAL SCIENCE
UGCF

Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VII

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B.Sc. (H) Biological Sciences
Summary of papers
SEM VII

Type of paper	Name of papers	Credits
DSC	**DSC – 19** **Bioinformatics and Biostatistics**	**2L+2P**
Any 3 DSEs (Discipline Specific Electives) to be chosen out of 4 (for the DSE pool)	**1. Research methodology*** **2. Advanced Techniques in Biological Research** **3. Plant Diseases and Management** **4. Ecotourism, Nature and Wildlife photography**	**2L+2P** **2L+2P** **2L+2P** **2L+2P**
Dissertation Or Academic Project Or Entrepreneurship (6 credits)		**6 credits**

* This paper is compulsory for the students who have not opted for Research Methodology in semester VI.

Category I

Biological Science Courses for Undergraduate Programme of study with BiologicalScience as a Single Core Discipline

(B.Sc. Honors in Biological Science in three years)

STRUCTURE OF SEVENTH SEMESTER

A student who pursues undergraduate program with Biological Science as single core discipline isoffered the following courses:

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 Credits *	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 credits	Total Credits
VII	DSC – 19 (4)	Choose 3 DSEs courses OR Choose 2 DSEs and 1 GE course OR Choose 1 DSE and 2GE courses (total 12 credits)		NA	NA	Dissertation OR Academic Project/Entrepreneurship (4+2)	NA	22 credits

* However, GE courses are not offered by Biological Science Course.

3 Discipline Specific Cores (DSCs) - 3 courses of 4 credits = 12 credits

Discipline Specific Electives (DSE) – Students Can choose three DSEs (4 credits each) OR
Two DSEs (4 credits each) and One GE (4 credits) OR
One DSE (4 credits) and Two GEs (4 credits each) OR
Three GEs (4 credits each)

Dissertation (4+2) OR
Academic Project/Entrepreneurship (4+2)

DISCIPLINE SPECIFIC CORE COURSE – 19:

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bioinformatics and Biostatistics (BS-DSC-701)	**4**	**2**		**2**	Class XII with Biology	**NA**

Learning Objectives

The Learning Objectives of this course are as follows:

- The objective of this course is to impart basic understanding of bioinformatics and biostatistics. The course will introduce the broad scope of bioinformatics by discussions on the theory and practices of computational methods in biology.
- This course also aims to provide students with a practical hands-on experience with common bioinformatics tools and databases.
- This course also provides foundational skills and the knowledge of analysis of scientific data and students will gain a deeper understanding of its relevance and applications in various fields of biological sciences.

Learning outcomes

- Students will understand the basics of bioinformatics and computational biology and develop awareness of the interdisciplinary nature of this field.
- Students will learn about Biological Databases and the types of databases.
- Students will understand protein structure using visualization softwares.
- Students will be able to gain understanding of sequence alignments and analyze phylogeny using alignment tools.
- Students will understand different applications of genomics in gene prediction and obtain knowledge on applications of bioinformatics from genomes to personalized medicine.
- Students will understand the basic concepts of sampling methods and data classification and presentation; variables and statistical methods.
- Students will acquire the understanding of interpreting the scientific data that is generated during scientific experiments.

SYLLABUS FOR DSC-19

2.2 Course Contents

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Introduction to Bioinformatics & Biological Databases **4 hours**

Scope of Bioinformatics, Historical Background, Biological Databases: Nucleotide Databases; Protein Databases, Biomedical Databases; Organismal Sequence Databases, Information Retrieval from Biological Databases: The Entrez system.

Unit 2: Sequence Alignment & Phylogenetics **5 hours**

Basic Concepts, Pairwise sequence alignment methods: Dynamic Programming**;** Global and Local Alignment Algorithms**;** Scoring Matrices: PAM and BLOSUM; Gap penalties**;** Overview of BLAST**;** Mega BLAST**;** PSI-BLAST**;** BLAT**;** FASTA , Multiple sequence Alignment methods**:** Practical issues and quality of alignment**;** Clustal Omega; Tree building and visualization; Phylogenetic analysis and data integration

Unit 3: Genomics & Proteomics **5 hours**

Genomics: Comparative Genomics & Functional Genomics, Gene Prediction Methods, Assessing the Gene Predictors; Genome annotation methods and pipelines. Proteomics: Protein Structure prediction approaches -Homology Modeling, Threading, Ab-initio methods, Alpha Fold; Protein structure Evaluation; Prediction of Transmembrane Alpha helices and Beta strands; Prediction of disordered regions; Predicting protein function; Motifs and domains; Subcellular localization

Unit 4: Applications of Bioinformatics **4 hours**

Computational Drug Discovery – Leads, Hits, Small molecule library, Drug Databases, Lipinsky's Rule of Five, Docking, Binding Energy Estimates, Bioinformatics in Plant Sciences, Bioinformatics & Environment.

Unit 5: Introduction to Biostatistics **2 hours**

Biostatistics - definition and basic principles. Variables - measurements, functions, limitations and uses of statistics.

Unit 6: Data and sampling methods **3 hours**

Primary and secondary data; Sampling methods (in brief); tabulation and presentation of data.

Unit 7: Measures of central tendency **4 hours**

Measures of central tendency - mean, median, mode, merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, standard error, quartile deviation –merits and demerits; Coefficient of variance.

Unit 9: Statistical inference **3 hours**

Hypothesis – (simple hypothesis), student's t test, chi-square test.

2.3 Practical

Credits: 2 **Total Hours: 60**

1. Sequence Retrieval from NCBI & GenBank
2. Protein Structure download from PDB and Structure visualization (Jmol/Pymol)
3. Pairwise sequence alignment and its interpretations using BLAST.
4. Multiple Sequence alignment using CLUSTALw and Phylogenetic tree construction.
5. Gene Prediction using Gene Prediction Tools
6. Protein structure prediction using homology modeling and structure validation using Ramachandran Plot .
7. Making of Bar diagrams, Pie chart, Histogram, Frequency polygon, Cumulative frequency curve (any four)in the given data set using Microsoft Excel.

8. Calculation of mean, mode, median, standard deviations, quartile deviations, standard error and coefficient of variance.

9. Student's t-test (using Microsoft Excel only), chi square test (Manual and using Microsoft Excel).

2.4 Suggested readings:

1. Ghosh, Z., Mallick, B. (2008). *Bioinformatics – Principles and Applications*, 1st edition. New Delhi,Delhi: Oxford University Press.

2. Baxevanis, A.D., Ouellette, B.F., John (2005). *Bioinformatics: A Practical Guide to the Analysis ofGenes and Proteins*, 3rd edition. New Jersey, U.S.: Wiley & Sons, Inc.

3. Roy, D. (2009). *Bioinformatics*, 1st edition. New Delhi, Delhi: Narosa Publishing House.

4. Andreas, D., Baxevanis, B.F., Francis, Ouellette. (2004). *Bioinformatics: A practical guide to theanalysis of genes and proteins*, 3rd edition. New Jersey, U.S.: John Wiley and Sons.

5. Khan, I.A., Khanum, A. (2004). Fundamentals of Biostatistics, 5th edition. Hyderabad: Ukaaz publications.

6. Campbell, R.C. (1998). Statistics for Biologists. Cambridge, U.S.A.: Cambridge University Press

2.5 Additional Resources:

1. Pevsner, J. (2009). Bioinformatics and Functional Genomics, 2nd edition. New Jersey, U.S.: Wiley Blackwell.

2. Xiong, J. (2006). Essential Bioinformatics, 1st edition. Cambridge, U.K.: Cambridge University Press.

3. Mount, D.W. (2004). Bioinformatics: Sequence and Genome analysis 2nd edition, Cold Spring Harbor Laboratory Press, USA.

4. Zar, J.H. (2012). Biostatistical Analysis, 4th edition. London, London: Pearson Publication.

5. Pandey, M. (2015). Biostatistics Basic and Advanced. New Delhi, Delhi: M V Learning.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-13

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Research methodology (BS-DSE-13)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

The main objective of this paper is to provide students with a general introduction to the methodological foundations and tools used in research for an understanding of the ways to identify problems, develop hypotheses and research questions and design research projects. The course will expose students to the range of designs used in research in laboratory, field experiments, surveys and content analysis. It will also provide an introduction to the concept of controls, statistical tools and computer applications used in research. In addition, the course will impart knowledge of scientific writing, oral presentation and the various associated ethical issues.

Learning Outcomes:

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

- Define research, learn the importance of research and its link with theoretical knowledge
- Describe the research process and the principle activities, skills and ethics associated with the researchprocess
- Describe and compare the major quantitative and qualitative research methods
- Construct an effective research proposal
- Understand the importance of research ethics use the computer software for organization and analysisof data.
- Develop skills in the art of scientific writing and oral presentation

SYLLABUS FOR DSE-19

Course Contents- Theory

Unit 1: Introduction to Research **No. of hours: 4**

Objectives and characteristics of research; significance of research, types of research methods-qualitative andquantitative; basic and applied; descriptive and analytical; various phases of research-problem identification, generation of hypothesis, experimental design, results and discussion. Writing a research proposal-schematic presentation.

Unit 2: Basic principles of research design **No. of hours: 8**

Review of literature using appropriate sources – reviews, patents, research papers, books and e-

resources; Significance of controls in research, Types of research designs – exploratory, descriptive, experimental, surveyand case study.

Unit 3: Statistical tools and Report writing **No. of hours: 12**

Data collection, analysis and graphical presentation; Sample – types and characteristics; Basic Statistical Tools - Measures of central tendency, Arithmetic mean, Median, Mode, Standard deviation, Co-efficient of variation (Discrete serious and continuous serious), Correlation, Regression, Multiple Regression, hypothesis testing, P- value, data analysis and interpretation; Report writing, format of publications and presentations-oral and poster.

Unit 4: Scientific conduct and ethics in Research **No. of hours: 6**

Biosafety and Ethics - compliance and concerns; Plagiarism-Software tools and Creative Commons; Introduction to Intellectual Property Rights; Citation and acknowledgement, Impact factor, h-index, Indianand international funding agencies.

3.1 PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Use of search engine tools for retrieving research papers
2. Preparation of bibliography in different formats
3. Use of Plagiarism tools
4. Design of a research survey on a specific problem
5. Writing a concept note / research proposal
6. Writing of a mini-review paper
7. Systematic review, meta data analysis and presentation
8. Poster/oral presentations

3.2 Essential readings

1. Cresswell, J. (2009) *Research Design : Qualitative and quantitative Approaches* Thousand Oaks CA, (3rd ed.), Sage Publications
2. Kothari, C.R. (2004) *Research Methodology: Methods and Techniques* (2nd ed.), New Age International Publishers.
3. Kumar, R. (2011) *Research Methodology: A Step-by-Step Guide for Beginners* (5th ed.), SAGE publisher
4. Walliman, N. (2017*) Research Methods: The Basics,* **(**2nd ed.), London ; New York : Routledge
5. *WHO (2001) Health Research Methodology – A Guide for Training in Research Methods.*

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

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-14:

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Techniques in Biological Research (BS-DSE-14)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

The objective of the course is to provide students with a sound background of latest techniques used in biochemistry research and to provide them with an understanding of the principles underlying these techniques. The course is designed to impart laboratory skills in the form of practical exercises so that students can apply this knowledge to augment their research acumen and improve their understanding of the subject.

2.1 Course Learning Outcomes

After completion of the course students will:

- Students will acquire knowledge about the principles and applications of latest methods used to analyse nucleic acids and proteins.
- Students will learn about the principle and applications of microscopy and various cell biology techniques. Students will also be exposed to various methods of labelling DNA, proteins and whole cells and their applications in research.
- Combine different biochemical methods to address a complex biological question.
- The course will also provide them an opportunity for hands-on-experience to develop their laboratory skills expected of any biochemist working in a research lab.

2.2 Course Contents

Theory

Credits: 2 **Total Hours: 30**

Unit I: Methods for Analysis of Nucleic Acids **No. of hours: 14**

Introduction to hybridization methods and labelling (Biotinylation, Fluorescent tags etc): Southern hybridization, *In situ* hybridization. Binding of nucleic acids with protein: Electrophoretic Mobility Shift Assay (EMSA), Chromatin immunoprecipitation (ChIP). Gene expression analysis: Reporter assays - example luciferase assay, semi-quantitative RT-PCR and quantitative real time PCR (qRT-PCR), DNA Microarrays and NGS.

Unit II: Methods for Analysis of Proteins **No. of hours: 09**

Protein-Protein Interaction: Immunoprecipitation, Yeast two hybrid, Quantitative Proteomics: 2D protein gel electrophoresis, 2D-DIGE, Structural Analysis: Mass Spectrometry, MS/MS, CD Spectra and X Ray Crystallography.

Unit III: Microscopy Based Techniques **No. of hours: 04**

Fluorescence microscopy, Confocal microscopy, Scanning electron microscopy, Transmission electron microscopy.

Unit IV: Cell Biology Techniques **No. of hours: 03**

Flow cytometry, FACS, BrDU assay, Annexin V assay and TUNEL assay

2.3 Practical:

Credit: 2 **Total Hours: 60**

1. Southern Blotting
2. RT-PCR /qRT-PCR
3. SDS PAGE and Western Blotting
4. Virtual Lab for EMSA
5. Virtual lab on 2D-DIGE
6. Virtual lab on Microarray
7. Tour of State-of-the-art Central Instrumentation Facility

2.4 Essential readings:

1. Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual* (4th ed., Vol. 1-3). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Wilson, K., & Walker, J. (Eds.). (2010). *Principles and techniques of biochemistry and molecular biology* (7th ed.). Cambridge: Cambridge Univ. Press.
3. Ausubel, F.M. et al. (2012). *Current protocols in molecular biology*. New York: John Wiley & Sons.
4. Bisen, P. S., & Sharma, A. (2013). *Introduction to instrumentation in life sciences*. Boca Raton: CRC Press.
5. Bonifacino, J. S., Dasso, M., Lippincott-Schwartz, J., Hartford, J. B., & Yamada, K. M. (Eds.). (1999). *Current protocols in cell biology*. New York: John Wiley.
6. Coligan, J. E., Dunn, B. M., Ploegh, H. L., Speicher, D. W., & Wingfield, P. T. (1995). *Current protocols in protein science*. New York: John Wiley & Sons.
7. Levine, S., & Johnstone, L. (2008). *The ultimate guide to your microscope*. New York: Sterling Pub.
8. Schimmel. (2013). *Biophysical Chemistry*. MacMillan Higher Education.

Suggested readings:

1. Golemis, E., & Adams, P. D. (2005). *Protein-protein interactions: A molecular cloning manual* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Sheehan, D. (2010). *Physical biochemistry: Principles and applications* (2nd ed.). Chichester: Wiley-Blackwell.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	The student will learn about the methods used in analysis and manipulation of nucleic acid	Classroom teaching with visual aids, power point presentations, videos, discussions on applications	Quizzes, assignments and analytical problem-solving questions, paper presentations
II	The student will understand about the various techniques involving protein-protein interactions, their separation, and structural characterization	Classroom teaching with visual aids, power point presentations, experimental data from journals, 3D models, discussions	Assignments, class tests, analytical questions. Students will be asked to analyze and present papers on protein-protein interactions.
III	The students will get familiar with microscopy-based techniques and their application	Presentations, classroom teaching, audio and visual aids, trip to a facility. MOOCs will be used.	Assignments, class tests, class presentations, Mid-term assessment
IV	The students will understand the basics and application of various techniques in the field of cell biology	Powerpoint presentations, trip to a facility to show instruments, audio & visual aids. Special lecture will be arranged by expert in cell biology techniques.	Assignments, class tests, class presentations

(Assessment tasks enlisted here are indicative in nature)**

4. Keywords

Southern Blotting, Colony hybridization, EMSA, Western Blotting, Immuno precipation, Pull down assay, FACs, Flow Cytometry

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-15

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Diseases and Management (BS-DSE-15)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

Plant diseases have resulted in severe losses to humans in ways more than one. To quote a few, Irish famine caused due to potato late blight (caused by Phytophthora infestans) led to the loss of many lives, the American chestnut was virtually lost by chestnut blight (caused by Cryphonectria parasitica). The goal of plant disease management is to impart awaren ess about the economic and aesthetic damage caused by plant diseases. The course focuses on various plant diseases and multifaceted approaches to disease management, and integrated disease management.

2. Course Learning Outcomes:

The purpose of this course is

- To introduce the subject of Plant pathology, its concepts and principles.
- To impart training on various methods/instruments used in the study of plant diseases/pathogens.
- To acquaint the students with different strategies for management of plant diseases.
- To emphasize the importance and need of IDM in the management of diseases of important crops.

3. Course Contents:

3.1 THEORY

CREDITS: 2 TOTAL HOURS: 30

Unit 1: Introduction to Plant Diseases No. of Hours: 4

Scope and significance of plant pathology; milestones of phytopathology, terminology of plant pathology, Diseases: causative agents (Bacteria, viruses, prions, fungi, nematodes, insect pests with suitable examples). Survival of important plant pathogens and their dispersal; role of environment and host nutrition on disease development.

Unit 2: Host- parasite interactions No. of Hours: 6

Molecular mechanisms of pathogenesis: recognition concept, penetration, invasion and infection, symptomatology. Role of enzymes and toxins in disease development. Defence strategies, oxidative burst, phenolics, phytoalexins, PR proteins and elicitors. Altered plant metabolism as affected by plant pathogens, molecular basis of host plant-pathogen interaction (gene for gene

concept).

Unit 3: Plant Diseases No. of hours: 7

Introduction, characteristic features, general symptoms, survival and spread of pathogens and control of - Bacterial diseases: Citrus canker, Angular leaf spot of Cotton, Leaf blight of rice, Red stripe of sugarcane; Fungal diseases: Root rot in Cucurbits, Late blight of Potato, Ergot of bajra, Black stem rust of Wheat and Loose smut of Barley; Viral Diseases: TMV, Yellow mosaic of Ladyfinger, Leaf curl of Papaya. Nematode & Prion Diseases: General account.

Unit 4: Integrated Disease Management No. of Hours: 13

Introduction, definition, concept and tools of disease management, Koch's postulates, Development of IDM- basic principles, biological, chemical and cultural disease management. Disease resistance and molecular approach for disease management. Biological Control– Concept of biological control, definitions, importance, types of biological interactions (competition, mycoparasitism, exploitation for hypovirulence, rhizosphere colonization, competitive saprophytic ability, antibiosis), induced resistance, role of mycorrhiza, commercial formulations of antagonists, biopesticides available in the market. Chemical Control – classification of chemicals based on structure and function; chemical types i.e. fungicides, bactericides and botanicals. Components of integrated disease management (IDM) - their limitations and implications. IDM in important crops- rice, wheat, cotton, sugarcane, chickpea, rapeseed mustard, pearl millet, kharif pulses.

3.2 PRACTICALS

CREDITS: 2 TOTAL HOURS: 60

1. Preparation and inoculation of culture media for bacteria and fungi.
2. Study of important Bacterial diseases: Citrus canker, Angular leaf spot of cotton.
3. Study of important Nematodal (any one) and Viral diseases: TMV, (Necrosis,Chlorosis,leaf curl with suitable examples) through specimens and photographs.
4. Study of asexual stage from temporary mounts and sexual structures through permanent slides of (Red rot of Sugarcane) *Puccinia* (Black stem rust of Wheat), *Alternaria* (Early blight of Potato), *Ustilago/Claviceps*
5. Field/Museum visit- Report on collection and preservation of diseased specimens of important crops
6. Qualitative estimation of total phenols in diseased and healthy crop plants
7. Estimation of phenyl-alanine lyase activity (PAL activity) in diseased and healthy crop plants.
8. A comparative case study of Disease resistant Transgenic Plants with wild type plants

3.3 Essential Readings

1. Agrios GN. 2005. Plant Pathology. 5th Ed. Academic Press, New York.
2. Mehrotra RS & Aggarwal A. 2003. Plant Pathology. 2nd Ed. Oxford & IBH, New Delhi.
3. Singh RS. 2002. Introduction to Principles of Plant Pathology. Oxford & IBH, New Delhi.
4. Singh DP & Singh A. 2007. Disease and Insect Resistance in Plants. Oxford & IBH, New Delhi.
5. Upadhyay RK & Mukherjee KG. 1997. Toxins in Plant Disease Development and Evolving Biotechnology. Oxford & IBH, New Delhi. 69
6. Sharma PD, 2006. Plant Pathology. Narosa publishing house pvt. Ltd.. 22 Daryaganj Delhi

7. Chaube HS, Pundhir VS, 2014. Crop diseases and their management. PHI learning pvt. Ltd. Delhi – 110092

8. Gupta VK & Sharma RC. (Eds). 1995. Integrated Disease Management and Plant Health. Scientific Publ., Jodhpur.

9. Mayee CD, Manoharachary C, Tilak KVBR, Mukadam DS & Deshpande Jayashree (Eds.). 2004.

10. Biotechnological Approaches for the Integrated Management of Crop Diseases. Daya Publ. House, New Delhi.

4. Teaching Learning Process and Assessment Methods

Facilitating the achievement of Course Learning Outcomes**

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
1	Students will be introduced to the subject of plant diseases- its concept, components and causes. This introductory unit will help them understand the basics of plant pathology and disease symptoms	Teaching will be conducted both through black board mode and power point presentation mode.	Group discussions in the class will help students understand the concepts well
2	Students will learn about host parasite interactions. They will also gain an understanding of plant defences and altered plant metabolism resulting from pathogen infection	The traditional chalk and talk method along with power point presentations will be used .	Oral questions will be asked in the class. Problems will be assigned to encourage them to explore more about the concept.
3	Students will develop an understanding of Characteristic features, general symptoms, survival/ spread of pathogens and control of bacterial, fungal and viral diseases	Teaching will be conducted through black board and power point presentation. A Field/ Museum visit will help them in understanding the taught concepts better	The concepts in this unit will be taught both theoreticaly and in practical classes. Students will also prepare a report on their Field/Museum visit.
4	Students will understand the Integrated disease management approaches for the effective control of pathogen spead in economically important crops and understand different cause of epidemics. Students will also learn various methods of disease control using biocontrol agents, practices to prevent multiplication of pests under conducive conditions and role of hormones in inducing resistance in plants.	Teaching will be conducted through powepoint presentations on previous case studies explaining the causes and management of pathogens responsible for epidemic losses of crops in India.	The concept will be taught theoratically and students will be asked to prepare a report on current scenario of disease management in important crop plants.

(**Assessment tasks enlisted here are indicative in nature)

5. Keywords:
Plant diseases, Integrated Disease Management, Rust, Smut, Blight, Pathogens, oxidative burst, PR proteins

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-16

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ecotourism, Nature and Wildlife Photography (BS-DSE-16)	**4**	**2**		**2**	NIL	**NA**

Learning Objectives:

Students will learn how the emerging concept of ecotourism and outdoor recreation fits into natural resource management. Also in this digital age Photography can be used as a way of documenting and admiring nature. Specifically, this paper will take an approach that natural resource managers are in control of recreation and can actively plan and manage for the individual, social, economic, and environmental benefits associated with recreation and ecotourism. The paper will introduce students to identification of a potential site for ecotourism, future conditions like projected footfall and sustainability and Identifying management strategies and tactics that can transform a natural area into the desired condition. With digital photography becoming more affordable and taken up as a hobby by increasing number of people topics on nature photography have been introduced as it now forms an important part of ecotourism with everyone trying to capture their surrounding in their lenses. The paper will introduce students to what and how of digital nature photography and ethics associated with it. The paper focuses on developing the skills of student so that they may become inclined towards taking up ecotourism as a profession or pursue nature photography in future after doing advanced courses.

2.1 Course Learning Outcomes

1. Students will learn about the origins and development of ecotourism as a new concept.
2. Students will learn about market strategies for ecotourism
3. Students will learn about basic equipment
4. Students will understand importance of aesthetic value of nature and how it can be used to generate finances
5. Students will learn about basic nature photography
6. Photographs or videos taken by students will form the basis of mini-research projects on the chosen subjects to greatly expand their knowledge beyond what they could observe in a brief moment in time.
7. Students will be going outdoors and work towards making their own nature photo albums

2.2 Course Contents

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Ecotourism **No of hours: 4**

Ecotourism: Definition, history , concept. Types of Ecotourism. Nature, Principles and guidelines of ecotourism. Characteristics and functions of ecotourism.

Unit II: Ecotourism Planning and Management: **No of hours: 8**

Site selection, destination marketing, and managing the impacts of ecotourism on the environment and local communities. Carrying capacity, responsible tourism practices, and community participation. Ecotourism activities, such as wildlife watching, bird watching, and nature-based recreation, assessment of their potential impacts on the environment, Community Participation and Benefit Sharing

Unit III : Photography **No of hours: 6**

Film versus Digital photography (Pros and cons), The Camera :Point and Shoot, DSLR, Mirrorless , Videography, Phone . Basics of Spotting and photography. Different types of photography

Unit IV: Themes in Nature Photography **No of hours: 4**

Renowned Indian and international wildlife photographers and documentary makers and their work. Subjects: Plants, Landscape , climate, Vertebrates and invertebrates, flowers , Pollution, native people.

Unit V: Wildlife Identification and Photography **No of hours: 6**

Definition of Wildlife , identification of birds, mammals and other wildlife . Variable conditions in outdoor photography and composition of shots. Landscape , closeup , macro and micro photography. Assessment of right locations and seasons for photographing specific animals.

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Unit VI: Photography as source of information and entertainment **No. of Hours: 2**

Drone photography basics, rules and etiquettes , Importance of Scaling in outdoor and aerial photography. Wildlife Sanctuaries and National parks of India and animals found there.

2.3 Practical

Credits: 2 **Total Hours: 60**

1. Understanding Ecotourism: Market and Market Trends, Ethics and Management using case study.
2. Key Principles and Characteristics of Ecotourism: Nature Area Focus & Interpretation, Environmental Sustainability Practice.
3. Demonstration of Basic Equipment: Use, Care and Maintenance (Binoculars, Spotting scope, Various types of Cameras and lenses).
4. Fundamentals of Camera Lenses and Accessories.

5. Basic Principles of Digital Photography (Using Masks and Make Digital Composites, Downloading, Scanning, Printing, Editing).
6. Saving, Storing and archiving your pictures
7. Identification of Wildlife through Various Identification apps.
8. Outdoor Photography: Insect photography, Bird photography, Animal photography, Nature photography.
9. Techniques for Capturing Shots (Using lenses effectively, Macro- vs Microphotography, wide-angles to Close-ups via Macros or Telephotos, Day/Night shooting aspects).
10. Scaling from Photographs.
11. Visit to Wildlife Sanctuary/National Park and making Wildlife Photo Album.

2.3 Essential reading

1. Jaime Seba (2011). Ecotourism and sustainable tourism : new perspectives and studies. Apple Academic Press
2. Ramirez F, Santana J (2019), Environmental Education and Ecotourism, Springer International Publishing
3. Sean T. McHugh (2018) Understanding Photography: Master Your Digital Camera and Capture That Perfect Photo, No Starch Press
4. Tom Ang (2018) Digital Photography: An Introduction, Dorling Kindersley
5. Jeffrey Rich (2018) The Complete Guide to Bird Photography: Field Techniques for Birders and Nature Photographers, Amherst media
6. Laman T , Melford M (2016) , The National Geographic Guide to Landscape and Wildlife Photography

Suggested readings:

1. Ballantyne R and Packer J (2013), International Handbook on Ecotourism, Edward Elgar Pub
2. Hansen Chris J (2014) Secrets of Backyard Bird Photography , Rocky Nook
3. Laurie Excell (2012) , Wildlife Photography: From Snapshots to Great Shots, Peachpit Press
4. Noraman Arlott (2015) Collins Field Guide Birds of India Pakistan, Nepal, Bhutan, Bangladesh, Sri Lanka, HarperCollins Publishers Limited
5. Thompson R, (2007) Close-up and Macro: A Photographer's Guide . David and Charles

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1 and 2	The case study approach with real-life examples from the field will give a better understanding of the subject and its applications. Basics of Planning and Management in	The traditional chalk and talk method will be supplemented with LCD projection system and use of visualizer for classes. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding.	Internal assessment tests. Students will be given questions that are application based and require analytical skills They will have to submit a formulated questionnaire for

	Ecotourism		assessment and defend it.
3	The next set of practical mainly deals with basics of spotting and photographic instruments. Students will be introduced to Camera basics	Students will be given hands on training with cameras , and available apps on the internet	Internal assessment tests. Students will be given questions that are application based and require analytical skills Case studies discussions in relevant public health areas.
4 and 5	Importance of themes in Photography. Students will learn to identify common birds and wildlife of India. Field based research projects will develop interest in the subject, enhance their mental and physical health and motivate students to peruse research as a career in future.	Projection of videos or short movies available on the subject will enhance the understanding of the subject. Digital collection of pictures of Animals, Birds, bird's nests, wild fauna and flora will facilitate observation of their characteristic features with ease.	Internal assessment tests. Group discussions, book reviews, paper presentations, videos, animations, are some methods that can be employed for effective teaching. Project based reports, assignments and E-posters can also form an important part of learning regime.
6	Learn Scaling from photographs and Identify birds and other animals	Students will be given photographs from which they may have to find actual size of objects or area. Students will visit a bird sanctuary or wildlife sanctuary to test their identification and photography skills. Field based research projects will develop interest in the subject and motivate students to peruse research as a career in future. Laboratory visits to renowned institutions like WII, Dehradun and Field visits to various conservation sites like Jim Corbett National Park, Aravali Biodiversity Park and National Zoological Park, Sultanpur and Bharatpur Bird sanctuaries will provide students a practical or hands on knowledge of the subject. Students should participate in citizen science initiatives related to wildlife such as bird	Assignment and class test. Students will prepare an Album of photographs and a field report

		counts and uploading of the data on E-bird.org.	
➢ Summative assessment: Semester-end written and practical examinations will be an indicator of student's learning throughout the semester and analyses comprehensive knowledge gained by the students.			

(**Assessment tasks enlisted here are indicative in nature)

4. **Keywords**

Wildlife Photography, Ecotourism, National Park, Wildlife Sanctuaries, Camera, Lenses

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

The course being taught by 3 separate departments does not offer any General electives. Students will choose from the General electives being offered by other departments.

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Undergraduate Certificate in Political Science.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Diploma in Political Science.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Bachelor of Arts (Honours) in Political Science.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Political Science as a single core discipline and writes dissertation, the student shall be awarded **Bachelor of Arts (Honours with Research) in Political Science.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Political Science as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded **Bachelor of Arts (Honours with Academic Project/Entrepreneurship) in Political Science.**

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VIII

Disclaimer: The syllabi are uploaded as provided by the Faculty concerned to the Academic Council. The same has been approved by the Academic Council on …… and Executive Council on ….

B.Sc. (H) Biological Sciences
Summary of papers
SEM VIII

Type of paper	Name of papers	Credits
DSC	**DSC – 20** **Biotechnology**	**2L+2P**
Any 3 DSEs (Discipline Specific Electives) to be chosen out of 5 (from the DSE pool)	**1. Plant Signaling and Behaviour** **2. Advanced Immunology** **3. Humans: Evolution, Variation and Population Dynamics** **4. Ayurbiology and Health** **5. Environment Management and Sustainability**	**2L+2P** **2L+2P** **2L+2P** **2L+2P**
Dissertation **Or** **Academic Project** **Or** **Entrepreneurship** **(6 credits)**		**6 credits**

Category I

Biological Science Courses for Undergraduate Programme of study with Biological Science as a Single Core Discipline
(B.Sc. Honors in Biological Science in three years)

STRUCTURE OF EIGHTH SEMESTER

A student who pursues undergraduate program with Biological Science as single core discipline isoffered the following courses:

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 Credits *	Ability Enhance-ment Course (AEC) – 2 credits	Skill Enhance-ment Course (SEC) – 2 credits	Internship/ Apprentice-ship/Project/ Community outreach 2 credits	Value addition course (VAC) 2 Credit	Total Credits
VII	DSC – 20 (4)	Choose 3 DSEs courses OR Choose 2 DSEs and 1 GE course OR Choose 1 DSE and 2GE courses (total 12 credits)		NA	NA	Dissertation OR Academic Project/Entrepreneurship (4+2)	NA	22 credits

*** However, GE courses are not offered by Biological Science Course.**

1 Discipline Specific Cores (DSC) - 4 credits

Discipline Specific Electives (DSEs) – Total 12 credits

Students Can choose three DSEs (4 credits each) OR
Two DSEs (4 credits each) and One GE (4 credits) OR
One DSE (4 credits) and Two GEs (4 credits each)

Dissertation (4+2) OR
Academic Project/Entrepreneurship (4+2)

DISCIPLINE SPECIFIC CORE COURSE – 20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biotechnology (BS-DSC-801)	**4**	**2**		**2**	Class XII with Biology	**NA**

Learning Objectives

The objective of the course is to expose students to the basic principles and applications of biotechnology. It will also teach them the basics of animal and plant tissue culture and various methods of gene transfer for the generation of transgenics. The course will also provide an understanding of the applications of biotechnology in medicine, forensics, archaeology and agriculture.

2.1 Course Learning Outcomes

The students after completing this course will be able to:

- Understand animal and plant tissue culture along with their applications
- Gain knowledge about methods of gene transfer in biotechnology
- Appreciate the use of biotechnology in medicine
- Gain insight into other industrial applications of biotechnology
- Become aware of the impact of biotechnology on agriculture

2.2 Course Contents

Theory

Credits: 2 **Total Hours: 30**

Unit I: Methods in animal and plant biotechnology **No. of hours: 07**

Introduction to cell and tissue culture.

Overview of Reproductive Animal Biotechnology and livestock improvements: *artificial* insemination, embryo transfer, in-vitro fertilization, somatic cell nuclear transfer (Dolly the sheep). Methods of gene transfer: viral mediated gene transfer, direct gene transfer using PEG, micro injection, electroporation, microprojectile (biolistics) method, liposome mediated DNA delivery. Fermentation technology and upscaling to industrial production

Unit II: Medical Biotechnology **No. of hours: 06**

Production of recombinant pharmaceuticals: insulin, factor VIII, human growth hormones, erythropoietin. Recombinant Vaccines. Pharming—recombinant protein from live animals and plants. Gene therapy: Gene therapy for inherited diseases and cancer with suitable examples. The ethical issues related to gene therapy.

Unit III: Agricultural Biotechnology **No. of hours: 06**

The gene addition approach to plant genetic engineering: plants that make their own insecticides, Herbicide resistant crops. Gene subtraction: Antisense RNA and the engineering of fruit ripening in tomato, other examples of the use of antisense RNA in plant genetic engineering. Overview of plants as biofactories: plant based vaccines, plantibodies and biopharmaceuticals. Safety and ethical concerns of genetically modified plants.

Unit IV: Environmental Biotechnology **No. of hours: 06**

Concept of ecosystem structure and function and importance of microbial ecology in Environmental Biotechnology. Functions of various microbial groups relevant to environmental systems, including waste treatment and resource recovery. Cooperation between different microbial species for enhanced biodegradation, Bio detoxification, Bioremediation Technologies, Biogeochemistry, and Bio hydrometallurgy. Microbial interaction with plastics, antibiotics and others emerging pollutants. Microbially Enhanced Phosphorus and Nitrogen Removal. Microbially Enhanced Oil Recovery; Microbial role in Carbon Storage and Capture (sequestration, conversion to useful biopolymers, etc.).

Unit V: Other Industrial Applications of Biotechnology **No. of hours: 05**

Preparation of fermented food products and beverages. Single cell proteins. Treatment of wastewater (Municipal treatment plant) and sewage. Bioremediation and biodegradation. Production of recombinant enzymes for use in industries.

2.3 Practical

Credit: 2 **Total Hours: 60**

1. Plant tissue culture
2. Restriction Fragment Length Polymorphism (RFLP) profiling of genetically modified plants.
3. Extraction of DNA from buccal swab.
4. Presentation of research papers.
5. Virtual lab for bioreactors
6. Educational trip to industrial plants/fermentation units
7. Case studies of the use of DNA profiling for kinship analysis
8. Designing of antisense RNA against polygalacturonase (*in silico*)
9. Group discussion on Archaeogenetics—using DNA to study human prehistory

ESSENTIAL READINGS

- Brown, T. A. (2016) Gene Cloning and DNA Analysis: An Introduction, (7th ed.). Wiley-Blackwell Publishing (Oxford, UK); ISBN: 978-1-119-07256-0
- Glick, B.R., Pasternak, J.J., Patten, C. L. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th ed.). ASM Press (Washington DC); ISBN: 978-1-55581-498-4.
- Primrose, S.B., and Twyman, (2006) Principles of Gene Manipulation and Genomics (7th ed.), R. M. Blackwell Publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.
- Buchann (2015). Biochemistry and Molecular Biology of plants. (2nd ed.). I K International. ISBN-10: 8188237116, ISBN- 978047 07 14218

- Willey, J., Sherwood, L., Woolverton, C. (2017). Prescott's Microbiology (10th ed.). McGraw Hill international. ISBN 13: 9781259657573.

SUGGESTED READINGS:

- Freshney, R. I. (2010). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley-Blackwell, 6th Edition.
- Roberta H. Smith. (2013) Plant Tissue Culture: *Techniques and Experiments*. 3rd edition. Academic Press. ISBN: 978-0-12-415920-4
- Adrian Slater, Nigel Scott and Mark Fowler. (2003) Plant Biotechnology: The genetic manipulation of plants, 1st Edition, Oxford University Press
- Verma, A. S. and Singh, A. (2014). Animal Biotechnology. Academic Press, Elsevier, USA.
- Microbial Biotechnology, Glazer et al, 2nd edition, 2007, Cambridge University Press

3. Teaching Learning Process and Assessment Methods:

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	**Course Learning Outcomes**	**Teaching and Learning Activity**	**Assessment Tasks**
I	Students will be introduced to the animal cell and tissue culture. They will gain insight into various methods of livestock improvements. They will also understand about different methods of gene transfer in animal and plant biotechnology. They will gain insight into fermentation technology and upscaling.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions will be conducted on various recent methodologies in biotechnology.	Students will be given questions that are application based and require analytical skills. Quizzes will be held to gauge their conceptual understanding.
II	Students will be introduced to various applications of biotechnology in medicine. Students shall gain insight into gene therapy, pharming, recombinant vaccines and pharmaceuticals.	Classical chalk and board teaching, oral discussions and powerpoint presentations whenever needed.	Students shall be asked to make power-point presentations on latest advances in applications of biotechnology in medicine. Open book tests will be held to promote self-learning. Practical related oral question

			will be asked.
III	Understand the applications of biotechnology in agriculture. Gain knowledge about the insecticides, Herbicide resistant crops. Understand about Antisense RNA and the engineering of fruit ripening in tomato, They shall learn about plants as biofactories and genetically modified plants	Teaching will be conducted both through black board mode and power point presentation mode. Practical knowledge used field visits shall be imparted.	Regular class question-answer sessions. Students will be asked to prepare PowerPoint presentations Internal assessment tests will be conducted. Discussions using case studies will be conducted.
IV	Students shall be introduced to various methods of preparation of fermented food products and beverages. They shall gain knowledge about Single cell proteins, Treatment of wastewater Bioremediation, biodegradation and recombinant enzymes.	Teaching will be conducted through black board and power point presentation. Useful video clips will be shown for better clarity.	Regular oral evaluation will be done. Internal assessment tests will be conducted

(Assessment tasks enlisted here are indicative in nature)**

4. Keywords: Biotechnology, gene transfer, livestock improvements, animal and plant tissue culture, gene therapy, recombinant vaccine, pharming, genetically modified plants, fermentation, bioremediation.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-17

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Signaling and Behaviour (BS-DSE-17)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

Plant physiology is a fascinating field of plant sciences and gives the students an insight into the structure - function integration in plants. The complex interactions of the plant with the environmental and edaphic factors form a major portion of plant physiological studies. How plants respond to maintain their homeostasis in the changing environmental conditions is one of the most recent fields of investigation in plant stress physiology. The course aims to familiarize the students with this important subject alongwith the signaling pathways associated with physiological phenomena.

Course Learning Outcomes:

On successful completion of the course, a student will:

- Understand the complex regulation of phenomena of signal transduction in combating stress etc.
- Learn to design experiments dealing with signal transduction in the plant cell and analyse papers on signaling pathways.
- Understand various aspects of stress physiology such as physiological and molecular basis of abiotic stress tolerance in plants
- Gain the knowledge in stress physiology that will be useful for developing climate resilient genotypes for sustainable crop production.

3. Course Contents

3.1 THEORY

Credits: 2 **Total Hours: 30**

Unit 1: Signal transduction **No. of Hours: 6**

Brief historical account of signaling in plants; Concept of signal transduction; Signal perception at plasma membrane (characteristic features of membrane receptors, receptor kinases), stress sensing mechanism: concept of second messengers like calcium, calmodulin, lipid signaling molecules, mitogen-activated protein (MAP) kinase cascade, cyclic nucleotides.

Unit-2: Abiotic stress **No. of Hours: 6**

Introduction to stress: definition; acclimation and adaptation; Factors causing plant stress- abiotic and biotic; Abiotic stress- strategies and mechanisms, Physiological and cellular responses to drought stress, salinity stress, temperature stress (freezing and heat); developmental and physiological mechanisms that protect plants against environmental stress

Unit 3: Lipid Metabolism **No.of Hours:5**

Introduction to Plant Lipids;Biosynthesis and breakdown of Triglycerides; Oxidation of Fatty acids; Glyoxylate cycle; Gluconeogenesis and its role in mobilisation of lipids during seed germination

Unit 4: Nitrogen metabolism **No. of Hours: 8**

Biological Nitrogen fixation by free living organisms and in symbiotic association (nodulation, signals between host and symbiont, genetics of fixation); structure and function of enzyme Nitrogenase; Nitrate assimilation: Nitrate and Nitrite reductase; ammonia assimilation GS, GOGAT, GDH; reductive amination and transamination.

Unit 5: Plant Movements **No. of Hours: 5**

Tropic Movements (Phototropism, Gravitropism, Chemotropism); Nastic Movements (Epinasty, Hyponasty, Nyctinasty, Thigmonasty); Circadian rhythms; Turgor and growth mediated movement; prey- driven movements (Insectivorous plants)

3.2 PRACTICAL

Credit: 2 **Total Hours: 60**

1. To study the activity of nitrate reductase in leaves of two plant sources.
2. To study the activity of enzyme urease and the effect of substrate concentration on its activity.
3. To estimate the peroxidase activity in seedlings in the presence and absence of salt stress.
4. To study the activity of enzyme catalase in two or more plant sources.
5. To study the effect of pH/enzyme concentration on the activity of enzyme catalase.
6. To study the activity of enzyme superoxide dismutase in the absence and presence of salt stress.
7. To study the effect of stress (salt/water/heavy metal) on seed germination and seedling growth.
8. To study the activity of Lipase and its role in mobilisation of lipids during seed germination.
9. To estimate proline content in the seeds germinated in the presence and absence of salt/heavy metal.

3.3 Essential readings:

1. Hopkins, W.G. and Huner, A. (2008) *Introduction to Plant Physiology*. John Wiley and Sons.U.S.A. 4th edition.
2. Kochhar, S.L. and Gujral, S.K. (2011) *Comprehensive Practical Plant Physiology*. Macmillan India Ltd, New Delhi.
3. Noggle, G.R. and Fritz, G.J. (1986) *Introduction to Plant Physiology*, 2nd Ed. Prentice-Hall of India Ltd., New Delhi.
4. Salisbury, F.B. and Ross, C.W. (2005) *Plant Physiology*, Thomson Wadsworth, 4th edition.

5. Taiz, L., Zeiger, E. Moller, I.M. and Murphy, A (2015). *Plant Physiology and Development,* Sinauer Associates Inc. U.S.A 6th edition.

Additional readings

1. Bhatla, S.C. and Lal M.A. (2018).*Plant Physiology, Development and Metabolism*, Springer Nature, 1st edition.
2. Lodish (2021) Molecular Cell Biology.

4. Teaching Learning Process and Assessment Methods

Facilitating the achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will learn about the concept of signal perception and transduction. Students will also learn about the various kinds of second messengers.	Teaching using chalk and board; Assignments given to the students followed by discussions in the class; Appropriate videos to supplement the theoretical concepts.	Problems will be assigned to students for understanding various important concepts.
2	Students will gain insights into various abiotic stresses affecting plant growth and the physiological and developmental mechanisms to protect plants.	Chalk and board teaching method; illustrations and flow charts through e-presentations; understanding the plant signaling pathways through latest research and review articles.	Group discussions in the class. Class tests will be conducted for internal assessment. Practicals designed in such a way so as to reinforce the concepts learnt in theory.
3	Students will be familiarized with different types of lipids and its biosynthesis and breakdown in plants.	Teaching using chalk and board; Oral discussion sessions in the class; Theoretical concepts to be supplemented with projects; computer animations of physiological phenomena.	Assessment on the basis of practicals performed; Questions will be asked in the class

4	Students will learn about the mechanism and the genetics of nitrogen metabolism and assimilation of ammonia.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations may be used for explaining certain topics.	Class tests will be conducted for internal assessment. Oral questions will be asked in the class.
5	Students will gain insight into the different tropic and nastic movement in plants. They will also learn about the growth and turgor-mediated movements.	Teaching using chalk and board; Assignments given to the students followed by discussions in the class; Appropriate videos to supplement the theoretical concepts.	Group discussions in the class. Class tests will be conducted for internal assessment.

(Assessment tasks enlisted here are indicative in nature)**

5. Keywords:

Signal transduction, abiotic stress, nitrogen fixation, fatty acid oxidation, tropism, nastic movement.

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-18

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Immunology (BS-DSE-18)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

This course covers advanced topics in immunology for students who already have a basic knowledge of immunology. The course is designed to understand the mechanisms in humoral and cell mediated immune responses during altered host conditions either due to changes in self or upon infection. Thus, central topics are allergy, autoimmunity, transplantation and immunodeficiency disorders.

2.1 Learning Course Outcomes

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

- understand and explain the basis of immunological tolerance, autoimmunity, and transplantation
- understand the principles governing vaccination and the mechanisms of protection against infectious diseases
- understand and explain the basis of allergy and allergic diseases
- understand regulation of immune response and use of monoclonal antibodies as therapeutics

2.2. Theory

Credits: 2 **Total Hours: 30**

Unit I- Tolerance & Autoimmunity **No. of Hours: 5**

Tolerance , B cell tolerance and T cell tolerance, Central and Peripheral Tolerance, Organ specific and systemic autoimmune diseases; mechanisms for the induction of autoimmunity and treatment,

Unit II -Hypersensitivity & Immunodeficiency Disorders **No. of Hours: 10**

Hypersensitivity, Gell and Coombs classification; representative examples of type I, II, III and IV Hypersensitivity, Allergy, Hypersensitive reactions against innocuous antigens, and potentially harmful antigens. Immunodeficiency primary (humoral and cell mediated) and secondary immunodeficiency, treatment.

Unit III -Transplantation immunology & Vaccines **No. of Hours: 8**

Typing of tissues; characteristics of graft rejection; major and minor histocompatibility antigens; alloreactivity of T cells; Graft Vs host disease (GVHD), Xenotransplantation and privileged

sites, Immunosuppressive drugs, Vaccines: types of vaccines-live attenuated, inactivated organisms, toxoids, subunit vaccines, DNA vaccines and recombinant vector vaccines; Active and Passive Immunization; requirements for an effective vaccine and recommended childhood vaccination schedules in India.

Unit IV- Immunoregulation and Immunotherapy **No. of Hours:7**

Regulatory T cells**,** Immunoregulation Regulation by Cytokines, Hypothalamus-Pituitary Immune Axis, Hybridoma Technology for Production of Monoclonal Antibodies, Chimeric and humanized Monoclonal Antibodies, Therapeutic Applications of Monoclonal Antibodies.

2.3 PRACTICALS

1. Immuno-electrophoresis
2. Active and Passive agglutination
3. Isolation of lymphocytes from blood/spleen
4. Cytotoxic Assay
5. Phagocytic activity of Macrophages
6. Hybridoma Production (video)

3. Essential Reading

1. Kuby Immunology (2007) 6th ed., Kindt, T.L., Goldsby, R.A. and Osborne, B.A,W. H. Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3/ ISBN: 10:0-7617-8590-0
2. Immunology: A Short Course (2009)6th ed., Coico, R. And Sunshine, G., John Wiley & Sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.

Suggested Textbooks:

1. Janeway's Immunobiology (2012) 8th ed., Murphy, K., Mowar, A.,and Weaver, C.T., Garland Science (London & new York), ISBN: 978-0-8153-4243-4
2. Cellular and Molecular Immunology (2021), 10th edition, .Abbas, A.K., Lichtman, A.H., Shiv Pillai, Elsevier, ISBN: 9780323757485

4. Teaching Learning Process and Assessment Methods

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will understand the concepts of tolerance and induction of autoimmunity that leads to autoimmune disorders	Teaching will be conducted both through Traditional chalk talk mode, presentations and case studies	Students will be asked questions related to the topic and class discussion will be held

II	Students will learn about various types of hypersensitivity and immunodeficiency disorders	Teaching will be conducted both through Traditional chalk talk mode, presentations and case studies	Assignment will be given and class discussion will be held
III	Students will learn about the immunological basis of transplantation and learn about vaccines	Teaching will be conducted both through Traditional chalk talk mode, presentations and case studies	Quiz and classroom discussions will be held
IV	Students will understand regulation of immune responses and immunotherapy	Teaching will be conducted both through Traditional chalk talk mode, presentations and case studies	Mid semester test will be held and assignments will be given

5. Keywords

Tolerance, Autoimmunity, Hypersensitivity, Immunodeficiency, Transplantation, Vaccines, Immunoregulation, Immunotherapy

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-19

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Humans: Evolution, Variation and Population Dynamics (BS-DSE-19)	**4**	**2**		**2**	Class XII pass with Biology	**NA**

Learning Objectives:

Charles Darwin's *The Descent of Man* exerted a vast influence over scientific and religious thinking in the 19th century, disturbing widely-held views on the origin of the human species, the age of the earth, and humans' supposedly special role in the universe. This course intends to give the student a foundational understanding in evolution of mankind, human variation and their population dynamics. They will develop a deep understanding of the mechanisms that fuelled the evolution of humans from their ape-like ancestors. The course will help students to develop concepts pertaining to the relation of modern humans with living and non-living primates. It will give the student a foundational understanding in population structure, growth and its implications

2.1 Course Learning Outcomes

On successful completion of the course, a student will:

- learn about the origins and development of evolutionary thought regarding human evolution.
- learn about the compelling evidences in favor of evolution like fossils, comparative anatomy and molecular homologies.
- learn about basal hominins, Australopithecines and members of Genus *Homo*
- know about variations, natural selection and population dynamics of Humans

2.2 Course Contents

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Introduction to Biological anthropology **No. of Hours: 04**

Debate around Darwin's "Descent of Man". Basic concepts of human evolution and variation, Scope and relationship of biological anthropology with other disciplines, brief Classification and characteristics of living primates.

Unit 2: Primate Radiation and Basal Hominins **No. of Hours: 07**

Geochronology of Pleistocene Epoch. Comparative anatomy (Skull, Dentition, Vertebral Column, Girdles, forelimbs and Hindlimbs) and behavior of humans and non-human primates. Primate origins and radiation: phylogenetic relationships of living primates with special reference to Miocene hominoids. *Orrorin, Sahelanthropus, Australopithecines*: distribution, features and their phylogenetic relationships.

Unit 3: Genus *Homo* **No. of Hours: 10**

Appearance of genus *Homo*: *Homo habilis*. *Homo erectus* from Asia, Europe and Africa: Distribution, features and their phylogenetic status. The origin of Homo sapiens: Fossil evidences of Neanderthals. Origin of modern humans (*Homo sapiens sapiens*): Archaic and Modern humans, Distribution and features. Multiregional and Out of Africa Model with evidences. Use of Y chromosome and mitochondrial DNA population structure in tracing human migrations. Technique of tool manufacture and estimation of their relative efficiency. Classification of tools.

Unit 4: Recent human evolution **No. of Hours: 05**

Evolutionary adaptation, sexual and natural selection, and genetic drift within *Homo sapiens* populations. Concept of Biological Variability; Concept of Race, Genetic basis of race; UNESCO Statement on RACE; Human Adaptation and mechanisms. Human Genome Diversity Project; Genetic adaptation: lactose intolerance, Sickle Cell Anemia, High altitude genetic adaptation in Tibetans.

Unit 5: Human Population Growth **No. of Hours: 4**

Population theories of John Graunt, Thomas R. Malthus and Demographic transition model. Sources of demographic data. Population structure: Age and sex composition and its importance, Demographic structure of Indian population, Estimates of different demographic rates and ratios. National policies: National Population Policy, National Health Policy, Factors affecting population growth.

2.3 Practical

Credits: 2 **Total Hours: 60**

1. Typo-technological Analysis of Prehistoric Tools: Identification, Interpretation and Drawings of the tool Types
2. Identification of important fossils of family Hominidae from Images
3. To study Changes in skull shape and cranial capacity during Human evolution
4. Size and Shape Measurements: a). Stature b). Sitting Height c). Body Weight d). Total Upper Extremity Length Size and Shape Indices e). Body Mass Index f). Total Lower Extremity Length.
5. Construction of Cladogram based on morphological characters for Living Primates and Extinct Hominins
6. Exploration of key dimensions of human variation, including skin color, altitude, climate, ABO blood alleles, and lactose tolerance with focus on the adaptive significance of the variation and what these variations tell us about human population histories.
7. To study major skeletal adaptations for bipedalism, as well as the advantages afforded by each of these adaptations.

8. Preparation of Atlas of Human morphological Variations across the world /Educational visit: Anthropology museums, Delhi University or any other museum

2.4 Essential readings:

1. Futuyma Douglas and Mark Kirkpatrick (2017) 3rd Ed.*Evolutionary Biology*, Oxford University Press
2. Hall B. K. and Hallgrimson B., (2014) 5thEd.*Strickberger's Evolution.* Jones and Bartlett
3. H. Schutkowski. Human Ecology: Biocultural adaptations in Human communities, Springer, Germany, 2006
4. Jurmain R., Kilgore L., Trevathan W., Ciochon R.L. (2012). Introduction to Physical Anthropology. Wadsworth Publications, 2012
5. John Relethford (2010). The human species : an introduction to biological anthropology. McGraw Hill
6. Lundquist J. H., Anderton D L and Yaukey D (2015) Demography : the study of human population. Waveland Press, Inc.

Suggested readings:

- Darwin C., (2003)*The Origin of Species: 150th Anniversary Edition* , Penguin USA
- Darwin C., (1871), The Descent of Man, Neeland media llc
- Xaxa V. (2003). Tribes in India. In Veena Das (ed.), The Oxford Indian Companion to Sociology and social anthropology Vol. 1. Delhi : Oxford University Press.
- Trautmann, T.R. (2011). India: Brief history of Civilization. Oxford University Press: Delhi.

3. Teaching Learning Process and Assessment Methods
Facilitating the achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1	Students will be introduced to the concept of anthropology	Teaching using chalk and board; Power point presentations.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
2	Students will learn about Comparative anatomy and behavior of humans and non-human primates; their origins and radiation.	Power point presentations Teaching using chalk and board; Documentaries relevant to the topic will be shown.	Class tests will be conducted for internal assessment. Students will be given assignments to test their understanding of the subject.
3	Understand about genus *Homo: Homo habilis*, *Homo erectus*, *Homo sapiens*; and Out of Africa Model with evidences. Students will also learn classification of tools.	Teaching using chalk and board; Power point presentations. Relevant documentaries will be shown.	Class tests will be conducted for internal assessment. Students will be given assignments to test their understanding of the unit

4	Students will learn about genetic variations within human populations and the concept of race Gain knowledge about adaptation with respect to certain conditions.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class. Simulation exercises in associated practicals to help understand the concepts.	Class tests will be conducted for internal assessment. Students will be given assignments to test their understanding. Students will be tested for their problem solving ability in population genetics.
5	Understand population theories, and population structure with respect to India.	Teaching using chalk and board; Power point presentations; Visit to Anthropology museum	Students will be given Class test and assignments to test their understanding of the subject.

(**Assessment tasks enlisted here are indicative in nature)

5. Keywords

Human Evolution, Human Population, Anthropology, Race, Policies

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-20:

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ayurbiology and Health (BS-DSE-20)	**4**	**2**		**2**	NIL	**NA**

Learning Objectives:

Though *Ayurveda* is an ancient science, its principles and practices are relevant even today; particularly in the health care sector. The need for a modern scientific evaluation of *Ayurveda* has been recognized. Till date research in *Ayurveda* has however focused on studies on medicinal herbs and their constituent bioactive compounds for herbal drug development and identification of New Chemical entities. However, it is important now to also explore new educational and research programs in *Ayurveda*, that focus on integrating it with the current understanding of Modern Biology that would enable a more rational approach towards harnessing knowledge of Ayurveda for modern day healthcare.

This course is focused on the theme of *Ayurveda Biology,* and intends to generate a knowledge interface between *Ayurveda* and life sciences for applications in contemporary healthcare Science. The program aims at providing a platform to students of Modern Biology an understanding of the systemic theoretical foundations, principles and practices of *Ayurveda.* Thus, it works towards bridging the understanding of traditional Indian health sciences with *modern Life Science.*

Course Learning Outcome

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

1. Define Health and Wellness as understood in Ayurveda
2. Be familiar with factors contributing to Prakriti.
3. Understand the correlation of the physiological and biochemical basis of Prakriti
4. Discuss concept of nutrition and lifestyle management as a model of disease prevention in Ayurveda.
5. To create awareness of how ill-health is conceptualized in Ayurveda and what is the basis for disease diagnosis.
6. Understand factors that contribute to disease therapy in Ayurveda
7. Understand the physiological basis of panchakarma
8. Understand and appreciate the AUSHADHI in Ayurveda
9. Appreciate the use of medicinal plants and minerals in the formulation of medications
10. Understand the concept of polyherbal formulations in Ayurvedic herbal therapy

Course content

THEORY

Credits:2

Total hours: 30

UNIT I: Introduction to Ayurbiology 2 hrs

History of Ayurveda and Vedic culture. Understanding from Descriptions in Ayurvedic classical texts about Methods of Education & learning, research & documentation, Ethics & regulations in medical Practices. The contemporary relevance of Ayurveda in modern times: Basic tenets of holistic and personalized medicine.

UNIT II: Dosha- Prakriti- environment and phenotypes: Principles of Ayurveda 4 hrs.

Understanding the concept of Tridosha; the common organizing principles of Trisutra; Physiological group of enties The concept of Deh and Manas Prakriti. Factors and mechanisms contributing to development of Prakriti; clinical features and importance in health & disease management. Influences of diet, environment, seasons, life style, age on Prakriti

UNIT III: *Anagatbadhapratishedha:* Preventive diet and lifestyle regime 5 hrs

Ayurveda Nutrition, Seasonal & daily regimen including diet management for health maintenance. Concept of Diet Design: Deriving nutrition according to your body constitution, age, place and time as well as Dosha Imbalance; Yogic classification of diet- Satavic, Rajasic & tamasic food. Concept of Langhana- Fasting (non-pharmacological intervention) Correlating dietary regimens of Ayurveda with modern Nutrition concepts. Importance of physical activity and Sleep in health and disease. Concept of sleep and meditation in Ayurveda.. Understanding the importance of Yoga and pranayama in Health lifestyle management

UNIT IV: Bridging Ayurveda with modern biology: Concepts of AyurBiology 7 hrs

Bridging the gap between Modern Biology, genomics and Ayurveda. Tridosha Biology and molecular basis of prakriti and dosha. Understanding variability in physiological parameters in health and disease in relation to tridosha concept. Use of these parameters in predicting health and disease outcomes based on variability. Understanding the effects of Yoga and meditation on indicators like EEG, Pulmonary and cardiac functions. Pranayama and physiology of breathingResearch avenues in AyurBiology/ Ayurgenomics.

UNIT V: *Roga Samprapti:* Physiology vs pathophysiology; Prakriti vs Vikriti 4hrs

Health to disease transitions: Understanding from the Ayurveda point of view. Concept of Dushyas viz; *Dhatu, srotas, Agni* (digestive fire) mala & *Ama* . Concept of Oja- Bala. Roga-Rogi Pariksha: Clinical examination methods described in Ayurveda for personalised management of health & Disease like Prakriti and Vikriti ; in vikriti- agni- ama- khavaigunya etc

UNIT VI: Aushadha Skandha: Therapeutic avenues in Ayurveda 8 hrs

Internal Medication Strategies: Shodhana: Detoxification (*panchakarma*) and Shamana: Medication for rejuvenation (*Rasayana*) etc. External Medication Stratergies: Massage (*Abhyangam*), *shirodhara* and other local therapies with herbal formulations. Physiological basis of these therapies.

Drug development related aspects as described in Ayurveda. Medicinal botany and Polyherbal formulations. Inter-phasing Ayurpharma with modern predictive medicine and pharmacogenomics

PRACTICALS

Credits: 2 **Total hours: 60**

1. **Prakriti assessment by questionnaire**
2. **Correlation of Prakriti with Physiological tests**

- Body types vs Prakriti through Anthropometric indices
- Assessment methods skin parameters analysis and prakriti
- inter-individual variability in PFT, heart rate, Blood pressure and biochemical parameters and Prakriti

3. **Identification of secondary metabolites in Ayurvedic Formulations**

- Though qualitative assays
- Quantitative estimation of Polyphenols, flavanols and alkaloids
- Separation of the metabolites through TLC

4. **Preparation of herbarium of medicinal plants present in ayurvedic formulations**
5. **Field Visit for collection of Medicinal plants**
6. **Field visit to an Ayurvedic hospital**.

SUGGESTED BOOKS:

1. **Ayurveda and Marma Therapy: Energy Points in Yogic Healing by Dr. David Frawley, Dr. Subhash Ranade and Dr. Avinash Lele. https://www.amazon.in/Ayurveda-Marma-Therapy-Energy-Healing/dp/0940985594**
2. **Ayurveda: The Science of Self Healing. Dr.Vasant Lad. https://www.amazon.in/Ayurveda-Science-Self-healing-Practical-Guide/dp/0914955004**
3. Prakriti: your ayurvedic constitution. R.E Sovoboda https://www.goodreads.com/en/book/show/217494

Ayurvedic science of Food and Nutrition. https://www.amazon.in/Ayurvedic-Science-Nutrition-Sanjeev-Rastogi/dp/1461496276

DISCIPLINE SPECIFIC ELECTIVE COURSE –DSE-21:

Course title& Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Environment Management and Sustainability (BS-DSE-21)	**4**	**2**		**2**	NIL	**NA**

Learning Objectives:

This course will provide understanding of environment around and which pollutants are of concern to us. It will provide knowledge of sustainability and methods which can help to improve the sustainability. It will also make students understand how toxicity can be monitored in our body and how our body copes to detoxify its internal system. It will also introduce methods which can be used to monitor the pollutants in various samples.

Learning Outcomes:

Students will:

- Understand the various components of the environment.
- Understand and evaluate the local and global scale of environmental problem.
- Gain knowledge and skills necessary to understand multifaceted nature of environmental studies.
- Get informed perspective of biological, chemical and physical processes relevant to environmental problems.
- Get hands on experience of some quantitative and qualitative research tools to assess and analyse the environmental problems

Theory

Credits: 2 **Total Hours: 30**

Unit 1: Introduction to Environment and the Pollutants **No. of hours: 8**

Normal Chemistry of - Air, Water, Soil. Environmental Toxins-Physical Pollutants- Noise, Light and Radiation and Air Pollutants- Carbon Monoxide, Lead, Nitrogen Oxides, Ozone, Particulate Matter, Sulphur Dioxide, Methane Volatile Organic Chemicals (VOC); Water Pollutants - Volatile Organic Chemicals (VOC), Heavy Metals, Insecticides, Herbicides/ Endocrine Disruptors; Soil Pollutants- Heavy metals, Herbicides/pesticides, Polyaromatic Carbon (PAH), Microplastics; Source, Effect and Impact on Flora, Fauna including Human Beings. Definition of Terminologies: Air Quality Index (AQI) Suspended Particulate matter (SPM), Water Quality Index (WQI), Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API).

Unit 2: Environment and Xenobiotics **No. of Hours: 8**

Understanding the principle of Toxicity. Concept of Dose and Response (LD50). Process of Bioaccumulation, Bioaugmentation and Biotransformation. Impact of pollutants on human health Mammalian Detoxification by Liver to Organic Chemicals (Heavy Metals, Endocrine Disruptors, Microplastics).

Unit 3: Sustainability and its Enhancement **No. of Hours: 8**

Concept of Sustainability and Enhancement of Sustainability, Waste Management (Refuse, Reduce, Reuse and Recycle), Bioremediation- Introduction and Types of Bioremediations- Phytoremediation, Microbial Bioremediation, In-situ Remediation, Ex-situ Remediation.

Unit 4: Techniques to Analyse Pollutants **No. of Hours: 6**

Determination of pollutants in soil, water, air, blood by following Analytical Techniques: Flame Photometer; Atomic Absorption Spectroscopy (AAS); Inductive Coupled Plasma (ICP) & Mass spectroscopy MS; Gas Liquid Chromatography (GC-MS); Ion Chromatography; High Performance Liquid Chromatography (HPLC); UV spectrophotometer; Biosensors and its application in pollution detection;

Practical:

Credits: 2 **Total Hours: 60**

1. Evaluating APTI and API of Herbs/Shrubs/Trees
2. Evaluating seasonal variations of AQI and SPM
3. Evaluating C/N/P/K content of soil by Spectrophotometry/Titrimetric method
4. Detecting Microbial Contamination of water
5. Composting of waste (Leaf/Kitchen Waste/Cow dung) and Detecting Maturity by pH and Electric conductivity (EC) content changes
6. Studying Enzymatic Activity (amylase/urease) in the soil sample due to microbial activity
7. Student Environment Projects.

Essential readings:

- Basic Concepts on Environmental Chemistry by Des. W. Conwell (2005) 2nd edition, CRC press, ISBN 9781498770484
- Environmental Chemistry by Stanley E Manahan, 11th Edition, Taylor and Francis,2022, ISBN 9780367560546
- Biodegradation and Bioremediation by Alexander Martin, 2nd Edition, Academic Press, ISBN 978-0-12-049861-8
- Fundamentals of Ecology author Eugene Odum, Cary W. Barrett, ,5th edition Cengage learning India. ISBN 9788131500200
- Environment and Ecology author P.D. Sharma, 12th Edition, Rastogi Publication. ISBN 978-93-5078-068-8

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

The course being taught by 3 separate departments does not offer any General electives. Students will choose from the General electives being offered by other departments.

Nomenclature of certificate/diploma/degrees:

- ✓ After securing 44 credits (from semester I and II), by completing one year of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Undergraduate Certificate in Political Science.**

- ✓ After securing 88 credits (from semester I, II, III & IV), by completing two years of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Diploma in Political Science.**

- ✓ After securing 132 credits (from semester I to VI), by completing three years of study of the UG Programme with Political Science as a single core discipline, if a student exits after following due procedure, he or she shall be awarded **Bachelor of Arts (Honours) in Political Science.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Political Science as a single core discipline and writes dissertation, the student shall be awarded **Bachelor of Arts (Honours with Research) in Political Science.**

- ✓ After securing 176 credits (from semester I to VIII), by completing four years of study of the UG Programme with Political Science as a single core discipline and engages in Academic Project/Entrepreneurship, the student shall be awarded **Bachelor of Arts (Honours with Academic Project/Entrepreneurship) in Political Science.**