दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Hons) Biological Science

(Effective from Academic Year 2019-20)

Biological Science
Sri Venkateswara College
University of Delhi
New Delhi-110021

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges

List of Contents

Page No.

PREAMBLE

The undergraduate level education in basic science as well as in applied science has to be broad based. Well established disciplines like Physics, Chemistry, Mathematics, Botany, Zoology, Geology and many others have long developed interfaces with each other so much that areas like Chemical Physics, Biochemistry, Biophysics, Mathematical Biology or Geophysics have themselves emerged as major disciplines. Conceptualization in each of the above fundamental disciplines has made much of the information gathered meaningful. Mechanisms underlying many biological phenomena have been discovered. These mechanisms have been shown to transcend the boundaries between plant kingdom, animal kingdom and the microbial world. As a matter of fact the new knowledge in Biology essentially deals with developmental, genetic, environmental and molecular aspects. The teaching of such a course that is truly interdisciplinary is best achieved through Choice-based Credit System (CBCS) since it offers sound foundations in the form of Core Courses at the same time allowing freedom to students to select discipline specific courses that augment the understanding of the subject at various levels. This freedom is further extended by giving students a choice in selecting the Generic Elective courses that broaden their learning horizons and widen the scope for higher education and the employment avenues. The Learning Outcome-based Curriculum Framework (LOCF) built into the CBCS mode offers focus and purpose to the programme. The combination of LOCF and CBCS also allows for lateral movement of students between institutes of higher learning offering another level of flexibility. Education in the 21st century has undergone a paradigm shift, which necessitates frequent updates in any curriculum to reflect the dynamic changes in knowledge outcome, more so for biological sciences where advances are rapid and far-reaching. The revised Choice-Based Credit System (CBCS) curriculum to be introduced in the academic session 2019-2020 conforms to Learning Outcome Based Curriculum Framework (LOCF) and aims at imparting concept based learning with emphasis on skill development and research.

B.Sc. (Hons) Biological Science

1. Introduction

Biological Science is an inter-disciplinary science and relies on strong foundations of Chemistry, Biophysics Biochemistry, Botany and Zoology. It aims to study the structure and function of different constituent parts/biomolecules of living organisms and their complex inter relationships to maintain and perpetuate various life forms. The scope of Biological Science as an interdisciplinary subject is very broad. The Biological Science programme at the undergraduate level has been envisioned in order to emphasize the importance of inter-disciplinary nature underlying the study of all the aspects of structure and function of living organisms.

The programme has been envisioned and developed with the following ideas and features:

- It tries to integrate the quantum of information from the interface areas of related sciences.
- It brings various biology related areas under a single umbrella of Biological Science
- It provides a balanced emphasis to courses like Chemistry, Biophysics, Biodiversity, Light and Life, Proteins and Enzymes, Cell Biology, Ecology, Systems Physiology, Molecular biology, Metabolism and Integration, Growth and Reproduction, Genetics, Defense Mechanisms and Evolutionary Biology.
- It tries to remove in effect, artificial barriers among the existing sub-disciplines of Biology like Botany and Zoology with an aim to study and understand Biology with a holistic view.
- It emphasizes the importance of living processes and phenomena rather than individual life forms.

2. Learning Outcome-based Curriculum Framework in B.Sc. Hons. Biological Sciences

The learning outcomes-based curriculum framework for a B. Sc (Honours) degree in Biological Science is intended to provide a broad framework within which Biological Science programme that responds to the needs of students and to the evolving nature of Biological Science as a subject could be developed. Its objective is to enable students to acquire a skill set that helps them to understand and appreciate the vast and fascinating world of living organisms. The framework is expected to assist in the maintenance of the standard of Biological Science programme across the country and to facilitate a periodic programme review within a broad framework of agreed expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The framework, however, does not seek to bring about uniformity in syllabi for a programme of study in Biological Science or in teaching-learning process and learning assessment procedures. Instead, the framework is intended to allow for flexibility and innovation in programme design and syllabi development, teaching-learning process, assessment of student learning levels.

2.1 Nature and Extent of the B.Sc. (Honours) Programme in Biological Science

Biological Science essentially deals with the complexity of living organisms, the microscopic and macroscopic structures within organisms that have specific functions and the mechanisms for extracting and transforming energy from the environment. It also explains how organisms exist in hormony with other organisms and how they adapt to their changing environments and gradually evolve. The key areas of study within the disciplinary/subject area of Biological Science comprise: Biodiversity, Light and Life, Proteins and Enzymes, Cell Biology, Ecology, Systems physiology, Molecular biology, Metabolism, Growth and Reproduction, Genetics, Defense mechanisms and Evolutionary Biology. The Honours degree programme in Biological Science includes core courses in Chemistry and Biophysics so as to provide a strong fundamental background for studying the complex nature of biological interactions and regulatory framework operating in a cell. As a part of the efforts to motivate the students of Biological Science programme to pursue research, the curricula for the programme are designed to incorporate learning experiences that offer opportunities for in depth study and hands-on laboratory experience.

2.2 Aims of the Programme

The overall objective of the Bachelors (Honours) Programme in Biological Science is to enable students to learn and integrate knowledge in Biophysics and Chemistry and Biology that is relevant to study and understand the complex biological processes and thus prepare them for post-graduate education and careers in research, medicine and industry.

The program aims to:

- Provide students with learning experiences that help instill deep interests in learning Biological Science; to develop an understanding of the complex nature of biomolecules, tissues and organs and their inter-relationship and inter-dependence.
- Encourage students to study the structure and function of specific molecules and pathways and their interactions and networking in biological systems with particular emphasis on regulation of chemical reactions in living cells.
- Encourage students to apply the knowledge and skills they have acquired to develop solutions for various applications in medicine like developing vaccines and drugs.
- Provide students with the knowledge and skill base that would enable them to undertake further studies in Biological Science and related areas or in multidisciplinary areas that involve Biological Science and help develop a range of generic skills that are relevant to pursue research, self-employment and entrepreneurship.

3. Graduate Attributes in B.Sc. Hons. Biological Science

A graduate in the Biological Science programme is expected to demonstrate the following attributes:

- **Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, principles and experimental findings in Biological Science and other related fields of study, including broader

interdisciplinary areas such as Microbiology, Biotechnology, Plant sciences, Evolutionary Biology, Ecology and Environmental sciences (ii) ability to use modern instrumentation/techniques for separation, purification and identification of biologically important molecules.

- **Skilled communicator:** Ability to convey complex technical information relating to Biological Science in a clear and concise manner both in writing as well as orally.
- **Critical thinker and problem solver:** Ability to employ critical thinking and efficient problem solving skills in different areas related to Biological Science like Protein and Nucleic Acid Chemistry, Cell Biology, Molecular Biology, Genetics, Microbiology, Animal Behavior, Plant Physiology and Evolutionary Biology.
- **Sense of inquiry:** Capability for raising relevant questions relating to basic understanding and applications in the field of Biological Science and planning, executing and reporting the results of an experiment or investigation.
- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory as well as in field-based situations.
- **Digitally literate:** Capable of using computers for simulation and computational work and appropriate software for analysis of data, and employing modern library search tools to locate, retrieve, and evaluate biology-related information.
- **Ethical awareness/reasoning:** Avoiding unethical behavior such as fabrication, falsification or misrepresentation of data or committing plagiarism, and sensitive towards environmental and sustainability issues.
- **Lifelong learners:** Capable of making conscious efforts to achieve self-paced and self-directed learning aimed at personal development and for improving knowledge and developing skill.

4. Qualification Descriptors for Graduates in B.Sc. Hons. Biological Science

The qualification descriptors for B.Sc. (Honours) programme in Biological Science include the following:

- A student should demonstrate (i) a comprehensive and coherent understanding of the field of Biological Science, its applications and links to related disciplinary areas of study; (ii) practical knowledge that enables different types of professions related to Biological Science, including research and development, teaching, entrepreneurship as well as industrial research abilities; (iii) skills in areas pertaining to current developments in the academic field of study, including a critical understanding of the latest developments in the field of Biological Science and an ability to use established techniques of analysis.
- Demonstrate comprehensive knowledge about materials, including current research, scholarly and professional literature, relating to essential and advanced learning areas pertaining to Biological Science, and techniques and skills required for identifying Biological Science-related problems and issues.
- Demonstration of skills in collection of relevant data gathered by reading or experimentation and analysis and interpretation of the data using appropriate methodologies.

- Ability to communicate the results of studies undertaken in an academic field accurately in the form of a paper, oral presentation or report.
- Apply one's knowledge and understandings of Biological Science and skills to new and unfamiliar contexts and to identify and analyze problems and issues and seek solutions to real-life problems.
- Demonstration of the ability to function in an effective manner both independently as well as a member of a team.

5. Programme Learning Outcomes (PO) for B.Sc. Hons Biological Science

The curriculum is designed to achieve the following outcomes:

PO1: To develop an in-depth knowledge and understanding of the fundamental concepts and principles underlying Biological processes.
PO2: To impart the procedural knowledge that creates different types of professionals in the field of Biological Science and related fields such as Plant physiology, Animal Behaviour, Natural Resource Management, Microbiology, Biotechnology, Nutritional Biochemistry and in teaching, research and environmental monitoring.
PO3: Students will be able to undertake hands on laboratory work and activities that help develop in students practical knowledge and skills that are required for pursuing career in clinical diagnosis, drug design, vaccine development, pharmaceutical industry, teaching, research, environmental monitoring.
PO4: Students will be able to use skills required for the extraction, separation, and synthesis of a variety of biomolecules utilized in clinical diagnosis, pharmaceutical industry or in research laboratories.
PO5: Students will be able to use various bioinformatics tools for training in the basic theory and application of programs used for database searching, protein and DNA sequence analysis and prediction of protein structures.
PO6: Students will be encouraged to effectively communicate scientific reasoning and data analysis in both written and oral forms.
PO7: Students will gain knowledge of ethical and good laboratory practices, health and biohazard regulations, plagiarism and intellectual property rights related issues practiced in modern era of scientific investigation.
P08: Students will recognize and appreciate the importance of the Biological Science and its application in academics, clinical diagnosis, prevention and treatment of diseases, agriculture, and industry and in the economic, environmental and social contexts.

6. Program Duration, Design and Structure

Duration of the Program:

The B.Sc. Honours in Biological Science is a three-year degree programme divided into six semesters. Each academic year (July - May) will consist of two semesters.

Program Design:

The program has been designed to offer a variety of discipline specific and interdisciplinary courses disseminated through class-room, laboratory and out-of-classroom modes of teaching, monitored through a repertoire of assessment methods. The teaching-learning process will include theory classes of one hour duration and practical classes of two hour duration for every credit offered. The curriculum will be delivered through various methods including classical chalk and talk, power-point presentations, essay writing and quiz contests, audio and video tools, e-learning and e-content, virtual labs, field trips or educational tours, seminars by external experts, workshops and symposiums and class discussions and debates. The learning outcome will be assessed by direct and indirect methods comprising broadly of Internal Assessment or Continuous Evaluation and End-Semester Examination. The internal assessment will include mid-term written tests, multiple choice questions, home and class assignments, oral presentations (seminars), group tasks, class discussions and debates, essay and report writing. End-semester assessments will include written tests and practical examinations. Each theory course will carry a maximum of 100 marks, with 25% marks allotted for internal assessment and 75% for end-semester examination. Each practical course will carry a maximum of 50 marks wherein 25 marks are for end semester examination and 25 marks for continuous evaluation reflecting the performance and regular attendance of the student throughout the semester.

Structure of the Programme*:*

The programme is structured into a variety of courses with different credits, some mandatory while others elective. Broadly, the programme comprises of Core Courses (CC) and elective courses. The core courses are all compulsory courses. The elective courses are of three kinds: Discipline-Specific Elective (DSE), Skill Enhancement Course (SEC) and Generic Elective (GE). The programme also includes two compulsory Ability Enhancement Courses (AEC).

To successfully complete the program, a student must study fourteen Core Courses, four Discipline-Specific Electives, two Skill Enhancement Courses and two compulsory Ability Enhancement Courses. The Core Courses, Discipline-Specific Electives and Generic Electives are six-credit courses. The Skill Enhancement Courses are four-credit courses while the Ability Enhancement Courses are two credit-courses. A student has to earn a minimum of 144 credits to get a degree in B.Sc. (H) Biological Science.

The six-credit courses will include theory classes of four credits each and practicals of two credits each. The four-credit courses will comprise of two-credit theory classes and two-credit practical courses. However, the two-credit courses will include only theory classes. One credit is equivalent to one-hour lecture per week for theory classes and two-hour sessions for practical classes. Each batch of students for practical sessions will be of fifteen members. If the number of students exceed fifteen (by at least ten), they will be divided into two equal batches.

It is mandatory for students to study two Core Courses each in Semesters I and II, three Core Courses each in Semesters III and IV, and two Core Courses each in Semesters V and VI. The Core Courses will be of six credits each (four credits theory and two credits practicals).

Eight courses of Discipline-Specific Electives (DSE) are offered in the programme, of which students will have an option to choose any two in each of the Semesters V and VI. The DSE courses will be of six credits each (four credits theory and two credits practicals). A particular DSE course will be offered only if the minimum number of students opting for that course is 10.

Generic Elective (GE) courses for the programme will be offered by other departments of the respective college. Students will select one GE course each in Semesters I, II, III, and IV. The GE courses will be of six credits each (four credits theory and two credits practicals).

From a list of six Skill Enhancement (SE) courses provided, students will choose two Skill Enhancement (SE) courses of four credits each in Semesters III and IV. The SE courses will be of four credits each (two credits theory and two credits practicals). The two compulsory Ability Enhancement Courses (AEC), AE1 (Environmental Sciences) and AE2 (English communication), will be of two credits each (theory only). Students will undertake one course each in Semesters I and II.

6.1 Scheme For Choice Based Credit System In B.Sc. Honours Biological Science

SEMESTER	COURSES OFFERED	COURSE NAME	CREDITS
I	Ability Enhancement Compulsory Course 1	English communication / Environmental Science	2
	Core course 1	Chemistry	4
	Core course 1 Practical	Chemistry	2
	Core course 2	Light and Life	4
	Core course 2 Practical	Light and Life	2
II	Ability Enhancement Compulsory Course 2	English communications/ Environmental Science	2
	Core course 3	Biophysics	4
	Core course 3 Practical	Biophysics	2
	Core course 4	Biodiversity	4
	Core course 4 Practical	Biodiversity	2
III	Core course 5	Proteins and Enzymes	4
	Core course 5 Practical	Proteins and Enzymes	2
	Core course 6	Cell Biology	4
	Core course 6 Practical	Cell Biology	2
	Core course 7	Ecology	4
	Core course 7 Practical	Ecology	2
	Skill Enhancement Course -1	BS SEC-1	2

	Skill Enhancement Course -1 Practical	BS SEC-1	2
IV	Core course 8	Systems Physiology	4
	Core course 8 Practical	Systems Physiology	2
	Core course 9	Molecular Biology	4
	Core course 9 Practical	Molecular Biology	2
	Core course 10	Metabolism and Integration	4
	Core course 10 Practical	Metabolism and Integration	2
	Skill Enhancement Course - 2	BS SEC-2	2
	Skill Enhancement Course -2 Practical	BS SEC-2	2
V	Core course 11	Growth and Reproduction	4
	Core course 11 Practical	Growth and Reproduction	2
	Core course 12	Genetics	4
	Core course 12 Practical	Genetics	2
	Discipline Specific Elective-1	BS DSE-1	4
	Discipline Specific Elective-1 Practical	BS DSE-1	2
	Discipline Specific Elective-2	BS DSE-2	4
	Discipline Specific Elective – 2 Practical	BS DSE-2	2
VI	Core course 13	Immunobiology	4
	Core course 13 Practical	Immunobiology	2
	Core course 14	Evolutionary Biology	4
	Core course 14 Practical	Evolutionary Biology	2
	Discipline Specific Elective-3	BS DSE-3	4
	Discipline Specific Elective-3 Practical	BS DSE-3	2
	Discipline Specific Elective-4	BS DSE-4	4
	Discipline Specific Elective-4 Practical	BS DSE-4	2

Note: 1 Credit is equivalent to 1 hour of teaching per week for theory courses and 2 hour of teaching for practical courses.

6.2 Course Structure of B.Sc. (Hons) Biological Science under CBCS

SEMESTER I		SEMESTER II	
C1	Chemistry	**C3**	Biophysics
C2	Light and Life	**C4**	Biodiversity
AECC1	English/MIL Communication or EVS	**AECC2**	English/MIL Communication or EVS
SEMESTER III		**SEMESTER IV**	
C5	Proteins and Enzymes	**C8**	Systems Physiology
C6	Cell Biology	**C9**	Molecular Biology
C7	Ecology	**C10**	Metabolism and Integration
SEC1	Skill Enhancement Course (*Any one*)	**SEC2**	Skill Enhancement Course (*Any one*)
	I. Medicinal Botany		I. Organic Farming
	II. Medical Diagnostics		II. Public Health Management
	III. Bioinformatics		III. Biochemical Techniques
SEMESTER V		**SEMESTER VI**	
C11	Growth and Reproduction	**C13**	Immunobiology
C12	Genetics	**C14**	Evolutionary Biology
DSE1	Discipline Specific Elective (*Any two*)	**DSE2**	Discipline Specific Elective (*Any two*)
	I. Plant Physiology		I. Natural Resource Management
	II. Animal Behavior and Chronobiology		II. Wildlife Biology and Conservation
	III. Biotechnology		III. Nutritional Biochemistry
	IV. Endocrinology		IV. Microbiology

C: Core Courses (14); **AECC**: Ability Enhancement Compulsory Course (02); **SEC**: Skill Enhancement Courses (02); **DSE**: Discipline Specific Elective (04).
Numbers within bracket indicate the total number of courses to be taken up by the student in each category.

7. Courses for B.Sc. (Honours) Biological Science Programme

Core Courses

BS C-1: Chemistry
BS C-2: Light and Life
BS C-3: Biophysics
BS C4: Biodiversity
BS C-5: Proteins and Enzymes
BS C-6: Cell Biology
BS C-7: Ecology
BS C-8: Systems Physiology
BS C-9: Molecular Biology
BS C-10: Metabolism and Integration
BS C-11: Growth and Reproduction
BS C-12: Genetics
BS C-13: Immunobiology
BS C-14: Evolutionary Biology

Discipline Specific Elective Courses (*Any four*)

BS DSE-1: Plant Physiology
BS DSE-2: Animal Behaviour and Chronobiology
BS DSE-3: Biotechnology
BS DSE-4: Endocrinology
BS DSE-5: Natural Resource Management
BS DSE-6: Wildlife Biology and Conservation
BS DSE-7: Nutritional Biochemistry
BS DSE-8: Microbiology

Ability Enhancement Compulsory Courses

AECC-1: English communication
AECC-2: Environmental science

Skill Enhancement Elective Courses (*Any two*)

BS SEC-1: Medicinal Botany
BS SEC-2: Medical Diagnostics
BS SEC-3: Bioinformatics
BS SEC-4: Organic Farming
BS SEC-5: Public Health Management
BS SEC-6: Biochemical Techniques

B.Sc. (HONOURS) BIOLOGICAL SCIENCE
(CBCS STRUCTURE)
CORE COURSES

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Chemistry (BS C-1)
Semester – I

1. Course Objective

The objective of this course is to develop a basic understanding of the structure, bonding, stability, stereochemistry and reactivity of organic molecules with focus on biomolecules. The course will cover thermodynamic studies with the calculation of energies and interaction of biomolecules with their neighbouring environment. This basic knowledge will empower the students to develop an understanding about chemistry of biomolecules such as proteins, nucleic acids, carbohydrates and lipids.

2. Course Learning Outcomes

- Students will understand and apply the fundamental principles of chemistry which include bonding, electronic effects, molecular forces and stability of reactive intermediates to biomolecules.
- The students will gain an insight into the influence of chemical bond polarization on a molecular structure and its reactivity.
- Students will be able to identify the type of metabolic reaction and draw reaction mechanisms for key metabolic processes.
- Students will learn to recognize stereochemistry of a biomolecule and give a rational explanation of its biological reactivity based on stereochemistry.
- The students will gain an insight into thermodynamics and basic principles of thermochemistry and successfully extend the concepts learnt in this course to biological systems.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

UNIT I: Chemical Bonding and Introduction to Nanomaterials. No. of Hours: 12

Lattice energy and solvation energy, Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, Covalent Bonding: VB Approach, Lewis theory, VSEPR theory to explain the shapes of molecules, salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach, salient features of the MO theory. Rules for the LCAO method, MO treatment of homonuclear diatomic molecules such as O_2 and heteronuclear diatomic molecules such as CO, An overview

of nanomaterials and classification, bioinorganic nanomaterials, DNA & nanomaterials, natural and artificial nanomaterials, bio-nanocomposites

UNIT II: Chemical Thermodynamics No. of Hours: 12

Qualitative idea of thermodynamics, First Law of Thermodynamics: Calculation of work (w), heat (q), changes in internal energy (ΔE) and enthalpy (ΔH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, ΔE, and ΔH for processes involving changes in physical states .Important principles and definitions of thermochemistry .Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchhoff's equation, Second law of thermodynamics, concept of entropy, Gibbs free energy and Helmoltz free energy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions, Criteria of spontaneity, Gibbs Helmholtz equation. Maxwell's relations, Statements of Third Law of thermodynamics: calculation of absolute entropies of substances

Unit III: Fundamentals of Organic Chemistry No. of hours: 14

Electronic effects and their application- Inductive, resonance and Hyperconjugation, Structure and relative stability of reactive carbon intermediates-carbocations, carbanions and free radicals, intramolecular and intermolecular molecular forces including hydrophobic, hydrophilic interactions and Hydrogen bond and their effect on stability of biomolecules, Criterion for aromaticity-carbocyclic and heterocyclic compounds- furan, pyrrole, thiophene and Indole and imidazole, Reaction mechanism-Nucleophilic substitution and addition reaction with mechanism, Electrophilic addition to C=C systems example X_2, HX and water. Functional group approach for the following reactions to be studied with mechanism in context to their structure-Alcohols- esterification, ethers-Cleavage of C-O bond with HI, aldehydes and ketones-Nucleophilic addition and Nucleophilic addition–elimination reactions including, ammonia derivatives, Aldol condensation, carboxylic acids and acid derivatives-acidity and reactivity towards nucleophiles including solvolysis reactions. Amines-basicity and acetylation.

Unit IV: Stereochemistry No. of hours: 10

Stereochemistry and its importance to biologists, Geometrical isomerism, cis-trans and E/Z nomenclature, Optical isomerism–optical activity, chirality, specific rotation, Stereoisomerism with two chiral centers: Enantiomers, Diastereomers, mesoisomers, Erythro and threo designation. Resolution of racemic modification, Fischer, Newman and Sawhorse projections, Relative Configuration: D/L designation. Absolute Configuration: R/S, designation of chiral centers (upto two chiral centres), Conformational isomerism – ethane, butane and cyclohexane, diagrams and relative stability of conformers.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture
2. Estimation of Mohr's salt by titrating it with $KMnO_4$.
3. Synthesis and characterization of silver nanoparticles using UV-Visible spectrophotometer
4. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide
5. Determination of basicity of a diprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of integral enthalpy (endothermic and exothermic) solution of salts
7. Determination of melting and boiling points of organic compounds
8. Mechano-Chemical solvent free synthesis of azomethine
9. Acetylation of amines using green approach
10. Qualitative functional group tests for alcohols, aldehydes, ketones, carboxylic acids, esters, amines and amides

3.3. REFERENCES

1. Ahluwalia, V. K., Dhingra, S., Gulati, A. (2005). *College Practical Chemistry*. India: University Press (India) Private Limited.
2. Atkins, P., Overton, T., Rourke, J., Weller, M. & Armstrong, F. (2011-12). *Shriver and Atkins' Inorganic Chemistry*. Oxford, UK: Oxford University Press.
3. Gulati, S., Sharma, J. L., Minocha, S. (2017). *Practical Inorganic Chemistry*. New Delhi, India: CBS publishers and distributors Pvt. Ltd.
4. Huheey, J. E., Keiter, E.A., Keiter, R. L. (2008). *Inorganic Chemistry: Principles of Structure and Reactivity*. London, UK: Dorling Kindersley Pvt. Ltd.,
5. Kalsi, P. S. (2005). *Stereochemistry, Conformation and Mechanism*. Delhi, India: New Age International.
6. Kapoor, K.L. (2017). *A Textbook of Physical Chemistry, Thermodynamics and Chemical Equilibrium, Vol.* 2. India: McGraw-Hill Education.
7. Khosla, B. D., Garg, V. C., Gulati, A. (2011). *Senior Practical Physical Chemistry*. New Delhi, India: R. Chand & Co.
8. Lee, J.D. (1999). *A New Concise Inorganic Chemistry*. USA: Wiley-Blackwell
9. Mann, F.G., Saunders, B.C. (2009). *Practical Organic Chemistry*. India: Pearson Education.
10. Morrison, R.T., Boyd, R.N. (1992). *Organic Chemistry*. New Jersey: Prentice Hall Inc.
11. Rastogi, R. P., Mishra, R. R. (2009). *An Introduction to Chemical Thermodynamics*. India: Vikas Publication.

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
I	Students will learn about the basics of chemical bonding, the structure of chemical compounds including biomolecules and get an overview of nanomaterials and their applications.	Teaching using chalk and board; Oral discussion sessions in the class, peer review activities, presentations, open book tests	Questionnaire will be discussed with students in the class and assignments will be given to practice them.
II	The students will learn about thermodynamics and basic principles of thermochemistry and successfully extend the concepts learnt to apply on biological systems.	Teaching using chalk and board; Oral discussion sessions in the class, peer review activities, open book tests and presentations.	Practice problems will be given in the class. Class tests will be conducted for internal assessment.
III	Students will get an insight into the structure, bonding, stability and reactivity of organic compounds with focus on chemical reactions.	Teaching using chalk and board; Oral discussion sessions in the class, peer review activities, open book tests and presentations.	Concepts related to reaction mechanism, stability andreactivity will be given to students.They will be asked to predict the products in chemical reactions.
IV	Students will be able to visualize the structure, bond attachments and orientation of molecules in 3-dimensional space and write the three types of projection formulae.	Teaching using chalk and board; power point presentations; 3-D models of molecules; Animations, videos and discussions in the class.	Demonstration by students with the help of models to test their understanding. Oral class tests to check their understanding.

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

5. Teaching Plan

Week 1: Lattice energy and solvation energy, Born-Haber cycle and its applications, Qualitative idea of thermodynamics, First Law of Thermodynamics, Electronic effects and their application- Inductive, Resonance and Hyperconjugation, Structure and relative stability of reactive carbon intermediates- carbocations, carbanions and free radicals.

Week 2: Polarizing power and polarizability ,Calculation of work (w), heat (q) for expansion or compression of ideal gases under isothermal conditions for reversible and irreversible processes, intramolecular and intermolecular molecular forces including hydrophobic, hydrophilic interactions and hydrogen bond and their effect on stability of biomolecules, Criterion for aromaticity-Carbocyclic compounds.

Week 3: Fajan's rules, ionic character in covalent compounds , Covalent Bonding: VB Approach, Calculation of work (w), heat (q) for expansion or compression of ideal gases under adiabatic conditions for reversible and irreversible processes Criterion for aromaticity- heterocyclic compounds- furan, pyrrole, thiophene , Indole and imidazole. Reaction mechanism-Nucleophilic substitution.

Week 4: Lewis theory, VSEPR theory to explain the shapes of molecules , Calculation of w, q, ΔE, and ΔH for processes involving changes in physical states, Reaction mechanism- Electrophilic addition to C=C systems example X_2, HX and water, Nucleophilic addition reactions with mechanism, Functional group approach for the following reactions to be studied with mechanism in context to their structure- Alcohols-esterification, ethers-Cleavage of C-O bond with HI.

Week 5: Salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach , Important principles and definitions of thermochemistry, Concept of standard state and standard enthalpies of formation , Functional group approach for the following reactions to be studied with mechanism in context to their structure: aldehydes and ketones- Nucleophilic addition and Nucleophilic addition–elimination reactions including, ammonia derivatives, Aldol condensation.

Week 6: MO Approach: limitations of the VB approach ,Salient features of the MO theory, integral and differential enthalpies of solution and dilution, Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data , carboxylic acids and acid derivatives-acidity(Cont.) and reactivity towards nucleophiles including solvolysis reactions.

Week 7: Rules for the LCAO method, MO treatment of homonuclear diatomic molecules such as O_2 , heteronuclear molecules like CO, Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, Variation of enthalpy of a reaction with temperature Kirchhoff's equation, Amines-basicity and acetylation, Stereochemistry and its importance to biologists.

Week 8: MO treatment of heteronuclear molecules like CO, Second law of thermodynamics, concept of entropy, Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal conditions, Geometrical isomerism, cis-trans and E/Z nomenclature, Optical isomerism–optical activity, chirality, specific rotation.

Week 9: An overview of nanomaterials and classification, Calculations of entropy change and free energy change for reversible and irreversible processes under adiabatic conditions, Stereoisomerism with two chiral centers: Enantiomers, Diastereomers, meso isomers, Erythro and threo designation. Resolution of racemic modification,

Week 10: Bioinorganic nanomaterials, DNA & nanomaterials ,criteria of spontaneity, Gibbs free energy and Helmoltz free energy, Fischer, Newman and Sawhorse projections, Relative Configuration: D/L designation,

Week 11: Natural and artificial nanomaterials, Gibbs Helmholtz equation, Maxwell's relations, Absolute Configuration: R/S, designation of chiral centres (up to two chiral carbons), Conformational isomerism–ethane and energy diagrams and relative stability of conformers.

Week 12: Bio-nanocomposites, Statements of Third Law of thermodynamics: calculation of absolute entropies of substances, Conformational isomerism–butane and cyclohexane, diagrams and relative stability of conformers.

6. Keywords

Chemical Bonding, Nanomaterials, Thermodynamics and Thermochemistry, Reaction mechanisms, Functional group, Stereochemistry.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Light and Life (BS C-2)
Semester – I

1. Course Objective:

The course explores the physical properties of light and its interplay with living organisms. Light as a source of energy and information has shaped life on earth over the last 3.6 billion years. We see the world around us because the light reflected to the retina is processed to our brain (Photoreception), we breathe in oxygen because it has been evolved by the plants around us due to the light dependent Photosynthesis. Where there is no natural light organisms produce their own (Bioluminescence). Maintaning co-ordination with the surrounding light regime is fundamentally important to the inherent biological clock in organisms which needs re-calibration almost every 24 hours (Circadian Rhythms); whereas a disruption may lead to adverse effects. Every part of the spectrum is used in one way or the other by different life forms. In this paper students will be able to appreciate the delicate processes of life that are dependent on light.

2. Course Learning Outcomes:

- Students will understand and appreciate the dual nature of light.
- Students will comprehend the impact of light on biodiversity from pole to pole.
- Students will gain knowledge about the various photoreceptors in plants and animals and will appreciate and understand the mechanism of photosynthesis.
- Students will understand bioluminescence, photoperiodism and biological rhythms.
- Students will gain knowledge about the ecological and physiological responses to light.

3. Course Contents:

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Light and Life No. of Hours: 7

Nature of light (Wave and Particle), spectrum of light. Measurement of light (Lux, Candela, Foot Candle).Polarized light, light attenuation in water.Light as an ecological factor affecting distribution of plants and animals (Phyto and Zoo geography), in terrestrial and aquatic ecosystems.Latitudinal Diversity gradient.Altitudinal and latitudinal variations in light intensity and photoperiod. Diel vertical migration.

Unit II: Photoreception No. of Hours: 7

Comparative account of chemistry and functional roles of pigments associated with harvesting light energy: photoreceptors in plants: chlorophylls, carotenoids, phycobilinoproteins, bacteriochlorophylls, etc. Photoreception in animals, opsins evolution of eyes, color vision and visual processing in human eye.

Unit III: Photosynthesis No. of Hours: 12

History, Structure of chloroplast, Photosynthetic equation, Photosynthetic electron transport (cyclic and non-cyclic), photolysis of water, oxygen-evolving complex (OEC), concept of Reaction centers, Q-cycle, Dark Reactions in Photosynthesis, C_3, C_4, CAM cycle, Regulation of PCR cycle, photorespiration (C_2 cycle), photoautotroph vs. photoheterotrophs; Photoautotroph vs. chemoautotroph, Anoxygenic and oxygenic photosynthesis.

Unit IV: Bioluminescence No. of Hours: 6

Definition, discovery, diversity of organisms, Functions and mechanism of Bioluminescence (*Photinus pyralis, Aequorea victoria*).

Unit V: Photoperiodism No. of Hours: 10

Photoperiodism: phytochromes, LDP, SDP, DNP plants, vernalization, vernalin, etiolation and de-etiolation. Animal responses to changing photoperiodism.Morphological, Anatomical, Physiological and Behavioural adaptations to extreme light conditions in plants and animals.Three rhythm domains, Biological clock and Circadian rhythms. Sleep disorders, Shift work disorder, Jetlag.

Unit VI: Ecological and physiological responses to Light No. of Hours: 6

Color in animals: chromatophores and colour changes in animals, morphological and physiological colour change. Light as an inducer for biosynthesis/activation of enzymes, hormones and other biomolecules (Vitamin D, Melatonin, RuBisco).Thymine dimer formation, skin cancer and cataract in response to UV exposure. Light pollution and its impacts on environment, ecosystems and wildlife.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. To study light penetration in water using Secchi disc.
2. To demonstrate the effect of light on soil fauna using Berlese funnel setup.
3. To study the effect of light and darkness on the chromatophores of fish.
4. To test / survey for color blindness using Ishihara charts.
5. To study oxygen liberation during photosynthesis using Hydrilla. Measurement of light using Luxmeter.
6. Separation of Chloroplast pigments by Paper Chromatography.

7. Demonstration of Hills Reaction and study the effect of Light intensity (any 2 light conditions).
8. To study the effect of Light intensity and CO_2 concentration on the rate of photosynthesis.

3.3 REFERENCES

1. Björn, L. O. (2015) 3rd Ed. *Photobiology: Science of Light and Life*, L.O. Bjorn., Springer
2. Buchanan, B. B., Gruissem, W., and Jones, R. L. (2000). *Biochemistry and molecular biology of plants*. Rockville, Md.: American Society of Plant Physiologists.
3. Huner, N. and Hopkins, W. (2013). *Introduction to Plant Physiology*. In: 4th ed. John Wiley & Sons, Inc.
4. Kohen E., Santus R., Hirschberg J.G. (1995) 1st Ed., *Photobiology* Academic Press
5. Randall D., Burggren W., & French k. (2001) 5th Ed. *Eckert, Animal Physiology-mechanisms and adaptations.* W.H. Freeman and Co.

Additional Resources

1. Gross M. (2003). *Light and Life*. Oxford University Press
2. Shimomura O., (2012) *Bioluminescence: Chemical Principles and Methods*, World Scientific,
3. Taiz, L., &Zeiger, E. (1991).*Plant physiology*. Redwood City, Calif: Benjamin/Cummings Pub. Co.

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
II	Students will learn about the various photoreceptors in plants as well as animals, evolution of the and vision in humans	The traditional chalk and talk method.Short movies showing the importance of photoreceptors will be shown.Students will understand the different types of plant pigments by separating them from plant material.	Oral questions will be asked in the class. Problems will be assigned to encourage them to explore more about the concept. Class tests will be conducted for internal assessment.
III	Students will learn about the process of photosynthesis and the various factors that affect it. They will also understand about its variations.	Students will understand the importance of an electron acceptor through Hills Reaction. A practical understanding of the various factors affecting rate of photosynthesis will be	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability. Class tests will be conducted for internal assessment

		developed.	
IV	Students will learn about mechanism and diversity of bioluminescence in the living world.	The traditional chalk and talk method supplemented with power point presentation; relevant documentary will be shown.	Oral questions will be asked in the class. Students will make a report on Bioluminescent Organisms.
V	Students will learn about photoperiodism , adaptations to extreme light conditions and biological rhythms.	Chalk and talk method will be supplemented with Power point presentations.	Group discussion on the given topic will be organized. Students will be asked to give short presentations or written assignments.
VI	Students will learn how organisms respond to light induced changes in their surroundings by changing colour , synthesizing biomolecules.	Chalk and talk method will be supplemented with Power point presentations.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Nature of light (Wave and Particle), spectrum of light. Measurement of light (Lux, Candela, Foot Candle). Light as an ecological factor affecting distribution of plants and animals (Phyto and Zoo geography), in terrestrial and aquatic ecosystems.Polarized light, light attenuation in water.

Week 2: Light as an ecological factor affecting distribution of plants in aquatic ecosystems. Comparative account of chemistry and functional roles of pigments associated with harvesting light energy: chlorophylls, carotenoids. Latitudinal Diversity gradient.Altitudinal and latitudinal variations in light intensity and photoperiod.

Week 3: Comparative account of chemistry and functional roles of pigments associated with harvesting light energy: phycobilinoproteins, bacteriochlorophylls, etc. Diel vertical migration, Photoreception in animals, opsins evolution of eyes.

Week 4: History, Structure of chloroplast, Photosynthetic equation, Photosynthetic electron transport (cyclic and non-cyclic), photolysis of water. Color vision, visual processing in human eye.

Week 5: Oxygen-evolving complex (OEC), concept of Reaction centers, Q-cycle. Definition, discovery, diversity of organisms showing bioluminescence.

Week 6: Dark Reactions in Photosynthesis, C_3 cycle Regulation of PCR cycle. Functions of bioluminescence in living world

Week 7: C_4, CAM cycle, Mechanism of Bioluminescence (*Photinus pyralis, Aequorea victoria*).
Week 8: Photorespiration (C_2 cycle), photoautotrophvsphotoheterotrophs; Photoautotroph vs. chemoautotroph, Anoxygenic and oxygenic photosynthesis. Three rhythm domains, Biological clock and Circadian rhythms.

Week 9: Photoperiodism: phytochromes. Sleep disorders, Shift work disorder, Jetlag.

Week 10: LDP, SDP, DNP plants, vernalization, vernalin. Color in animals: chromatophores and colour changes in animals, morphological and physiological color change.

Week 11: Etiolation and de-etiolation.Morphological, Anatomical, Physiological and Behavioural adaptations to extreme light conditions in plants (contd. in week 12) and animals. Light as an inducer for biosynthesis/activation of enzymes, hormones and other biomolecules (Vitamin D, Melatonin)

Week 12: Light as an inducer for biosynthesis/activation of RUBISCO.Thymine dimer formation, skin cancer and cataract in response to UV exposure. Light pollution and its impacts on environment, ecosystems and wildlife.

6. Keywords

Light, Pigments, Photoreceptors, Bioluminescence, Photosynthesis, Photoperiodism, Biological clock, Circadian rhythm, Biogeography.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Biophysics (BS C-3)
Semester – II

1. Course Objective

This interdisciplinary course introduces the basic concepts of physics and their applications in biology for better understanding of various biological processes at cellular and molecular level. This knowledge will empower the students to develop a basic understanding about the principles and concepts of Biophysics and will enable the students to develop quantitative approaches to solve physical/biological problems.

2. Course Learning Outcomes

- Students will learn basic concepts of physics and apply them to study the physicochemical properties of biomolecules.
- Students will learn to investigate the light absorption properties of biomolecules through spectrophotometry, for qualitative and quantitative analysis of biomolecules.
- Students will learn the concepts related to mechanics of solids and liquids to understand the basic mechanisms of cell biology especially cell adhesion, migration and mechanotransduction.
- Students will learn about the mechanism of transport of various ions/molecules across cell membranes and their significance in several biological processes.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Mechanics No. of Hours: 06

Conservation of momentum and energy, work energy theorem, Angular momentum, Torque, motion of a particle in central force field. Introduction to mechanical forces: mechanics of solids and fluids, viscous force, surface tension and viscoelasticity with examples.

Unit II: Electrostatics No. of Hours: 06

Introduction to electrostatics: Concept of charge in Gauss's law; point charge, line charge and surface charge, Electric Potential and Field. Dielectrics: Non polar/Polar dielectrics, Molecular theory of Dielectrics, Dielectric Constant, Gauss's Law in presence of dielectric, Three electric vectors and their relations, Electric susceptibility, Energy stored in dielectrics, Applications of dielectrics.

Unit III: Waves and Oscillations No. of Hours: 12

Simple harmonic motion, Vector and the complex-exponential representations of SHM (examples of a Pendulum, spring-mass system and the electric system), damped and driven harmonicoscillator.Coupled oscillator: capacitative and inductive coupling.
Superposition principle and Superposition of waves: Young's double slit interference, Diffraction: diffraction through a single slit/double slit and grating, Resolving power, Resolution of the eye, Lasers: Principle, Population inversion, He-Ne Laser, characteristics of laser, Applications of lasers in medical science, Polarization of EM wave, Nicol prism. Doppler effect, Effects of vibrations in humans: physics of hearing, heartbeat.

Unit IV: Biomolecules No. of Hours: 5

Amino acids, Amino acid structure, Physical properties: pI of amino acids, amino acids as ampholytes, melting point, optical rotation, UV absorption. peptide bond, peptides and proteins. Nucleic acids, Purine & Pyrimidine bases, Watson-Crick model of DNA & its features, Types of DNA. Physical properties of DNA - Effect of heat on physical properties of DNA (Viscosity, buoyant density), Types of RNA. Classification of carbohydrates (mono, oligo polysaccharides), Physical - isomerism D & L, optical; epimers :anomers. Classification of Lipids, Saturated fatty acids - classification of C2 to C20: even carbon: Common and IUPAC names. Unsaturated fatty acids MUFA, PUFA (2.3.4 double bonds), Omega - 3.6.9 fatty acids.Triacyl glycerol - simple and mixed - names and structure.

Unit V: Biological membranes No. of Hours: 13

Colloidal solution, Micelles, bilayers, membrane models, liposomes, phase transitions of lipids, Membrane asymmetry, active, passive and facilitated transport of solutes and ions, Fick's Laws, Nernst Planck Equations, Diffusion, Osmosis, Donnan effect, permeabilily coefficient. Ionophores, transport equation, membrane potential, action potential, neuronal synapse. Mechanobiology:Introduction to mechanobiology, Extracellular matrix, cytoskeleton, Durotaxis, mechanics of cell adhesion and migration, mechanotransduction.

Unit VI: Spectroscopic techniques No. of Hours: 6

Beer-Lambert law, light absorption and its transmittance.UV and visible and IR spectrophotometry-principles, instrumentation and applications.UV absorption of proteins and N.As - Hypochromism, hyperchromism, denaturation, fluorescence spectroscopy, static & dynamic quenching, fluorescent probes in the study of protein, nucleic acids.Light scattering in biology, optical rotatory dispersion.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDIT: 2**

1. Determination of acceleration due to gravity using Kater's pendulum.
2. Determination of the acceleration due to gravity using bar pendulum.
3. Study of Lissajous figures using CRO.

4. Determination of the frequency of an electrically maintained tuning fork by Melde's Experiment.
5. Determination of the wavelength of laser source by through diffraction of (1) Single slit, (2) Double slit.
6. Comparison of capacitances using De'Sautty's bridge.
7. Determination of the coefficient of Viscosity of water by capillary flow method (Poiseuille's method).
8. Verification of Beer Law
9. Determination of Molar Extinction coefficient
10. Qualitative analysis of proteins and Nucleic acids using spectrophotometer.
11. Determination of CMC for a detergent.

3.3 REFERENCES

1. D. Kleppner, R. J. Kolenkow (1973). *An introduction to Mechanics.* McGraw Hill.
2. David Freifelder (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Bioogy.* 2nd edition. W.H. freeman and Company.
3. Keith Wilson and John Walker (2005). *Principles and Techniques of Biochemistry and Molecular Biology*. 6th edition. Cambridge University Press.
4. N. K. Bajaj (2008). *The Physics of Waves and Oscillations*. 5th edition. Tata McGraw Hill.

Additional reading:

1. Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon (2012). *Introduction to cell mechanics and Mechanobiology* 1st editon. Garland Science (Taylor & Francis Group). ISBN: 978-0-8153-4425-4.

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
I.	Students will learn about various aspects of mechanics, centrifugal forces, mechanical forces in solids, fluids with examples.	Traditional chalk and board method with power-point presentations. Group Discussions with examples.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.
II.	Students will learn about electrostatics, electric potential, Gauss's law, Dielectrics and its applications.	Traditional chalk and board method with power-point presentations. . Group Discussions with examples.	Regular question- answer sessions in the class. Class tests will be conducted for internal assessment.

III.	Students will learn about simple harmonic motion, diffraction, lasers and its applications in medical science. Doppler effect, effects of vibrations in humans: physics of hearing, heartbeat.	Traditional chalk and board method with power-point presentations. Group discussions.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment.
IV	Students will learn about biomolecules, classification, and physicochemical properties	Traditional chalk & board method with power-point presentations.	Regular question- answer sessions in the class. Class tests will be conducted for internal assessment
V.	Students will learn about micelles, bilayers, liposomes, and membrane asymmetry and transport and neuronal synapse. Mechanobiology and mechanotransduction.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class.	Various analytical problems will be assigned to students related to DNA repair and related disorders.
VI.	Students will learn about UV-visible spectrophotometry, fluorometry and applications, optical rotation and light scattering.	Traditional chalk & board method with power-point presentations.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.

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

5. Teaching Plan

Week 1: Conservation of momentum and energy, work energy theorem, Angular momentum, Torque, motion of a particle in central force field. Introduction to mechanical forces: mechanics of solids and fluids, viscous force, surface tension and viscoelasticity with examples.

Week 2: Introduction to electrostatics: Concept of charge in Gauss's law; point charge, line charge and surface charge, Electric Potential and Field.

Week 3: Dielectrics: Non polar/Polar dielectrics, Molecular theory of Dielectrics, Dielectric Constant, Gauss's Law in presence of dielectric, Three electric vectors and their relations, Electric susceptibility, Energy stored in dielectrics, Applications of dielectrics.

Week 4: Simple harmonic motion, Vector and the complex-exponential representations of SHM (examples of a Pendulum, spring-mass system and the electric system), damped and driven harmonic oscillator. Coupled oscillator: capacitative and inductive coupling. Superposition principle and Superposition of waves: Young's double slit interference,

Week 5: Diffraction: diffraction through a single slit/double slit and grating, Resolving power, Resolution of the eye, Lasers: Principle, Population inversion, He-Ne Laser, characteristics of laser, Applications of lasers in medical science, Polarization of EM wave, Nicol prism. Doppler effect, Effects of vibrations in humans: physics of hearing, heartbeat.

Week 6: Amino acids, Amino acid structure, Physical properties: pI of amino acids, amino acids as ampholytes, melting point, optical rotation, UV absorption. peptide bond, peptides and proteins. Nucleic acids, Purine & Pyrimidine bases, Watson-Crick model of DNA & its features, Types of DNA. Physical properties of DNA - Effect of heat on physical properties of DNA (Viscosity, buoyant density), Types of RNA.Classification of carbohydrates (mono, oligo polysaccharides), Physical - isomerism D & L, optical; epimers :anomers. Classification of Lipids, Saturated fatty acids - classification of C2 to C20: even carbon: Common and IUPAC names. Unsaturated fatty acids MUFA, PUFA (2.3.4 double bonds), Omega - 3.6.9 fatty acids.Triacyl glycerol - simple and mixed - names and structure.

Week 7: Colloidal solution, Micelles, bilayers, membrane models, liposomes, phase transitions of lipids, Membrane asymmetry, active, passive and facilitated transport of solutes and ions.

Week 8: Fick's Laws, Nernst Planck Equations, Diffusion, Osmosis, Donnan effect, permeabilily coefficient. Ionophores, transport equation, membrane potential, action potential, neuronal synapse.

Week 9: Introduction to mechanobiology, Extracellular matrix, cytoskeleton, Durotaxis, mechanics of cell adhesion and migration, mechanotransduction.

Week 10: Beer-Lambert law, light absorption and its transmittance.UV and visible and IR spectrophotometry-principles, instrumentation and applications.

Week 11: UV absorption of proteins and N.As - Hypochromism, hyperchromism, denaturation.fluorescence spectroscopy, static & dynamic quenching, fluorescent probes in the study of protein, nucleic acids.

Week 12: light scattering in biology, optical rotatory dispersion

6. Keywords

Spectrophotometry, Momentum, Electric potential, Diffraction, Membrane transport, mechanotransduction.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Biodiversity (BS C-4)
Semester – II

1. Course Objectives

The course will acquaint students with variations and variability in the living world and the objectives of biological classification. The course covers important aspects of biodiversity, its components and relevance of conservation. Emphasis will be on developing interest and invoking a sense of responsibility among students towards conservation of plant and animal biodiversity. The course explores different tools and techniques used to study biodiversity such as mapping of forests and animal populations of rare and endangered species.

2. Course Learning Outcomes

- Students will study and understand characteristic features of different plant and animal life forms.
- Students will understand recent advances in technology used in mapping and conservation of biodiversity.
- Students will appreciate and understand the relevance of wild relatives of cultivated plants, their domestication and green revolution.
- Students will appreciate the relevance of bioremediation and role of indicator plants in combating threats to biodiversity.

3. Course Contents

3.1THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Defining Biodiversity No. of Hours: 24

Components of Biodiversity, Biodiversity crisis and biodiversity loss, Importance of biodiversity in daily life, Biodiversity vis-a-vis climate change. Types of Ecosystems: India as mega biodiversity nation; hot spots, endemism. Study of general characteristics of cryptogams (*Oedogonium*, *Polysiphonia*, *Rhizopus*, *Albugo*, *Anthoceros*,*Funaria*,*Selaginella*) and phanerogams (*Pinus*), Angiosperm systematics: Outline of Bentham and Hooker classification
Introduction to animal diversity, Whittaker's five kingdom classification, Systematic classification and general features of chordates and non chordates (Protista, Porifera, Cnidaria, Platyhelminthes, Aschelminthes, Annelida, Arthropoda, Mollusca, Echinodermata, Protochordata, Osteichthyes, Amphibia, Reptilia, Aves and Mammals.Principles of taxonomy, Linnaean system of classification, Binomial nomenclature, Species concepts.

Unit II: Modern Tools in the study of Biodiversity No. of Hours: 8

Natural Resources from plants: Food Crops, beverages, timber, fibres. Endemism, endemic animals; Assessment of mapping of biodiversity; GIS/Remote sensing; Biotechnology and Conservation, IUCN; Germplasm banks, National Parks, Botanical Gardens; Wildlife Sanctuaries, Sacred fauna

Unit III: Crop Diversity No. of Hours: 8

Wild relatives of cultivated plants; Domesticated diversity-its advantages and disadvantages, Centres of origin of cultivated plants (Vavilov), Green revolution, the origin of *Triticumaestivum* and *Oryza sativa* through domestication, Spice diversity, Forest diversity-Types of forests (classification by Champion and Seth (1968), Agroforestry

Unit IV: Bio-prospecting No. of Hours: 8

Phytoremediation: Plants as indicators and remediators of air, water and soil pollution (heavy metals, oil spills). Bioremediation, Biomass utilization, Bioethics

3.2 PRACTICALS

TOTAL HOURS: 48 CREDITS: 2

FAUNA

1. Study of following specimens: *Euglena, Paramecium, Sycon, , Tubipora,Taenia, Ascaris Aphrodite, Leech, Peripatus, Limulus,* Hermitcrab, Beetle, *Pila, Chiton, Dentalium, Octopus, Asterias*
2. Dissections/ Virtual demonstration: Digestive and nervous system of Cockroach; Unstained mount of Placoid scales.
3. Study of following specimens: *Balanoglossus, Amphioxus, Petromyzon, Pristis, Hippocampus, Labeo, Icthyophis/Uraeotyphlus, Salamander, Draco,Naja,*any three common birds,Bat.
4. Study of a few endangered species of amphibians, reptiles, birds and mammals of India
5. To study faunal composition of water samples (Lucky drop method)
6. Report on: Biodiversity park/reserve/ NBPGR (Botany + Zoology)

FLORA

7. Study through specimens/photographs of
   a) Food crops: Wheat, rice
   b) Fibres: Cotton, jute
   c) Timber: Teak, shisham
   d) Oils: Mustard and soybean
8. Study of vegetative and reproductive structures of the following genera: *Chlamydomonas* (Electron microphotograph), *Oedogonium, Vaucheria, Polysiphponia,Fucus* (specimen), *Rhizopus, Penicillium, Albugo, Riccia,*

Anthoceros, Funaria, Psilotum, Selaginella, Pteris, Cycas, Pinus, Lichens (specimens)

9. Study of the characteristic features of any one member from each family
   (a) Malvaceae/ Fabaceae/Brassicaceae/Ranunculaceae (anytwo families),
   (b) Asteraceae
   (c) Euphorbiaceae
   (d) Poaceae/Liliaceae (any one family)

3.3 REFERENCES

1. Barnes, R.D. (1982). *Invertebrate Zoology*, 5th. Edition
2. Campbell N. A., (2008).*Biology* 8th Edition, Pearson
3. Kocchar, S.L., (2016). *A Economic Botany comprehensive study*. Cambridge University Press.
4. Singh, G., (2018). *Plant Systematics: Theory and Practice*. Oxford & IBH Publishing Co. Pvt. Ltd.
5. Young, J. Z., (2004). *The Life of Vertebrates*.III Edition.Oxford university press.

Additional Reading:

1. Ennos, R., & Sheffield, E., (2000). *Plant Life*. UK: University Press, Cambridge.
2. Ingrowille, M., (1992).*Diversity and Evolution of land plants*. Chapman and Hall
3. Wilson, E. O., (1998). *Biodiversity*.National Academic Press.

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
I	Students will learn about the basic concepts of biodiversity and characteristic features and systems of classification of plants and animals	Teaching using chalk and board; Power point presentations; Group discussion sessions in the class	Questions will be asked in the class.
II	Students will learn about the different types of tools and assessment techniques used in mapping biodiversity. They will able to list and define various methods used in conservation	Power point presentations; Teaching using chalk and board; Group discussion, Case studies	Students will take up case studies and participate in group discussion.
III	Students will learn about diversity of crop plants and their wild relatives, process of domestication, green revolution and basic concepts of agroforestry	Power point presentations; Teaching using chalk and board; Role play, Case studies	Students will be given worksheets / assignments to test their understanding of the unit.
IV	Students will learn about basics of bioprospecting, bioremediation and bioethics.	Power point presentations; Teaching using chalk and board; Oral discussions in the class	Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Components of Biodiversity, Biodiversity crisis and biodiversity loss, Importance of biodiversity in daily life, Biodiversity vis-a-vis climate change. Introduction to animal diversity, Whittaker's five kingdom classification

Week 2: Study of general characteristics of cryptogams (*Oedogonium*, *Polysiphonia*, *Rhizopus*, *Albugo*, *Anthoceros*, *Funaria*, *Selaginella*) Systematic classification and general features non chordates (Protista,Porifera, Cnidaria)

Week 3: Types of Ecosystems: India as mega biodiversity nation; hot spots, endemism. Angiosperm systematics: General features ofPlatyhelminthes, Aschelminthes, Annelida

Week 4: General features of phanerogams (*Pinus*), Arthropoda, Mollusca, Echinodermata

Week 5: General features of chordates: Protochordata, Osteichthyes, Amphibia, Reptilia, Aves and Mammals

Week 6: Principles of taxonomy, Linnaean system of classification, Binomial nomenclature, Species concepts, Outline of Bentham and Hooker classification

Week 7: Natural Resources from plants: Food Crops, beverages, timber, fibres,Endemism, endemic animals

Week 8:Assessment of mapping of biodiversity; GIS/Remote sensing; Biotechnology and Conservation, IUCN; Germplasm banks, National Parks, Botanical Gardens; Wildlife Sanctuaries, Sacred fauna

Week 9:Wild relatives of cultivated plants; Domesticated diversity: advantages and disadvantages, Centers of origin of cultivated plants (Vavilov)

Week 10:Green revolution, the origin of *Triticumaestivum* and *Oryza sativa* through domestication, Spice diversity, Forest diversity-Types of forests (classification by Champion and Seth (1968), Agro forestry

Week 11: Phytoremediation: Plants as indicators and remediators of air, water and soil pollution (heavy metals, oil spills)

Week 12: Bioremediation, Biomass utilization, Bioethics

6. Keywords:

Systematics, Conservation, Biodiversity mapping, Bioprospecting, Bioremediation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Proteins and Enzymes (BS C-5)
Semester - III

1. Course Objective

The objective of the course is to introduce the students to proteins, most remarkable biomolecules in terms of diversity of function, their structure and various techniques employed to purify proteins and to the world of enzymes, biological catalysts with remarkable properties with an aim to develop an understanding of enzyme kinetics, mechanism of enzyme action, regulatory properties and their applications in medicine.

2. Course Learning Outcomes

- Students will acquire basic knowledge about the functional diversity of proteins and different levels of structural organization of proteins
- Students will learn about the relationship between protein structure and function and the techniques that are used to purify proteins
- Students will acquire insight into enzyme kinetics, inhibition, regulation and mechanism of action.
- Students will acquire knowledge about the application of enzymes in medicine and industry.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to structures of protein No. of Hours: 8

Amino acids and their properties.Biologically important peptides - hormones, antibiotics and growth factors.Conjugated proteins, multimeric proteins and metalloproteins.Diversity of proteins.Organization of protein structure- primary, secondary, tertiary and quaternary structures.Protein sequencing- Edman degradation.Solid phase peptide synthesis.Nature of stabilizing bonds- covalent and non covalent.Peptide bond- dihedral angles. Ramachandran map, Secondary structure- Helices, sheets and turns.

Unit II: Tertiary structures and Protein Folding No. of Hours: 8

Tertiary and quaternary structures.Motifs and domains.Structures of myoglobin and haemoglobin. Oxygen binding curves, influence of 2,3-BPG, CO_2. Concerted and sequential models for allosteric proteins.Haemoglobin disorders.Denaturation and renaturation of proteins.Introduction to thermodynamics of folding.Role of chaperones, chaperonins and PDI. Defects in protein folding: Alzheimer's and Prion based.

Unit III: Purification and analysis of proteins No. of Hours: 8

Ammonium sulphate fractionation, dialysis.Ion exchange chromatography, molecular sieve chromatography, affinity chromatography, HPLC and FPLC. Gel electrophoresis, SDS-PAGE, IEF and 2-D electrophoresis.

Unit IV: Introduction to enzyme kinetics No. of Hours: 12

Nature of enzymes - protein and non-protein (ribozyme, abzymes).Cofactor and prosthetic group.Classification of enzymes. Fischer's lock& key and Koshland's induced fit hypothesis. Enzyme specificity. Enzyme Kinetics- Michaelis-Menten equation, Lineweaver-Burk plot. Determination of Km, Vmax, Kcat.Factors affecting enzyme activity.Enzyme Inhibition- Reversible (competitive, uncompetitive, non-competitive, mixed). Mechanism based inhibitors.

Unit V: Mechanisms of enzyme action and regulation No. of Hours: 8

Acid-base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, Allosteric regulation and feedback inhibition (ATCase), reversible covalent modification (glycogen phosphorylase). Proteolytic cleavage-zymogen.Multienzyme complex.Coenzymes.

Unit VI: Enzymes in medicine and industry No. of Hours: 4

Isoenzymes. Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), Enzyme immunoassay (HRP), enzyme therapy (Streptokinase). Metal base drug interaction. Enzyme immobilization and its applications.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. Estimation of proteins by Biuret and Lowry's method.
2. Determination of isoelectric pH of casein.
3. Ammonium sulphate fractionation of crude homogenate from germinated mung beans
4. Assay for acid phosphatase activity and specific activity.
5. Progress curve of enzyme
6. Effect of pH on enzyme activity.
7. Determination of Km and Vmax using Lineweaver-Burk plot.

3.3 REFERENCES

1. Cooper, T. G. (2009). *The tools of biochemistry.* Chichester: John Wiley.
2. Nelson, D. L. and Cox, M. M. (2008). *Lehninger, Principles of Biochemistry*, 5th Ed., W.H. Freeman and Company (New York, USA.).
3. Price, N. C., and Stevens, L. (1999). *Fundamentals of enzymology*. Oxford: Oxford University Press.

4. Voet, D. and Voet, J.G. (2004). *Biochemistry.* 3rd Ed., John Wiley & Sons, Inc. USA.

Additional Resources

1. Sheehan, D. (2010). *Physical biochemistry: Principles and applications*. Chichester: Wiley-Blackwell.

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
I.	Students will learn about the diverse functions of proteins, about hierarchy of protein structures and structure and classification of amino acids.	Traditional chalk & board method with power-point presentations. Group Discussions with examples.	Numerical problems on pKa and pI of amino acids and exercises on protein sequencing will be given.
II.	Knowledge about tertiary and quaternary structure of proteins. Basic concepts of protein folding and role of chaperones.	Traditional chalk & board method with power-point presentations. Research papers will be discussed and Videos will be shown.	Class presentations and discussions. Post lecture students will be given home assignments for assimilation of concepts.
III.	Students will understand the principles and applications of biochemical techniques used for protein purification.	Traditional chalk & board method with power-point presentations. Group discussions.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts.
IV	Students will gain knowledge about the kinetics of enzyme catalyzed reaction.	Traditional chalk & board method with power-point presentations. Group discussions with examples	Discussions on different types of enzymes, specific activity and reaction rates.
V.	Students will understand the mechanism of enzyme action and regulation of enzyme activity.	Traditional chalk & board method with power-point presentations. Group discussions with examples.	Discussions and class tests. Post lecture students will be given home assignments to enhance their learning.
VI.	Students will acquire knowledge about the various applications of enzymes in therapeutics and industries.	Traditional chalk & board method with power-point presentations. Group Discussions with examples.	Assignments on specific enzymes to each student for their applications in industries.

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

5. Teaching Plan

Week 1: Amino acids and their properties. Biologically important peptides - hormones, antibiotics and growth factors.Conjugated proteins, multimeric proteins and metalloproteins.Diversity of proteins.Organization of protein structure- primary, secondary, tertiary and quaternary structures.

Week 2: Protein sequencing- Edman degradation. Solid phase peptide synthesis. Nature of stabilizing bonds- covalent and non covalent.Peptide bond- dihedral angles. Ramachandran map, Secondary structure- Helices, sheets and turns.

Week 3: Tertiary and quaternary structures. Motifs and domains.Structures of myoglobin and haemoglobin. Oxygen binding curves, influence of 2,3-BPG, CO_2. Concerted and sequential models for allosteric proteins.Haemoglobin disorders.

Week 4: Denaturation and renaturation of proteins. Introduction to thermodynamics of folding.Role of chaperones, chaperonins and PDI. Defects in protein folding: Alzheimer's and Prion based.

Week 5: Ammonium sulphate fractionation, dialysis. Ion exchange chromatography, molecular sieve chromatography, affinity chromatography.

Week 6: HPLC and FPLC. Gel electrophoresis, SDS-PAGE, IEF and 2-D electrophoresis.

Week 7: Nature of enzymes - protein and non-protein (ribozyme, abzymes).Cofactor and prosthetic group.Classification of enzymes. Fischer's lock& key and Koshland's induced fit hypothesis. Enzyme specificity.Factors affecting enzyme activity.

Week 8: Enzyme Kinetics- Michaelis-Menten equation, Lineweaver-Burk plot. Determination of Km, Vmax, Kcat.

Week 9: Enzyme inhibition, irreversible and reversible (competitive, uncompetitive, non-competitive, mixed). Mechanism based inhibitors.

Week 10: Acid-base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes. Coenzymes.

Week 11: Allosteric regulation and feedback inhibition (ATCase), reversible covalent modification (glycogen phosphorylase). Proteolytic cleavage-zymogen.Isoenzymes.Multienzyme complex.

Week 12: Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases), Enzyme immunoassay (HRP), enzyme therapy (Streptokinase). Metal based drug interaction. Enzyme immobilization and its applications.

6. Keywords

Proteins, Peptide bond, Conformation, Enzyme, Catalysis, Kinetics, Inhibition.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Cell Biology (BS C-6)
Semester – III

1. Course Objective

The objective of the course is to introduce to the students, the basic concepts and processes in cell biology. The emphasis will be on understanding of structure and function of cell organelles, how they communicate with each other, how cell division and regulation occurs in somatic cells and in germ cells. The practical content of this course is designed to understand the cellular diversity, cell measurement methods, cell division, different staining procedures and tonicity through different laboratory excercises.

2. Course Learning Outcomes

- Students will be able to understand cell and its biology which will help them to get an insight into the origin of cells, cell diversity, cellular structure, survival and function.
- Students will learn the basic difference between prokaryotic and eukaryotic cells, various components of membranes and organelles, how cells obtain energy, synthesize new molecules, proliferate and communicate.
- Students will acquire knowledge about how cells divide by means of meiosis and mitosis and will be able to correlate different factors which control cell cycle progression.
- They will learn and appreciate the role of receptors and ligands in cell signalling.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: An Overview of Cells, Cell Wall and Cell Membrane No. of Hours: 12

History of cell biology, cell theory, overview of prokartyotic and eukaryotic cells, plant and animal cells, phages, virioids, mycoplasmas, prions.Cell wall, distribution, chemical composition, functions and variations in prokaryotic and eukaryotic cells (primary and secondary wall). Structure and functions of membrane, models of membrane structure, transport across membranes (with examples): simple diffusion, facilitated diffusion, active transport (Na+/K+ pumps, sodium/glucose symport, proton pumps) and passive transport. Phagocytosis, pinocytosis, exocytosis.

Unit II: Mitochondria, Chloroplasts, and Nucleus and Glyoxysomes No. of Hours: 8

Structural organization and function of mitochondria, chloroplast and nucleus, (electron transport chain and oxidative phosphorylation), marker enzymes, biogenesis of mitochondria and chloroplasts, transport in mitochondria and chloroplasts (Tim/Tom; Tic/Toc) and semi-autonomous nature of mitochondria and chloroplast. Nuclear

envelope, structure of nuclear pore complex, nuclear lamina, transport across nuclear membrane. Glyoxysomes function.

Unit III: Cytoskeleton system, Cellular Movement, Extra Cellular Matrix and Cell interactions. No. of Hours: 8

Structure and organization of microfilaments, intermediate filaments, microtubules, their functions, role of motor proteins (Kinesin, Dynein, myosin) in cellular movement, cilia and flagella. Extracellular matrix: composition and function (collagens, elastins, adhesive glycoproteins, fibronectins, integrins). Glycocalyx, cell-cell junctions, adhesive junctions, gap junctions and tight junctions.

Unit IV: Endomembrane system and peroxisomes No. of Hours: 8

Structure and functions of endoplasmic reticulum and Golgi apparatus, protein trafficking, coated vesicles in cellular transport processes, GERL. Structure, polymorphic form and functions of lysosomes. Structure and function of peroxisomes.

Unit V: Signal transduction mechanism No. of Hours: 4

Signaling molecules and their receptors, functions, brief introduction of the six types of signaling pathways, intracellular signal transduction pathways, GPCR, protein kinase associated receptors.

Unit VI: Cell cycle and regulation, programmed cell death and cancer No. of Hours: 8

Overview of cell cycle. Regulation: Various check points and the role of cyclins and Cdks. Overview of mitosis and meiosis. Programmed Cell Death.Biology and elementary knowledge of development and causes of cancer. Salient features of transformed cells. Tumor viruses, oncogenes and suppressor genes.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. Estimation of cell size by micrometry.
2. To study plasmolysis and deplasmolysis in cell.
3. To identify Gram positive and Gram negative bacteria by Gram staining.
4. Preparation of temporary slides of the following (any two):
    i. Cytochemical staining of polysaccharides by PAS
    ii. Cytochemical staining of proteins by Bromophenol blue
    iii. Cytochemical staining of mitochondria by Janus Green B.
5. Study of ultastructure of cell (Plasma membrane, Nucleus, Nuclear Pore Complex, Chloroplast, Mitochondrion, Golgi bodies, Lysosomes)
6. Study of different stages of mitosis by temporary preparation/ permanent slides of onion root tips.
7. Study of different stages of meiosis by temporary preparation /permanent slides.

3.3 REFERENCES

1. Becker, W. M., Kleinsmith, L. J., Bertni, G. P. (2009).*The World of the Cell* (7th Ed.). Pearson Benjamin Cummings Publishing, San Fransisco.
2. Cooper, G.M. and Hausman, R.E., (2009). *The Cell: A Molecular Approach*.(7th ed.). ASM Press & Sunderland (Washington DC), Sinauer Associates, MA.
3. Karp, G., (2010). *Cell and Molecular Biology: Concepts and Experiments* (8th ed.). John Wiley & Sons.

Additional Reading

1. EDP De Robertis, and RE De Robertis (2009).*Cell and Molecular Biology* (8th Ed.). Lippincott Williams and Wilkins, Philadelphia.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7^{th}ed.). W.H. Freeman & Company (New York).

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
I.	Students will learn about the origin of cells, cell diversity, cellular structure, survival and function.	Traditional chalk and board method with power-point presentations. Group Discussions with examples.	Assignments will be given to enhance the learning and understanding.
II.	The students will learn about structural organization and function of mitochondria, chloroplast, nucleus and Glyoxysomes	Traditional chalk and talk method of teaching; powerpoint presentations;	Regular question-answer sessions in the class. Class tests will be conducted for internal assessment
III.	The students will learn about various cellular movements and how cell communicate with each other	Traditional chalk and talk method of teaching; powerpoint presentations; Diagrams or additional material may be shown as slides.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment
IV	Students will learn about about endomembrane system and protein trafficking	Traditional chalk and talk method; powerpoint presentations; Students will be encouraged for group discussions.	Regular question-answer sessions in the class. Class tests will be conducted for internal assessment.
V.	Students will be able to	Power point presentations;	Various analytical

	explain role of receptors and ligands in cell signaling	Chalk and board method of teaching; Student interaction in class.	problems will be assigned to students related to cell signaling.
VI.	Students will learn about how cells divides and about different factors which control cell cycle progression and how unregulated cell division leads to cancer	Chalk & board method of teaching; Group discussions; Powerpoint presentations to enhance understanding.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.

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

5. Teaching Plan

Week 1: History of cell biology, cell theory, overview of prokartyotic and eukaryotic cells, plant and animal cells, phages, virioids, mycoplasmas, prions.

Week 2: Cell wall, distribution, chemical composition, functions. variations in prokaryotic and eukaryotic cells (primary and secondary wall). Structure and functions of membrane, models of membrane structure,

Week 3: Transport across membranes (with examples): simple diffusion, facilitated diffusion, active transport (Na+/K+ pumps, sodium/glucose symport, proton pumps) and passive transport. phagocytosis, pinocytosis, exocytosis.

Week 4: Structural organization and function of mitochondria, chloroplast and nucleus, (electron transport chain and oxidative phosphorylation), marker enzymes, biogenesis of mitochondria and chloroplasts, transport in mitochondria and chloroplasts (Tim/Tom; Tic/Toc) and semi-autonomous nature of mitochondria and chloroplast.

Week 5: Nuclear envelope, structure of nuclear pore complex, nuclear lamina, transport across nuclear membrane. Glyoxysomes function.

Week 6: Structure and organization of microfilaments, intermediate filaments, microtubules, their functions, role of motor proteins (Kinesin, Dynein, myosin) in cellular movement, cilia and flagella.

Week 7: Extracellular matrix: composition and function (collagens, elastins, adhesive glycoproteins, fibronectins, integrins). Glycocalyx, cell-cell junctions, adhesive junctions, gap junctions and tight junctions.

Week 8: Structure and functions of endoplasmic reticulum and Golgi apparatus, protein trafficking, coated vesicles in cellular transport processes, GERL.

Week 9: Structure, polymorphic form and functions of lysosomes. Structure and function of peroxisomes.

Week 10: Signaling molecules and their receptors, functions, brief introduction of the six types of signaling pathways, intracellular signal transduction pathways, GPCR , protein kinase associated receptors.

Week 11: Overview of cell cycle. Regulation: Various check points and the role of cyclins and Cdks. Overview of mitosis and meiosis.

Week 12: Programmed Cell Death. Biology and elementary knowledge of development and causes of cancer. Salient features of transformed cells. Tumor viruses, oncogenes and suppressor genes.

6. Keywords

Cell Structure, Cell cycle, Organelles, Mitochondria, Cytoskeleton, Nucleus.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Ecology (BS C-7)
Semester – III

1. Course Objective

The course will enable students to understand the basic concepts in ecology and levels of organization. It will help them understand various aspects of a population and interactions among individuals of same as well as different species. It will help them to understand the structure and functions of community and its processes. Students will be able to understand the components of an ecosystem, energy flow and nutrient cycling. The course covers basics concepts as well as applied aspects required in restoration of degraded ecosystems. Students will be able to understand trade-off in life history characteristics of organism and various behaviours shown by organisms.

2. Course Learning Outcomes

- Students will be able to comprehend the principles and applications of ecology and ecosystem.
- The course will create awareness about the importance of ecosystem in general and the effects of changes in ecosystem.
- Students will understand the techniques used for the quantitative and qualitative estimation of biotic and abiotic components of an ecosystem.
- Students will gain knowledge about the density, frequency and diversity of species in an ecosystem.
- Students will understand the key factors responsible for changes in natural ecosystem such as urbanization and human interference.
- Students will perform literature review; scientific writing as well as presentations; and participate in citizen science initiatives from an ecological perspective.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Ecology No. of Hours: 6

Relevance of studying ecology, History of ecology, Autecology and synecology, levels ofOrganization, Laws of limiting factors (Liebig's law of minimum, Shelford's law of tolerance), ecological range (Eury, Steno). Ecological factors (abiotic and biotic): temperature, light and soil.

Unit II: Population Ecology No. of Hours: 14

Population: Unitary and Modular populations; Metapopulation: Density, natality, mortality,life tables, fecundity tables, survivorship curves, age ratio, sex ratio, dispersal

and dispersion;carrying capacity, population dynamics (exponential and logistic growth equation andpatterns), r and K selection, density-dependent and independent population regulation; Niche concept, Population interactions: Positive and negative interactions; Competition, Gause's Principle for competition with laboratory and field examples, Lotka-Volterra equation for predation.

Unit III: Community Ecology No. of Hours: 8

Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices; Ecotone and edge effect; Community dynamics (succession): Primary and secondary succession, Succession on a bare rock. Climax: monoclimax and polyclimax concepts (preclimax, postclimax, disclimax etc.). Concept of keystone, indicator, umbrella and flagship species.

Unit IV: Ecosystem Ecology No. of Hours: 8

Concept, components, types of ecosystem with one example of Pond ecosystem in detail (abiotic and biotic components, BOD, eutrophication).Energy flow (Grazing and Detritus food chain), linear and Y-shaped energy flow model, food web.Ecological pyramids and Ecological efficiencies.Nutrient cycle with one example of Nitrogen cycle.

Unit V: Restoration Ecology No. of Hours: 6

Introduction to ecology of perturbance; Major ecological disturbances (Physical and biological origin): Flood, fire invasive species, anthropogenic disturbance; Management of degraded ecosystems**.**

Unit VI: Behavioral Ecology No. of Hours: 6

Social, reproductive and territorial behavior, Evolution of optimal life history, Trade-offs, semelparity and iteroparity.

3.2 PRACTICALS

TOTAL HOURS: 48 CREDITS: 2

1. (a) To understand the principle and working of ecological instruments such as Anemometer, Hygrometer, Luxmeter, Rain gauge, turbidity meter, pH meter, Soil thermometer, Min-Max thermometer.
   (b) To observe and record microclimatic variations (light intensity, temperature and wind velocity) at different sites in the campus.
2. (a) To study biotic interactions using specimens/ photographs/ permanent slides of Parasitic angiosperms, Saprophytic angiosperms, root nodules, velamen roots and lichens
   (b) To study plant-microbe interactions by preparing temporary stained mounts of VAM fungi / mycorrhizal roots

3. To determine a minimal quadrat area for sampling and determine density, frequency and abundance of the vegetation by quadrat method
4. (a) To determine the texture, density, bulk density, particle density and pore space in the given soil sample
   (b) To determine pH, Cl, SO4, NO3, base deficiency, organic matter, cation exchange capacity in the given soil sample
5. To estimate dissolved oxygen content of given water sample using Winkler's method.
6. Plotting of survivorship curves from hypothetical life table data.

3.3 REFERENCES

1. Barrick, M., Odum, E. P., Barrett, G. W., (2005).*Fundamentals of Ecology*.5th Edition.Cengage Learning.
2. Miller, G., T., & Spoolman, S..(2016).19th Edition.*Living in the Environment.* Cengage Learning.
3. Ricklefs, R. E., & Miller, G. L., (2000).*Ecology*, 4thEdition 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.

MOOCs

1. 'Ecology: Ecosystem Dynamics and Conservation from American Museum of Natural History on Courserahttps://www.classcentral.com/course/coursera-ecology-ecosystem-dynamics-and-conservation-10618
2. http://www.usu.edu/search/?q=Gray_March_26_DisturbanceEcology
3. https://alison.com/course/diploma-in-ecology-studies
4. https://swayam.gov.in/ Any ecology based online course that may be available during the semester, depending on its relevance to the present syllabus

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
I	Students will learn about the basics concepts in ecology, levels of organization and laws governing ecological interactions	Teaching using chalk and board; Power point presentations; discussion sessions in the class	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
II	Students will learn about characteristics of a population, its dynamics and regulation. They will learn about competition and predation in detail among various intra and interspecific interactions.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class and associated practicals	Oral questions will be asked in the class. Class tests will be conducted for internal assessment. Assignments to test their understanding of the unit
III	Students will be able to define community and enlist different characters of community. They	Teaching using chalk and board; Power point presentations; Group	Class tests will be conducted for internal assessment. Students

	will be able to explain process of succession and concepts associated with climax	discussion sessions in the class and practicals. Field visits and visit to a Biodiversity Park will provide students a practical or hands on knowledge of the subject.	will be given worksheets / assignments to test their understanding of the unit
IV	Students will understand the concept of ecosystem, its structure and function and dynamics.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class; Role play	Class tests will be conducted for internal assessment. Students will be given worksheets / assignments to test their understanding.
V	Students will know how disturbances can upset various ecosystems and humans. They will learn how degraded ecosystems can be managed**.**	The case study approach with real-life examples from the field to get a better understanding of the subject and its applications.	Students will be given assignments to test their understanding of the concepts.
VI	Students will be able to understand trade-off in life history characteristics of organism and various behaviours shown by organisms.	Teaching using chalk and board; Power point presentations; Group discussion sessions in the class	Students will be given assignments to test their understanding of the unit

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

5. Teaching Plan

Week 1: Relevance of studying ecology, History of ecology. Population: Unitary and Modular populations; Metapopulation: Density, natality, mortality, dispersal and dispersion

Week 2: Autecology and synecology, levels of Organization. Laws of limiting factors (Liebig's law of minimum, Shelford's law of tolerance), ecological range (Eury, Steno). Life tables , Fecundity tables

Week 3: Ecological factors (abiotic and biotic): temperature, light ,Soil- characteristics and horizons. Survivorship curves, age ratio, sex ratio, Carrying capacity.

Week 4: Community structure: Dominance, diversity, species richness, abundance, stratification; Diversity indices . Population dynamics (exponential and logistic growth equation and patterns) continued in week 5

Week 5: Ecotone and edge effect; Community dynamics (succession): Primary and secondary succession. Population dynamics (exponential and logistic growth equation and patterns) density-dependent and independent population regulation

Week 6: Succession on a bare rock.Climax: monoclimax and polyclimax concepts (preclimax, postclimax, disclimax etc.). Population interactions: Positive and negative interactions; Niche concept

Week 7: Concept of keystone, indicator, umbrella and flagship species. Competition, Gause's Principle for competition with laboratory and field examples

Week 8: Concept, components, types of ecosystem with one example of Pond ecosystem in detail (abiotic and biotic components .Lotka-Volterra equation for predation.

Week 9: BOD, eutrophication).Energy flow (Grazing and Detritus food chain), linear and Y-shaped energy flow model, food web.Nutrient cycle with one example of Nitrogen cycle.

Week 10: Introduction to ecology of perturbance; Major ecological disturbances (Physical and biological origin) Social, reproductive and territorial behavior

Week 11: Flood, fire invasive species, anthropogenic disturbance .Evolution of optimal life history.r and K selection.

Week 12: Management of degraded ecosystems**.** Trade-offs, semelparity and iteroparity.

6. Keywords:

Population, Niche, Behavioral Ecology, Predation, Community, Degraded Ecosystem.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Systems Physiology (BS C-8)
Semester –IV

1. Course Objective

The course provides an understanding of fundamental principles of animal physiology and how these principles are incorporated into adaptations of different animal groups. The curriculum emphasizes on integrating the knowledge of how systems within diverse organisms function and respond to changes in their environment. A comprehensive way to understand the complexity of an organ system is to cover the comparative aspects of animal physiology. An applied theme of the paper is based on the "Krogh's principle", named after the Danish physiologist August Krogh, winner of the Nobel Prize in Physiology in 1920, which proposes use of specific organisms convenient to study specific questions to address the central concept of evolutionary adaptations. This approach proves to be of practical value and provides the basis to understand vital functions in organisms.

2. Course Learning Outcomes

- Students will know how animals obtain energy from their environment.
- Students will understand the unique role of various organs and organ systems in performing various vital functions.
- Students will understand the role of physiology in adapting to various environments.
- Students will appreciate the importance of homeostasis in different animals.
- Students will learn to apply critical thinking and integrate scientific knowledge to understand the basic physiological principles which led to diverse evolutionary adaptations.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Production of Energy No. of Hours: 7

Feeding patterns found in different animals; Intracellular and extracellular digestion, digestive enzymes, cellulose digestion in animals

Unit II: Gas Exchange In Organisms No. of Hours: 7

Physiology of aquatic and terrestrial breathing; respiratory organs in aquatic and terrestrial organisms: tracheain insects, gills in fishes, lungs in birds; role of skin in respiration

Unit III: Bulk Transport No. of Hours: 8

General plan of circulatory system in invertebrates and vertebrates: closed and open systemof circulation, single circulation and double circulation: circulation patterns of cockroach, bony fishes and amphibians.Components of blood and its functions.Physiology of vertebrate heart: cardiac output, regulation of heartbeat-Starling's law

Unit IV: Regulatory Physiology No. of Hours: 18

Homeostasis in animals: regulation of water and solutes in aquatic and terrestrial animals; osmoconformers and osmoregulators; osmoregulatory organs: gills in fishes, rectal glands and nasal glands in birds; physiology of osmoregulation in marine invertebrates, elasmobranchs and bony fishes (freshwater and marine); water balance in terrestrial animals: arthropods and kangaroo rat
Excretion of nitrogenous wastes in animals: contractile vacuole,nephridia and malphigian tubules; ammonotelic,ureotelic and uricotelic organisms.
Patterns of thermoregulation: heat exchange with the environment. Ectotherms: tolerance to high temperature (lethal temperature), tolerance to cold and freezing temperature (freeze tolerant and intolerant animals). Endotherms: thermogenesis and regulation of body temperature. Structural and functional adaptations to temperature stress (taking examples of arctic fox, penguins, and camels)

Unit V: Integrative Physiology No. of Hours: 8

An overview of neuronal structure and function; general principles of sensory physiology- chemoreceptors (gustatory and olfactory); mechanoreceptors (statocyst in invertebrates and lateral line system of fishes);sonar system in bats; electroreceptors (electric organs in fishes); thermoreceptors.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Effect of isotonic, hypotonic and hypertonic saline solutions on erythrocytes
2. Preparation of temporary mounts: nerve cells
3. Enumeration of white blood cells using haemocytometer
4. Preparation of blood smear and Differential Leucocyte Count (D.L.C)
5. Study of permanent slides of mammalian oesophagus, stomach, ileum, rectum, liver, trachea, lung, kidney, skin
6. Mounting of septal and pharyngeal nephridia of earthworm (subject to UGC guidelines).

3.3 REFERENCES

1. Moyes, C. D., & Schulte, P. M. (2008). Principles of Animal Physiology. San Francisco, CA: Pearson/Benjamin Cummings.
2. Randall, D. C., Burggren, W. W., & French, K. (2002). Eckert Animal Physiology. New York: W. H. Freeman.
3. Schmidt-Nielsen, K. (2010). Animal Physiology: Adaptation and Environment. Cambridge: Cambridge University Press.

Additional Sources

1. Prakash, G. (2012). *Lab Manual on Blood Analysis and Medical Diagnostics*. S. Chand and Co. Ltd.
2. Reece, J. B., & Campbell, N. A. (2011). *Campbell Biology*. Boston: Benjamin Cummings / Pearson.

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
I	Students will learn how animals obtain energy from their environment.	The traditional chalk and talk method supplemented with power point presentations; Discussion of e-resources. Study of digestive organs with help of histology sections	Oral questions will be asked in the class. Students will be asked to gather information/videos from reputed online sources explaining functioning of various systems.
II	Students will learn about the respiratory physiology of aquatic and aerial organisms.	The traditional chalk and talk method supplemented with power point presentations; Oral discussion sessions in the class.Short video demonstrations displaying respiration process	Problems will be assigned to encourage them to explore more about the concept. Class tests will be conducted for internal assessment
III	Students will learn about the circulatory system in invertebrates and vertebrates, blood components in various organisms and physiology of vertebrate heart.	The traditional chalk and talk method supplemented with power point presentations; Students will study blood cells under a microscope	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.Class tests will be conducted for internal assessment
IV	Students will learn the importance of homeostasis in different animals	The traditional chalk and talk method supplemented with power point presentations; Students will observe effect of osmosis on erythrocytes	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
V	Students will learn about the integration of different systems and its importance	Students will prepare nerve cell mounts; Visit of students to an Institute of Eminence/ Organizing talks by eminent scientists/ physicians	Students will be asked to give short presentations related to the integration of various systems.

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

5. Teaching Plan

Week 1: Feeding patterns found in different animals; Intracellular and extracellular digestion.

Week 2: Digestive enzymes, cellulose digestion in animals. Physiology of aquatic and terrestrial breathing.

Week 3: Respiratory organs in aquatic and terrestrial organisms: trachea in insects, gills in fishes.

Week 4: Respiratory organs in terrestrial organisms: lungs in birds; role of skin in respiration. General plan of circulatory system in invertebrates and vertebrates: closed and open system of circulation, single circulation and double circulation: circulation patterns of cockroach.

Week 5: Circulation patterns of bony fishes and amphibians. Components of blood and its functions. Physiology of vertebrate heart: cardiac output.

Week 6: Physiology of vertebrate heart: regulation of heartbeat- Starling's law. Homeostasis in animals: regulation of water and solutes in aquatic and terrestrial animals; osmoconformers and osmoregulators.

Week 7: Osmoregulatory organs: gills in fishes, rectal glands and nasal glands in birds; physiology of osmoregulation in marine invertebrates, elasmobranchs and bony fishes (freshwater and marine).

Week 8: Water balance in terrestrial animals: arthropods and kangaroo rat. Excretion of nitrogenous wastes in animals: contractile vacuole, nephridia and malphigian tubules; ammonotelic, ureotelic and uricotelic organisms.

Week 9: Patterns of thermoregulation: heat exchange with the environment. Ectotherms: tolerance to high temperature (lethal temperature), tolerance to cold and freezing temperature (freeze tolerant and intolerant animals).

Week 10: Endotherms: thermogenesis and regulation of body temperature. Structural and functional adaptations to temperature stress (taking examples of arctic fox, penguins, and camels)

Week 11: An overview of neuronal structure and function; general principles of sensory physiology- chemoreceptors (gustatory and olfactory);

Week 12: General principles of sensory physiology- mechanoreceptors (statocyst in invertebrates and lateral line system of fishes); sonar system in bats; electroreceptors (electric organs in fishes); thermoreceptors.

6. Keywords

Homeostasis, Buoyancy, Respiration, Sensory physiology, Osmoregulation, Thermoregulation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Molecular Biology (BS C-9)
Semester – IV

1. Course Objective

The objective of the course is to introduce to the students the basic knowledge about how DNA is replicated, how genes are transcribed and how the process of translation takes place in prokaryotes and eukaryotes. The students can apply this knowledge in enhancing their analytical and problem solving skills and to develop an interest in the field of molecular biology to pursue research. It will also enable the students to apply the knowledge gained to tackle various challenges in pharmacology and medicine.

2. Course Learning Outcomes

- Students will acquire basic knowledge about the structure of DNA, about organization of genome in various life forms and how DNA is replicated in cells.
- Students will acquire basic knowledge about the process of transcription, RNA processing and translation in prokaryotes and eukaryotes.
- Students will learn about the various ways in which the DNA can be damaged leading to mutations and lesions and different ways to repair DNA damage.
- Students will learn about the various ways in which these biological processes are regulated and the significance of regulation in maintaining life forms.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Nucleic Acids: Structure and Organization No. of Hours: 8

History of discovery of DNA, features of the double helix, various forms of DNA. Denaturation and reassociation of DNA, hyperchromicity, melting temperature, factors affecting T_m of DNA molecules.Types of RNA and their structure.Definition of a gene, organization of genes in viruses, bacteria and eukaryotes. Complexity of eukaryotic genes and chromosomes, supercoiling of DNA and its importance, linking number, topoisomerases, inhibitors of topoisomerases and their application in medicine, Nucleosome structure and packaging of DNA into higher order structures.

Unit II: Replication of DNA No. of Hours: 8

General features of DNA replication, the chemistry of DNA synthesis, DNA polymerase, the replication fork, enzymes and proteins in DNA replication, E coli DNA polymerases, stages of replication-initiation, elongation and termination, origin of replication, replication in eukaryotes, end replication problem, telomerase, various modes of

replication. Comparison of replication in prokaryotes and eukaryotes.Inhibitors of replication.

Unit III: Transcription and RNA processing No. of Hours: 12

DNA-dependent RNA polymerase, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, three stages of RNA synthesis (initiation, elongation and termination), rho-dependent and rho-independent termination, Transcription in eukaryotes, Transcription factors, inhibitors of transcription and applications as antibiotics. RNA processing, modification of eukaryotic mRNA at the 5' and the 3' end, splicing introns, alternative splicing, exon shuffling and RNA editing, processing of rRNAs and tRNAs.

Unit IV: Translation No. of Hours: 8

Features of the genetic code, triplet nature, degeneracy, wobble hypothesis. Experimental approaches used to decipher the genetic code. The ribosome as a supramolecular machine, structure of tRNAs. The five stages of protein biosynthesis, charging of tRNAs, aminoacyl-tRNA synthetases, initiation in prokaryotes and in eukaryotes, elongation, termination. Inhibitors of protein synthesis and their application in medicine.

Unit V: DNA damage and Repair No. of Hours: 4

Molecular basis of mutations, types of mutations - transition, transversion, frame shift mutations. DNA damage by hydrolysis, alkylation, oxidation and radiation.Mutations caused by base analogs and intercalating agents.Ames test. Replication errors and their repair, mismatch repair system. Repair of DNA damage-direct reversal of DNA damage, base excision repair, nucleotide excision repair, translesion DNA synthesis.

Unit VI: Regulation of Gene expression No. of Hours: 8

Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains.Regulation of gene expression in bacteria, lac operon and trp operon, induction of SOS response, synthesis of ribosomal proteins. Overview of regulation of gene expression in eukaryotes, heterochromatin, euchromatin, chromatin remodeling, DNA binding activators and co-activators, regulation of galactose metabolism genes in yeast, Riboswitches, RNA interference, siRNA, miRNA.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDIT: 2**

1. Identification of nucleotide bases by paper chromatography
2. Ultraviolet absorption spectrum of DNA/RNA
3. Determination of DNA concentration by A_{260nm}
4. Quantitative estimation of DNA by DPA method
5. Quantitative estimation of RNA by orcinol method
6. Isolation of chromosomal DNA and to assess the purity by A_{260}/A_{280} Ratio
7. Isolation of total RNA from bacteria/yeast

3.3 REFERENCES

1. Nelson, D.L. and Cox, M.M., (2013). *Lehninger: Principles of Biochemistry*. 6th ed., W.H. Freeman & Company (New York).
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., (2008). *Molecular Biology of the Gene.* 6th ed., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York).

Additional Reading

1. Benjamin Lewin; Jocelyn E Krebs; Stephen T Kilpatrick; Elliott S Goldstein (2018). *Lewin's Gene X* , 10th Edition. Bartlett Learning Publishers, LLC.

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
I.	Students will learn about the double helical structure of DNA and understand the importance of supercoiling of DNA.	Traditional chalk and board method with power-point presentations. Group Discussions with examples.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.
II.	Students will learn about DNA replication and various proteins and enzymes involved in replication.	Traditional chalk and board method with power-point presentations. . Group Discussions with examples.	Regular question- answer sessions in the class. Class tests will be conducted for internal assessment
III.	The student will learn about transcription and applications of transcription inhibitors and about how RNA processed in the cell.	Group discussions. Some experiments can be designed into small projects to cultivate critical thinking skills.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment
IV	The students will learn about features of genetic code and about the process of translation.	Digital initiatives such as the Swayam portal, National digital library and open education resources.	Regular question- answer sessions in the class. Class tests will be conducted for internal assessment.
V.	Students will learn about different sources of mutations and various DNA repair mechanisms.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class.	Various analytical problems will be assigned to students related to DNA repair and related disorders.
VI.	The students will gain knowledge about regulation of gene expression concept of operon and regulatory RNAs.	Traditional chalk & board method with power-point presentations.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.

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

5. Teaching Plan

Week 1: History of discovery of DNA, features of the double helix, various forms of DNA. Denaturation and reassociation of DNA, Hyperchromicity, melting temperature, factors affecting T_m of DNA molecules.Types of RNA and their structure.

Week 2: Definition of a gene, organization of genes in viruses, bacteria and eukaryotes. Supercoiling of DNA and its importance, linking number, topoisomerases, inhibitors of topoisomerases and their application in medicine, Nucleosome structure and packaging of DNA into higher order structures.

Week 3: General features of DNA replication, the chemistry of DNA synthesis, DNA polymerase, the replication fork, enzymes and proteins in DNA replication. E coli DNA polymerases.

Week 4: Stages of replication-initiation, elongation and termination, origin of replication.Replication in eukaryotes, end replication problem, telomerase, various modes of replication.Comparison of replication in prokaryotes and eukaryotes.Inhibitors of replication.

Week 5: DNA-dependent RNA polymerase, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, three stages of RNA synthesis (initiation, elongation and termination), rho-dependent and rho-independent termination.

Week 6: Transcription in eukaryotes, Transcription factors, inhibitors of transcription and applications as antibiotics.

Week 7: RNA processing, modification of eukaryotic mRNA at the 5' and the 3' end, splicing introns, alternative splicing, exon shuffling and RNA editing, processing of rRNAs and tRNAs.

Week 8: Features of the genetic code, triplet nature, degeneracy, wobble hypothesis. Experimental approaches used to decipher the genetic code. The ribosome as a supramolecular machine, structure of tRNAs.

Week 9: The five stages of protein biosynthesis, charging of tRNAs, aminoacyl-tRNA synthetases, initiation in prokaryotes and in eukaryotes, elongation, termination. Inhibitors of protein synthesis and their application in medicine.

Week 10: Molecular basis of mutations, types of mutations - transition, transversion, frame shift mutations. DNA damage by hydrolysis, alkylation, oxidation and radiation. Mutations caused by base analogs and intercalating agents.Ames test. Replication errors and their repair, mismatch repair system. Repair of DNA damage-direct reversal of DNA damage, base excision repair, nucleotide excision repair, translesion DNA synthesis.

Week 11: Principles of gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains. Regulation

of gene expression in bacteria, lac operon and trp operon, induction of SOS response, synthesis of ribosomal proteins.

Week 12: Overview of regulation of gene expression in eukaryotes, heterochromatin, euchromatin, chromatin remodeling, DNA binding activators and co-activators, regulation of galactose metabolism genes in yeast, Riboswitches, RNA interference, siRNA, miRNA.

6. Keywords

DNA double helix, DNA replication, DNA damage, Transcription, Translation, Gene regulation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Metabolism And Integration (BS C-10)
SEMESTER – IV

1. Course Objective

The objective of this course is to offer a detailed and comprehensive knowledge about the various metabolic pathways that are operating in the cell for providing both, energy as well as synthesizing the major building blocks present in the cell. It also integrates all the pathways with respect to tissue specificity under healthy conditions and the aberrations that result in disease and disorders. It aims to empower the students for higher education in any field related to research in biological science and in clinical medicine.

2. Course Learning Outcomes

- Students will gain an understanding of the metabolic pathways operating in cell.
- Students will understand of the diversity of metabolic regulation and how this is achieved in different cell types.
- Students will appreciate how these biochemical processes are inter linked and integrated with each other.
- Students will learn about and correlate the specific symptoms in clinical case presentations to metabolic disorders.
- Students will perform and analyze various biochemical assays that will enable them to understand the concepts of clinical biochemistry.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Metabolism No of Hours: 8

Principles of bioenergetics, standard free energy change, metabolic roles of ATP, phosphorylgroup transfer, nucleotidyl group transfer. Experimental approaches to study of metabolism; primary and secondary metabolism. Energetics. Classification of organisms based on utilization of carbon and energy sources.

Unit II: Carbohydrate and Lipid Metabolism No of Hours: 16

Carbohydrates metabolism - Glycolysis, alcoholic and lactic acid fermentation, Pasteur Effect, gluconeogenesis, Cori cycle, glucose-alanine cycle, futile cycle.TCA cycle, HMP shunt, glycogen metabolism. Lipid metabolism - Mobilization of triglycerides, metabolism of glycerol, β-*oxidation* of saturated, monounsaturated and poly-unsaturated fatty acids, even and odd chain fatty acids. Ketogenesis and significance, Biosynthesis of C-16 palmitic acid, brief overview of cholesterol metabolism and lipoprotein cycle.

Unit III: Amino Acid and Nucleotide Metabolism No of Hours: 8

Protein catabolism – Transamination and deamination, Urea cycle, glycogenic and ketogenic amino acids, secondary metabolites from amino acids.Nucleotide metabolism – *De novo* and salvage pathway, porphyrin catabolism.

Unit IV: Oxidative Phosphorylation No of Hours: 4

Components, properties and function of electron transport system, chemiosmotic hypothesis, inhibitors and uncouplers, Shuttle systems.

Unit V: Metabolic Integration No of Hours: 4

Metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse, xenobiotic metabolism.

Unit VI: Metabolic Disorders No of Hours: 8

Inborn errors of metabolism - Phenylketonuria, Alkaptonuria,Maple syrup and Gauchers, Carbohydrate and metabolic disorders - fructose intolerance, lactose intolerance, lactic acidosis, Galactosemia, genetic deficiency of Glucose-6-phosphate dehydrogenase. Lipid and glycogen storage disorders.Lifestyle disorders - Diabetes Mellitus and obesity. Nutritional disorders-Kwashiorkor and Marasmus.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. Estimation of Random Blood Glucose – Glucose Oxidase method
2. Estimation of Oral Glucose tolerance test (O-GTT).
3. Determination of Lipid Profile: Total Cholesterol (TC), High Density Lipoproteins (HDL) and Triglycerides (TG).
4. Estimation of SGPT and SGOT in serum/plasma sample.
5. Estimation of Bilirubin in serum/plasma sample.
6. Estimation of creatinine in serum/plasma sample.
7. Estimation of Urea.

3.3 REFERENCES

1. Nelson, D. L. and Cox, M. M. Lehninger (2008). *Principles of Biochemistry*, 5th Ed., W.H. Freeman and Company (N.Y., USA.).
2. Peter W. Hochachka and George. N. Somero (1973). *Strategies of Biochemical Adaptation.* Saunders College Publishing.
3. Schlegel H.G. (1993). *General Microbiology*. Cambridge University Press Cambridge.
4. Thomas M. Devlin (2006). *Text Book of Biochemistry with Clinical Correlations.* 6th Ed., Wiley-Liss.

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
I	Students will learn about the bioenergetics of metabolic pathways, the energy-yielding and energy-requiring reactions in the cell.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.
II	Students will learn in detail about carbohydrate and lipid metabolism.	Practicals like, oral glucose tolerance test and lipid profile will further enhance the understanding of the students.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
III	Students will learn about amino acid and nucleotide metabolism.	Practicals such as estimation of SGPT and SGOT, bilirubin, creatinine and urea in serum/plasma will help students understand better the concepts of amino acid metabolism.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
IV	Students will understand about the components, properties and function of electron transport system.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
V	Students will learn about the about the integration of various metabolic pathways and metabolic changes during starve-feed cycle, exercise, diabetes and alcohol abuse, xenobiotic metabolism.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
VI	Students will learn about inborn errors of metabolism, disorders related to carbohydrate metabolism, lipid and glycogen storage, lifestyle and nutrition.	Clinical case studies related to metabolic disorders will help the students connect the core cocept with the etiology, symptoms and treatment of such diseases.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Principles of bioenergetics-Standard free energy change, metabolic roles of ATP-Phosphoryl group transfer, nucleotidyl group transfer. Experimental approaches to study of metabolism.

Week 2: Primary and secondary metabolism, Energetics, classification of organisms based on utilization of carbon and energy sources.

Week 3: Carbohydrates metabolism - Glycolysis, alcoholic and lactic acid fermentation, Pasteur Effect, gluconeogenesis.

Week 4: Cori cycle, glucose-alanine cycle, futile cycle, TCA cycle.

Week 5: HMP shunt, glycogen metabolism. Lipid metabolism-Mobilization of triglycerides, metabolism of glycerol, β-*oxidation* of saturated, monounsaturated and poly-unsaturated fatty acids.

Week 6: Even and odd chain fatty acids, Ketogenesis and significance, Biosynthesis of C-16 palmitic acid, brief overview of cholesterol metabolism and lipoprotein cycle.

Week 7: Protein catabolism-Transamination and deamination, Urea cycle, glycogenic and ketogenic amino acids secondary metabolites from amino acids.

Week 8: Nucleotide metabolism – De novo and salvage pathway, porphyrin catabolism. Components, properties and function of electron transport system.

Week 9: Chemiosmotic hypothesis, inhibitors and uncouplers, Shuttle systems.

Week 10: Metabolic changes during starve-feed cycle, exercise, diabetes, alcohol abuse.

Week 11: Xenobiotic metabolism.Inborn errors of metabolism - Phenylketonuria, Alkaptonuria, Maple syrup and Gauchers, Carbohydrate and metabolic disorders - fructose intolerance, lactose intolerance, lactic acidosis, Galactosemia.

Week 12: Genetic deficiency of Glucose-6-phosphate dehydrogenase, Lipid and glycogen storage disorders.Lifestyle disorders - Diabetes mellitus and obesity. Nutritional disorders like, Kwashiorkor and Marasmus.

6. Keywords

Metabolism, Bioenergetics, Metabolic integration, Metabolic disorders, Oxidative phosphorylation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Growth and Reproduction (BS C-11)
Semester V

1. Course Objectives:

The course is designed to allow students to explore the development of plant and animal from juvenile to mature phase. The course aims to enthuse the students to explore the myriad ways in which plants produce fruits and seeds, and encourage them to pursue further studies in pollen biology, fruit set, seed formation and other lucrative activities in economically important plants. The course also explores the fundamentals of reproduction and development of animals mainly vertebrates, from fertilization to organogenesis, primarily for the understandingof tissue differentiation and molecular mechanisms fundamental to development of animals.

2. Course Learning Outcomes

- Students will learn the path of development of plants from juvenile to senescent stages with the accompanying genetical, cellular, physiological and morphological changes.
- Students will appreciate the role of pollinators and get hands on experience of observing patterns on pollen grains, pollen germination, embryo and endosperm dissection, and collect seeds with different dispersal mechanisms.
- Students will understand the reproductive system in animals and human beings so as to relate with the control of population and environmental threats in the current scenario.
- Students will be able to explain how errors in development lead to congenital defects.
- Students will visualize and appreciate concepts learnt in theory and apply experimental approaches to understand these developmental events in the laboratory.

3. Course Contents:

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Growth and Reproduction No. of hours: 4

General growth and reproduction in plants: plant growth curves, Juvenile, Vegetative, and Reproductive phases in growth, senescence and abscission. Reproduction and growth in animals and human beings, Structure of male and female reproductive system

Unit II: Fertilization No. of hours: 12

Sexual reproduction in angiosperms: Structure and organisation of flower, organization of typical tetrasporangiate anther and eight nucleate embryo sac (*Polygonum* type), pre-fertilization events in plants, microgametogenesis and megagametogenesis, anther dehiscence, pollination, pollen-pistil interaction, pollen germination, double fertilization, pre-fertilization barriers to incompatibility.

Reproductive cycles: Estrus cycles (rat, pigs, cattle) and menstrual cycle in human beings, Reproductive hormones, contraception, Gametogenesis- Spermatogenesis and Oogenesis with reference to human.Types of eggs in animals, fertilization of oocyte by a sperm and development of an embryo from zygote.

Unit III: Embryogenesis in Plants and Animals No. of hours: 16

Post fertilization events in plants: Types of embryogenesis, endosperm development, types of endosperm, seed formation, seed dispersal: mechanism and agents, Apomixis: Types and relevance, genetic regulation. Embryogenesis; Types of cleavages; Blastula; Fate maps, Morphogenetic movements during gastrulation; Gastrulation in frog and chick; Fate of germ layers; Neural tube formation, embryonic stem cells, Extra Embryonic membranes in chick and mammal, Implantation, Placenta: Endocrine functions and types based on chorionic villi distribution and histology.

Unit IV: Differentiation No. of hours: 16

Post-embryonic meristem in plants with special reference to *Arabidopsis* embryogenesis.Role of meristem in differentiation, shoot apical meristem, root apical meristem, lateral meristem (vascular and cork cambium), floral meristem, ABC model of flowering, homeobox genes.Formation of organs during development, critical windows of development in humans during pregnancy.Regeneration: Modes of regeneration, epimorphosis (in salamander limb) and compensatory regeneration (Liver).

3.2 PRACTICALS

TOTAL HOURS: 48 CREDITS: 2

1. Study of whole mount and sections of frog (fertilized egg, 2, 4, 8, 16, 24 cell stage, blastula, gastrula-yolk plug stage, neural plate stage, neural tube stage, tadpole larva-external gill and internal gill stage)
2. Study of chick development from live/fertilized eggs (window viewing)
3. Study of whole mount and sections of chick (fertilized egg, primitive streak stage, 24hrs stage, 28hrs stage, 33hrs stage, 38hrs stage, 48hrs stage, 72hrs stage, 96hrs stages) (Hamburger-Hamilton stages)
4. Study different types of mammalian placenta on the basis of histology and morphology
5. Study different stages of micro and megagametogenesis in angiosperms-through permanent slides
6. To study per cent pollen germination using different media
7. To study embryo development in flowering plant/slides
8. To dissect out endosperm and embryo from angiosperm seeds
9. Study of apical and lateral meristem by permanent slides
10. Survey of dispersal mechanisms of seeds
11. Project report on Visit to Zebra Fish culture Lab

3.3 REFERENCES

1. Bhatnagar, S. P., Dantu, P. K., & Bhojwani, S. S. (2018). *The Embryology of Angiosperms, 6th Edition*.Vikas.
2. Gilbert, S. F. (2010). *Developmental Biology, Ninth Edition* (Ninth edition). Sunderland, Mass: Sinauer Associates, Inc.
3. Kalthoff, K. O. (2000). *Analysis of Biological Development* (2 edition). Boston: McGraw-Hill Science/Engineering/Math.
4. Raghavan, V. (2000).*Developmental Biology of Flowering Plants*.New York: Springer.
5. William. J. Larsen.(2001). *Human Embryology* (3 edition). New York: Churchill Livingstone.

Additional readings:

1. Carlson. (2014). *Patten's Foundation Of Embryology 6E* (6 edition). McGraw Hill Education.
2. Wolpert, L., & Tickle, C. (2011).*Principles of Development* (4 edition). Oxford ; New York: OUP Oxford.

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
I	The students will be able to describe the various types of reproduction and growth patterns in animals and plants and structures associated with it.	Projection of videos or short movies will be used. Visit to Zebra fish lab will help understand the process of fertilization and early developmental stages.	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals and class tests will be conducted for internal assessment.
II	The students will be able to explain the various reproductive cycles: Estrus cycles (rat, pigs, cattle) and menstrual cycle in human beings. Contraception, Spermatogenesis and Oogenesis. Fertilization of oocyte by a sperm and development of an embryo from zygote.	Students will be studying the chick development from live/fertilized eggs by performing window viewing method.Projection of videos on the subject will be used time to time to enhance the understanding of the subject.	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals and class tests will be conducted for internal assessment.
III	The students will be able to understand the process of embryogenesis; Morphogenetic movements during gastrulation; Fate of Germ layers; Neural tube formation, embryonic stem cells, Implantation. Placenta: Endocrine functions and types based on chorionic villi distribution and	Study different types of mammalian placenta on the basis of histology and morphology through photomicrographs and histological slides. To study embryo development in flowering plant-slides only. To dissect out endosperm and	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals, Assignments and Class tests will be conducted for internal assessment.

	histology. Explain and describe type of embryogenesis in plants; concept of Apomixis.	embryo from angiosperm seeds.	
IV	The students will be able to describe the formation of organs during development, critical windows of development in humans during pregnancy. Regeneration: Modes of regeneration, epimorphosis and compensatory regeneration. List different types of meristems and genetic regulation of floral meristem.	Study of whole mount and sections of Chick through different developmental stages will be observed to know the developmental time line of organs formation. Study of apical and lateral meristem by permanent slides	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals. Assignments and Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: General growth and reproduction in plants: plant growth curves, Juvenile, Vegetative, and Reproductive phases in growth, senescence, abscission. Reproduction and growth in animals and human beings, Structure of male and female reproductive system.

Week 2: Sexual reproduction in angiosperms: Structure and organisation of flower.Reproductive cycles: Estrus cycles (rat, pigs, cattle) and menstrual cycle in human beings.

Week 3: Organization of typical tetrasporangiate anther and eight nucleate embryo sac (*Polygonum* type), Reproductive hormones, contraception.

Week 4: Pre-fertilization events in plants – microgametogenesis and megagametogenesis, anther dehiscence.Gametogenesis- Spermatogenesis and Oogenesis w.r.t human.Types of eggs in animals

Week 5: Pollination, pollen-pistil interaction, pollen germination, double fertilization, pre-fertilization barriers to incompatibility.Fertilization of oocyte by a sperm and development of an embryo from zygote.

Week 6: Post fertilization events in plants: Types of embryogenesis.Embryogenesis; Types of Cleavages; Blastula; Fate maps, Morphogenetic movements during gastrulation

Week 7: Endosperm development, types of endospermGastrulation in frog and chick; Fate of germ layers

Week 8: Seed formation, seed dispersal: mechanism and agents.Neural tube formation, embryonic stem cells, Extra embryonic membranes in chick and mammal.

Week 9: Seed formation, seed dispersal: mechanism and agents, Apomixis: Types and relevance, genetic regulation Placenta: Endocrine functions and types based on chorionic villi distribution and histology

Week 10: Post-embryonic meristem in plants with special reference to *Arabidopsis* embryogenesis.Formation of organs during development.

Week 11: Role of meristem in differentiation, shoot apical meristem, root apical meristem, lateral meristem (vascular and cork cambium), floral meristem.Critical windows of development in humans during pregnancy.

Week 12: ABC model of flowering, homeobox genes.Regeneration: Modes of regeneration, epimorphosis (in salamander limb) and compensatory regeneration (Liver).

6.Keywords

Growth, Reproduction, Feritilization, Embryogenesis, Differentiation, Regeneration

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Genetics (BS C-12)
Semester V

1. Course Objective

The course in designed to provide the students with an understanding of both classical and modern concepts in genetics. Special emphasis has been laid on the areas of transmission genetics, molecular and developmental genetics, mapping techniques, chromosomal aberrations and population genetics. Practicals are well correlated with the theory topics and facilitate skill-oriented learning outcomes.

2. Course Learning Outcomes

- Students will understand the concept of genotype and phenotype, describe the basic principles of Mendelian genetics and appreciate the various factors that confer genotypic and phenotypic variability.
- Students will understand the inter relationship between environment (Nurture) versus inheritance (Nature) in determining the conversion of genotype to phenotype.
- Students will be able to use the concepts of bacterial and viral genetics to understand resistance patterns and to create linkage and genetic maps.
- Students will be able to describe population structure by genetic variation, pedigree analysis and develop broad and balanced knowledge and understanding of key biological concepts, principles and theories related to evolution, genetic change and speciation.
- Students will be able to bridge the gap between biology and mathematics by providing examples that require use of statistical tools for arriving at a conclusion.
- Students will be able to apply the principles of transmission and inheritance in real life situations.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Genetics No. of Hours: 2

Introduction to the basic principles of heredity. Model organisms: *Escherichia coli*, *Saccharomyces cerevisiae*, *Drosophila melanogaster*, *Caenorhabditis elegans*,*Danio rerio* and *Arabidopsis thaliana*.

Unit II: Transmission Genetics No. of Hours: 18

Mendelian Genetics and Extensions: Mendel's work on transmission of traits, genetic variation, molecular basis of Genetic Information. Principles of Inheritance, Chromosome theory of inheritance, Laws of probability, Incomplete dominance and co-

dominance, Multiple alleles, Lethal alleles, Epistasis, Pleiotropy Penetrance and expressivity, norm of reaction and phenocopy. Human pedigree analysis: Pedigree conventions, characteristics of dominant and recessive inheritance; sex linked, sex influenced and sex limited traits, applications of pedigree analysis. Organelle heredity: Chloroplast mutation/variegation in four 'o clock plant and Chlamydomonas, mitochondrial mutations in Neurospora and yeast, maternal effects, infective heredity-Kappa particles in Paramecium. Chromosomal aberrations: Variations in chromosome number- monosomy and trisomy of sex chromosomes and autosomes. Variations in chromosome structure- inversions, deletions, duplications and translocations.Inheritance of complex traits: Inheritance of complex trait, analysis of quantitative traits, narrow and broad sense heritability, quantitative trait loci (QTL) and their identification, hybrid vigor.

Unit III: Linkage, crossing over and mapping techniques No. of Hours: 4

Linkage and Crossing over, cytological basis of crossing over, Molecular mechanism of crossing over. Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, Interference and Coincidence

Unit IV: Molecular Genetics No. of Hours: 14

Genetics of bacteria and viruses: Complementation test, limitations of cis-trans test, intragenic complementation, rII locus of phage T4 and concept of cistron. Mechanism of genetic exchange - conjugation, transformation and transduction.Gene mapping in bacteria. Sex determination: Genetic basis of sex determination in Humans, Drosophila melanogaster and C.elegans. Genome dynamics-Transposable Genetic Elements. Prokaryotic transposable elements-IS elements, Composite transposons, Tn-3 elements. Eukaryotic transposable elements- Ac-Ds system in maize and P-elements in drosophila, uses of transposons. Epigenetics: Mechanism of dosage compensation; X chromosomal inactivation in humans. Monoallelic expressions.Epigenetic mechanisms of transcriptional regulation.Genomic imprinting.

Unit V: Population and Evolutionary Genetics No. of Hours: 4

Hardy-Weinberg law, predicting allele and genotype frequencies and exceptions to Hardy-Weinberg principle. Molecular evolution - analysis of nucleotide and amino acid sequences, molecular phylogenies, homologous sequences, sequence similarity and alignment, phenotypic evolution and speciation

Unit VI: Introduction to genomics and proteomics No. of Hours: 6

Genomes of bacteria, Drosophila and Humans; Human genome project; Introduction to Bioinformatics, Gene and Protein databases, sequence similarity and alignment, Gene feature identification. Gene Annotation and analysis of transcription and translation; Posttranslational analysis-Protein interaction.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Study of Linkage, recombination, gene mapping using marker based data from Drosophila.
2. Study of Phlox/ Allium karyotype (normal and abnormal).
3. PTC testing in a population and calculation of allele and genotype frequencies.
4. Study of abnormal human karyotype and pedigrees (dry lab).
5. Squash preparation of salivary glands of Dipteran larva to observe polytene chromosomes.
6. Smear technique to demonstrate sex chromatin in buccal epithelial cells.
7. Screening for an auxotrophic mutation in E.coli.

3.3 REFERENCES

1. Griffiths, A. J. F., Wessler, S. R, Carroll, S. B., Doebley, J. (2010). *An Introduction to Genetic Analysis* (10th ed.). W.H. Freeman & Company (New York). ISBN:10: 1-4292-2943-8
2. Pierce, B.A. (2012). *Genetics - A Conceptual Approach* (4th ed.). W.H. Freeman & Co. (New York). ISBN:13: 978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
3. Snustad, D. P., Simmons, M. J. (2015). *Principles of Genetics* (7th ed.). ISBN: 978-1-119-14228-7.

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
I.	Students will get an introduction to principles of heredity and learn about the different model organisms used for genetic studies.	Teaching using chalk and board; Oral discussion sessions in the class.	Oral questions will be asked in the class.
II.	Students will learn about Mendelian Genetics, human pedigree analysis, chromosomal aberrations and inheritance of complex traits. Students will learn the use of statistical tools for testing a genetic hypothesis.	Drosophila crosses as well and numerical problem for testing genetic hypothesis. Students will make their own family pedigrees for physical features and genetic conditions. Preparation of a chromosomal spread will be done using colchicine treated onion root tips.	Students will be given questions that are application based and require use of statistical tools like probability and chi-square analysis and hypothesis testing for goodness of fit.
III.	Understand the concept of recombination and linked genes. Use recombination frequencies to determine gene order and distance. Genetic mapping in	Teaching will be conducted both through black board and power point presentation. Numerical problems for genetic mapping using three point cross would be given for	Internal assessment tests will be conducted. Questions on drawing a genetic map with gene order, map distance. and centromere mapping

	eukaryotes using test crosses. Somatic cell hybridization for locating gene on a chromosome.	practice in class.	
IV	Basics of bacterial and viral genomes. Mechanisms of genetic exchange in prokaryotes. Gene mapping in bacteria.Understand the difference in the genetic basis of sex determination in Humans, *Drosophila and C.elegans.* Epigenetic phenomenon like dosage compensation and Genomic Imprinting.	Teaching will be conducted both through black board mode and power point presentation mode. Practical screening for auxotrophic mutants. Discussions on current topics of epigenetic influences.	Conduct of Internal assessment tests. Power Point presentation on the assigned topics. Students will be given questions that are application based and require analytical skills
V.	Understand concept of gene pool, allelic and genotypic frequencies. Understand Hardy Weinberg principle and its limitations. Understand concept of genetic drift, founder effect, genetic bottleneck. Factors that influence gene flow, fitness of a population and speciation.	Discussions using population genetics based case studies will be conducted. Practical collection of data from population to test Hardy-Weinberg principle.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment Numerical and case study analysis
VI.	Students will be given a brief insight into areas like genomics and proteomics They will be provided some computational training using bioinformatics tools.	Practical computational training on data mining, retrieval, protein structure determination.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Introduction to the basic principles of heredity. Model organisms: *Escherichia coli*, *Saccharomyces cerevisiae*, *Drosophila melanogaster*, *Caenorhabditis elegans,Danio rerio* and *Arabidopsis thaliana*. Mendel's work on transmission of traits, genetic variation, molecular basis of genetic information.

Week 2:Principles of inheritance, chromosome theory of inheritance, laws of probability, incomplete dominance and co-dominance, multiple alleles, lethal alleles, epistasis, pleiotropy penetrance and expressivity, norm of reaction and phenocopy.

Week 3: Pedigree conventions, characteristics of dominant and recessive inheritance; sex linked, sex influenced and sex limited traits. Applications of pedigree

analysis.Inheritance of complex trait, analysis of quantitative traits, narrow and broad sense heritability, quantitative trait loci (QTL) and their identification.Hybrid vigor.

Week 4: Chloroplast mutation/variegation in four ‘o clock plant and Chlamydomonas, mitochondrial mutations in Neurospora and yeast, maternal effects, infective heredity-Kappa particles in Paramecium.

Week 5: Variations in chromosome number- monosomy and trisomy of sex chromosomes and autosomes. Variations in chromosome structure - inversions, deletions, duplications and translocations.

Week 6: Linkage and Crossing over, cytological basis of crossing over, molecular mechanism of crossing over. Recombination frequency as a measure of linkage intensity, two factor and three factor crosses, interference and coincidence.

Week 7: Complementation test, limitations of cis-trans test, intragenic complementation, rII locus of phage T4 and concept of cistron. Mechanism of genetic exchange - conjugation, transformation and transduction.Gene mapping in bacteria.

Week 8: Genetic basis of sex determination in humans, *Drosophila melanogaster and C. elegans* Genome dynamics-transposable genetic elements.Prokaryotic transposable elements-IS elements, Composite transposons, Tn-3 elements.

Week 9: Eukaryotic transposable elements- Ac-Ds system in maize and P-elements in drosophila; uses of transposons. Mechanism of dosage compensation; X chromosomal inactivation in humans.Monoallelic expressions.

Week 10: Epigenetic mechanisms of transcriptional regulation. Genomic imprinting.Hardy-Weinberg law, predicting allele and genotype frequencies and exceptions to Hardy-Weinberg principle.

Week 11: Molecular evolution - analysis of nucleotide and amino acid sequences, molecular phylogenies, homologous sequences, sequence similarity and alignment, phenotypic evolution and speciation. Genomes of bacteria, drosophila and humans.Human genome project.

Week 12: Introduction to bioinformatics, gene and protein databases, sequence similarity and alignment, gene feature identification. Gene annotation and analysis of transcription and translation; Posttranslational analysis-Protein interaction.

6. Keywords

Mendelian laws, Pedigree analysis, Heredity, Chromosomal mutations, Population Genetics, Genomics, Gene mapping.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Immunobiology (BS C-13)
Semester VI

1. Course Objective

The course is designed to focus on the integrative working and regulation of both the innate and induced/adaptive defense mechanism that operate in the vertebrate system as well as in the plant kingdom. It will allow students to differentiate between innate and induced/adaptive immune mechanisms and their importance in maintaining a healthy system. The students will also understand the consequences of an inappropriate immune response. They will be able to appreciate the importance of immunity in medicine and public health and the importance of control of plant diseases in agriculture.

2. Course Learning Outcomes

- Students will have an overview of the immune system and learn about the various cells, organs and tissues of the immune system.
- Students will be able to describe the basic mechanisms, differences and functional interplay of innate and adaptive immunity.
- Students will be able to define the cellular and molecular pathways of humoral and cell-mediated immune responses and appreciate the importance of immune system in health and disease.
- Students will learn about the various preexisting structural and induced defenses in plants and how pathogens can cause disease in plants.
- Students will understand the genetic basis of plant-pathogen interaction and learn about the importance of genetic engineering in control of plant pathogens.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Defense Mechanisms No. of Hours: 2

Overview of defense mechanisms in plants and animals

Unit II: Introduction to Plant Defenses and Innate Immunity in plant No. of Hours: 4

Pre-existing structural defenses (first line of defense) - surface structures (waxy coat, cuticle, epidermal layer, hydathodes, thorns, sclereids), mineral crystals (idioblasts,) and cell wall. Biochemical defenses- secondary metabolites (terpenoids, glycosides, phenolics and alkaloids) Innate Immunity in Plants- Pattern triggered immunity (PTI),

Unit III: Innate Immunity in animals No. of Hours: 8

Anatomical barriers, soluble molecules and membrane associated receptors (PRR) Complement activation by classical, alternate and MBL pathway, biological consequences of complement activation, regulation and complement deficiencies.Haematopoiesis, cells of the innate immune system, primary lymphoid organs; cell adhesion molecules, chemokines, leukocyte extravasation, and the inflammatory response; connections between innate and adaptive immunity.

Unit IV: Induced Defenses in Plants No. of Hours: 8

Factors causing plant stress- abiotic and biotic. Abiotic- strategies and mechanisms, Physiological and cellular responses to drought stress, salinity stress, temperature stress (freezing and heat)
Biotic- Classification of biotic stresses, major pests and diseases of economically important crops, interaction in host-pathogen systems, Flor's gene for gene concept, R gene mediated resistance, effector trigerred immunity (ETI), receptor-elicitor model, Cytological protection and induced resistance. Concept of signal transduction and other host-defense mechanisms. Heatshock proteins, Basic ROS cycle and adaptation during stress, Systemic Acquired Resistance (SAR), Phytoalexins Jasmonic acid, MAPKS,SROS,HPL, systemins, , mechanism of production and scavenging of NO.

Unit V: Adaptive Immunity in Animals No. of Hours: 20

Antigens and haptens, Factors that dictate immunogenicity, B and T cell epitopes.Structure and distribution of classes and subclasses of immunoglobulins (Ig), Ig fold, effector functions of antibody, antigenic determinants on Ig and Ig super family.Monoclonal antibodies; Immunological methods- Antigen-antibody interactions.Secondary lymphoid organs and tissues.B cell maturation and generation of antibody diversity. Humoral immune response against T-dependent and T-independent antigens.Histocompatibility antigens – structure and function, T cell maturation and differentiation – Positive and Negative selection of thymocytes, Antigen Presentation by the exogenous and endogenous pathways, Activation of T cells and cell mediated immunity; Role of NK cells and Antibody dependent cellular cytotoxicity.

Unit VI: Immune dysfunction and applications No. of Hours: 6

Hypersensitivity and Transplantation Immunology; Vaccines; Control of plant pathogens and improving plant resistance by genetic engineering

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDIT: 2**

1. Characterization of diseases symptoms and identification of pathogenic organisms (bacterial- *Xanthomonas campestris;* viral- TMV; fungal- *Puccinia graminis-tritici*, pest and nematodes-*Meloidogyne* spp.).
2. Survey of structural plants defences: viz. cuticle, wax, lignin, bark, thorns, prickles, trichomes, armour in different plants species including thigmonasty, camouflage, mimicry.
3. Precipitation reactions – DID and SRID.
4. Immunoelectrophoresis (IEP), Countercurrent IEP, Rocket IEP

5. Agglutination reaction.
6. ELISA
7. Cell isolation and Counting- Spleen/PBMNC

3.3 REFERENCES

1. B.B.Buchanan, W. Gruissem & R.L.Jones. (2015). *Biochemistry and Molecular Biology of Plants*. Oxford: Wiley Blackwell.
2. Coico, R & Sunshine, G., John (2009). *Immunology: A Short Course*. New Jersey: Wiley& sons.
3. Kindt, T.J., Goldsby, R.A. & Osborne, B.A.(2007) . *Kuby Immunology*. New York: W.H Freeman.
4. Leslie Hudson & Frank C. Hay (1980). *Practical Immunology*. Oxford: Blackwell Scientific
5. Lincoln Taiz & Eduardo Zeiger.(2010). *Plant Physiology*. Sunderland, Mssachusetts: Sinauer associates Inc.

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
I.	An overview on immune mechanisms will be given. Students will be taught Innate Immunity in plants with focus on pre-existing structural and biochemical defences.	Traditional chalk and board method will be used	Students will be asked to correlate the importance of immunity in plants and animals by asking them to site examples from their experience
II.	Students will learn about the cells and organs of the immune system and various innate immune mechanisms and complement pathways.	Chalk and board method will be used and supplemented with powerpoint presentation	MCQ based assignments will be given to students to check their understanding of the subject.
III.	Abiotic and biotic stress in plants will be taught. Importance of reactive oxygen and nitrogen species in defense will be highlighted.Signalling pathways will be dealt with.	Chalk and board method will be used and powerpoint presentation for understanding the important signaling pathways	Oral questions will be asked in the class and class test will be taken
IV	Students will be explained the concept of foreign molecules acting as antigens and antibodies and their basic structure. How antigen and antibody interact with each other will be highlighted.	Chalk and board method will be used and powerpoint presentation will be used to understand the structure of antibodies	Assignments will be given and oral questions asked to check their understanding of the concepts
V.	Students will be taught about MHC structure, function and antigen processing.	Chalk and board method will be used and supplemented with	Class discussion will be encouraged to see if students have understood the concepts

	Students will understand how antibodies are generated in the body. They will understand the importance of humoral immune response in infections.	powerpoint presentation to understand the structure of MHC molecules and generation of humoral response	
VI.	Cytotoxic action of T cells and NK cells will be discussed. importance of vaccines and transplantation of organs& genetic engineering of plants will be discussed.	Powerpoint presentation wiil be used to understand the interaction of T cells and NK cells with target cells and learn the cytotoxic action of these cells.	Students will be asked to read articles related to immunity and its intervention in medicine and group presentation on these topics will be encouraged.

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

5. Teaching Plan

Week 1: Unit 1 Overviewof defense mechanisms in plants and animals. Describe the pre-existing structural defenses in plants.

Week 2: Unit 2 Elaborate on the various pre-existing biochemical defenses in plants. Discuss the various innate immune mechanisms present in plants and animals.

Week 3: Unit 3 Discuss Complement activation by classical, alternate and MBL pathway, biological consequences of complement activation, regulation and complement deficiencies.

Week 4: Unit 3 Elaborate on hematopoiesis, cells and organs of the immune system, inflammatory response; connections between innate and adaptive immunity.

Week 5: Unit 4 Discuss the abiotic and biotic stress in plants, major pests and diseases of economically important crops, interaction in host-pathogen systems.

Week 6: Unit 4 Describe Flor's gene for gene concept, R gene mediated resistance, effector trigerred immunity (ETI), concept of signal transduction and other host-defense mechanisms. heatshock proteins, basic ROS cycle and mechanism of production and scavenging of NO. Systemic Acquired Resistance.

Week 7: Unit 5 Learn about antigens and haptens, factors that dictate immunogenicity, structure and function of classes and subclasses of immunoglobulins . Monoclonal antibodies.

Week 8: Unit 5 Discuss various antigen-antibody interactions: precipitation reactions, agglutination reactions, radioimmunoassays, ELISA, flow cytometry, immunoprecipitation.

Week 9: Unit 5 Learn about MHC restriction, MHC classes, structure, distribution and role of MHC class I and class II proteins . Antigen Processing & Presentation.

Week 10: Unit 5 Describe B cell maturation and generation of antibody diversity. Humoral immune response against T-dependent and T-independent antigens.

Week 11: Unit 5 Elaborate on Cell Mediated Immunity T cell development, General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NK - T cells and antibody dependent cellular cytotoxicity (ADCC).

Week 12: Unit 6 Learn about hypersensitivity and transplantation Immunology, vaccines, control of plant pathogens and improving plant resistance by genetic engineering

6. Keywords

Antigen, Antibody, Complement, Cytokines, Vaccines, Secondary metabolites.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
CORE COURSE
Evolutionary Biology (BS C-14)
Semester VI

1. Course Objective

Theodosius Dobzhansky in 1973 famously argued that"nothing in biology makes sense except in the light of evolution". This course is being offered due to the central importance of evolution in biology and introduces students to all aspects of evolutionary biology. The course aims to make the students familiar with basic history of evolutionary concept, its criticism and development as a science. Students will learn about history of life through fossils and other evidences helping them analyze the evolutionary relationships between species. They will develop a deep understanding of the mechanisms that fuel the evolution of biological systems and will have an insight into the origin and evolution of species.

2. Course Learning Outcomes

- Students will learn about the origins and development of evolutionary thought.
- Students will learn about the compelling evidences in favour of evolution like fossils, comparative anatomy and molecular homologies.
- Students will learn about origin and history of life through fossil record.
- Students will understand how biodiversity is generated by repeated speciationsand lost over time due to mass extinctions.
- Students will how the forces of evolution like variations, natural selection, genetic drift and migration shape populations.
- Students will learn how novelty in organisms arises, how organisms adapt to their environment and about our origins from our primate ancestors.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Historical Review of Evolutionary Concept No. of Hours: 5

Pre-Darwinian ideas: List of contributors influencing Darwin indicated as a *timeline.*
Lamarckism: Merits and demerits. Darwinism: Merits and demerits, Post-Darwinian era: Modern synthetic theory; biomathematics and the theory of population genetics leading to Neo-Darwinism.

Unit II: History of Life No. of Hours: 10

Chemogeny: An overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Current concept of chemogeny: RNA first

hypothesis. Biogeny: Cellular evolution based on proto-cell models (coacervates andproteinoid microspheres). Origin of photosynthesis, Evolution of oxygen and ozone buildup.Evolution of Eukaryotes from Prokaryotes, multicellularity.Cambrian explosion and timeline of plant and animal evolution in the Phanerozoic eon.Mass-scale extinctions: causes, significance and events. Cretaceous: Tertiary Mass Extinction in detail.

Unit III: Evidences of Evolution No. of Hours: 9

Paleobiological: Concept of Stratigraphy and geological timescale; fossil study (types,formation and dating methods). Anatomical: Vestigial organs; Homologous and Analogousorgans (concept of parallelism and convergence in evolution). Taxonomic: Transitionalforms/evolutionary intermediates; living fossils. Phylogenetic: a) Fossil based: Phylogenyof horse as a model. b) Molecule based: Protein model (Cytochrome C); gene model (Globingene family). Basics of molecular phylogenetics.

Unit IV: Forces of Evolution No. of Hours: 12

A. Continuous and discontinuous variations, heritable variations and their role in evolution, recombination and random assortment (basis of sexual reproduction); gene regulation. Concept of micro- and macro-evolution: A brief comparison Natural selection as a guiding force: Its attributes and action Basic characteristics of natural selection. Coloration, camouflage and mimicry, Co-adaptation and co-evolution, Man-madecauses of change: Industrial melanism; antibiotic resistance. Modes of selection, artificial selection, Polymorphism, Heterosis and Balanced lethal systems.

B. Hardy-Weinberg's Law of Genetic Equilibrium. Genetic Drift (Sewall Wright effect) as a stochastic/random force: Its attributes and action. Basic characteristics of drift; selection vs. drift, Bottleneck effect, Founder principle. Alteration in gene frequency (when selection operates), Calculation based on Selection Coefficient and Fitness).Fluctuations in gene frequency (when drift operates): Calculation based on standard deviation.

Unit V: Product of Evolution: Speciation No. of Hours: 6

Concept of species as a real entity- species concept, Mechanisms of speciation, Allopatric,Peripatric, Parapatric and sympatric; Patterns of speciation. Anagenesis and Cladogenesis; Phyletic Gradualism and Punctuated Equilibrium (Quantum Evolution), Basis of speciation: Isolating mechanisms

Unit VI: Human Ancestry and Phylogeny No. of Hours: 6

Primate characteristics and unique Hominin characteristics. Advantages and adaptations to bipedalism.Primate phylogeny leading to Homininline. *Australopithecines, Homo habilis, Homo erectus, Neanderthal man, Archaic and modern Homo sapiens.*Human migration. Theories. Brief reference to molecular analysis of humanorigin – Mitochondrial DNA and Y-chromosome studies.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

(A) Evidences of fossils

1. Study of types of fossils (e.g. Body fossils, trails, casts, moulds and others) and Index fossils of Palaeozoic era

2. Connecting links/transitional forms - Eg. Euglena, Neopilina, Balanoglossus, Chimaera,Tiktaalik, Archaeopteryx, Ornithorhynchus

3. Living fossils - Eg. *Limulus, Peripatus,Latimeria, Sphaenodon*

4. Vestigial, Analogous and Homologous organs using photographs, models or specimen

(B) Selection Exemplifying Adaptive strategies (Colouration, Mimetic form, Co-evolution; Adaptations to aquatic, fossorial and arboreal modes of life**)** using Specimens

(C) Neo-Darwinian Studies

1. Simulation experiments using coloured beads/playing cards to understand the effects of Natural selection on allele frequencies

2. Simulation experiments using coloured beads/playing cards to understand the role of Bottleneck effect and Founder effect on allele frequencies

(D) Phylogeny

1. Digit reduction in horse phylogeny (study from chart),

2. Study of horse skull to illustrate key features in equine evolution

3. Study of monkey and human skull - A comparison to illustrate common primate and unique Hominin features

4. Construction of Phylogenetic tree using morphological characters

Educational visit:

Visit to Geology/ Anthropology museums, Delhi University

3.3 REFERENCES

1. 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.
2. FutuymaD.,(2013)3rd Ed.*Evolutionary Biology,* Sinauer Associates
3. Hall B. K. and Hallgrimson B., (2014) 5th Ed.*Strickberger's Evolution.* Jones and Bartlett
4. Ridley M., (2003) 3rd Ed.*Evolution* Wiley-Blackwell
5. Zimmer C. and EmlenD. J., (2013) 1st Ed. *Evolution: Making Sense of Life*, Roberts & Co.

Additional resources

1. Darwin C., (2003)*The Origin of Species: 150th Anniversary Edition* , Penguin USA
2. https://evolution.berkeley.edu/evolibrary/home.php
3. Kolbert E., (2015)*The Sixth Extinction: An Unnatural History*, Bloomsbury
4. Weiner J. (1995),*The Beak of the Finch: A Story of Evolution in Our Time*, Vintage

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
I	Students will learn about the history of evolutionary concept, its criticism, major theories and development.	Teaching using chalk and board; Power point presentations.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
II	Students will learn about origin and history of life and role of mass extinctions.	Power point presentations; Teaching using chalk and board; Documentaries relevant to the topic will be shown. Visit to geology museum	Class tests will be conducted for internal assessment. Students will be given assignments to test their understanding of the subject.
III	Students will learn about the compelling evidences in favour of evolution like fossils, comparative anatomy and molecular homologies.	Teaching using chalk and board; Power point presentations. Relevant documentaries will be shown. Visit to geology museum.	Class tests will be conducted for internal assessment. Students will be given assignments to test their understanding of the unit
IV	How the forces of evolution like variations, natural selection, genetic drift, and migration shape populations. They will understand how novelty in organisms arises.	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.
V	Students will know about species concept and how new species are formed in course of evolution.	Teaching using chalk and board; Power point presentations.	Class tests will be conducted for internal assessment.
VI	Students will be able to understand human origins from primate ancestors	Teaching using chalk and board; Power point presentations; Visit to Anthropology museum	Students will be given assignments to test their understanding of the subject.

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

5. Teaching Plan

Week 1: Pre-Darwinian ideas, list of contributors influencing Darwin indicated as a *timeline.* Lamarckism, merits and demerits. Paleobiological evidences of evolution. Concept of Stratigraphy and geological timescale.

Week 2: Darwinism, merits and demerits, post-Darwinian era, modern synthetic theory. Fossil study, types, formation and dating methods.

Week 3: Biomathematics and the theory of population genetics leading to Neo-Darwinism. Basics of molecular phylogenetics. Anatomical, vestigial organs; Homologous and Analogousorgans (concept of parallelism and convergence in evolution). Taxonomic, Transitional forms/evolutionary intermediates; living fossils.

Week 4: Phylogenetic evidences of evolution, fossil based. Phylogeny of horse as a model. b) Molecule based – Protein model (Cytochrome C); gene model (Globingene family). Basics of molecular phylogenetics. Concept of species as a real entity- species concept Mechanisms of speciation , Allopatric.

Week 5: Chemogeny, an overview of pre-biotic conditions and events; experimental proofs to abiotic origin of micro- and macro-molecules. Mechanisms of speciation, Peripatric, Parapatric and sympatric; Patterns of speciation , Anagenesis and Cladogenesis; Phyletic Gradualism andPunctuated Equilibrium (Quantum Evolution) cond. in week 6

Week 6: Current concept of chemogeny – RNA firsthypothesis. Biogeny – Cellular evolution based on proto-cell models (coacervates andproteinoid microspheres). Origin of photosynthesis – Evolution of oxygen and ozone buildup.Basis of speciation – Isolating mechanisms

Week 7: Evolution of Eukaryotes from Prokaryotes, multicellularity.Cambrian explosion.Continuous and discontinuous variations,heritable variations and their role in evolution, recombination and random assortment (basis of sexual reproduction); gene regulation.

Week 8: Timeline of plant and animal evolution in the Phanerozoic eon. Concept of micro- and macro-evolution – A brief comparisonNatural selection as a guiding force – Its attributes and action Basic characteristics of naturalselection.

Week 9: Mass-scale extinctions – causes, significance and events. Cretaceous-Tertiary Mass Extinction in detail.Coloration, camouflage and mimicry, Co-adaptation and co-evolution, Man-madecauses of change – Industrial melanism; antibiotic resistance.Modes of selection, artificial selection.

Week 10:Polymorphism, HeterosisandBalanced lethal systems.Hardy-Weinberg's Law of Genetic Equilibrium. Genetic Drift (Sewall Wright effect) as a stochastic/random force – Its attributes and action.Primate characteristics and unique Hominincharacteristics.Advantages and adaptations to bipedalism.

Week 11: Basic characteristics of drift; selection vs. drift, Bottleneck effect, Founder principle.Alteration ingene frequency (when selection operates).Primate phylogeny

leading toHomininline.*Australopithecines, Homo habilis, Homo erectus, Neanderthal man, Archaic and modern Homo sapiens.*

Week 12: Calculation based on Selection Coefficient and Fitness). Fluctuations in gene frequency (when drift operates) – Calculation based onstandard deviation.Human migration – Theories.Brief reference to molecular analysis of humanorigin – Mitochondrial DNA and Y-chromosome studies.

6. Keywords

Darwinism, Chemogeny, Cambrian explosion, mass extinction, Variations, Natural selection, Genetic Drift, Speciation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE
(CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Plant Physiology (BS DSE-1)
Semester - V

1. Course Objective

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 physiology. The course aims to familiarize the students with this important subject alongwith the signaling pathways associated with physiological phenomena.

2. Course Learning Outcomes

- Students will appreciate the processes that occur at cellular level, at the level of organ and whole plant level.
- Students will understand the integration of soil, atmosphere, and plant in carrying out the life processes by plants.
- Students will understand the complex regulation of phenomena of growth, flowering, combating stress etc.
- Students will be able to assess the effect of climate change on some physiological phenomena and investigate mitigation measures.
- Students will be able to use the knowledge gained to help crop growers, fruit farmers, floriculturists and others in the related area.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Plant Nutrition: uptake and distribution No of Hours: 17

Water potential and its components (solute potential, pressure potential, gravimetric potential and matric potential); intercellular water transport (diffusion, mass flow and osmosis), short-distance transport (water absorption by roots), aquaporins, pathway of water movement (apoplast and symplast), water and ion uptake from soil into roots, structural features of xylem which facilitate water and solute transport, root pressure, guttation, ascent of sap, cohesion-tension theory; Transpiration and its significance, factors affecting transpiration, antitranspirants; Mechanism of stomatal movement (starch-sugar hypothesis, proton transport theory). Essential elements (macronutrients and micronutrients, criteria of essentiality, roles), methods of study and use of nutrient solutions (ash analysis, hydroponics and aeroponics), mineral deficiency symptoms, Soil cation exchange capacity, transport of ions across cell membrane-passive transport: simple (Fick's law) and facilitated diffusion (carrier and channel proteins), Donnan

equilibrium, Nernst equation, active transport, proton ATPase pump, P-type ATPase and V-type ATPase, electrochemical gradient, ion flux, uniport, co-transport.
Source-sink relationship, experimental evidence in support of phloem as the site of sugar translocation (aphid technique, girdling experiment), features of phloem cells with reference to photoassimilate translocation (phloem sealing mechanism, P-proteins, sieve tube-companion cells interaction, composition of phloem sap), pressure flow model, mechanism of photoassimilate translocation (phloem loading and unloading).

Unit II: Nitrogen metabolism No of Hours: 8

Biological Nitrogen fixation by free living organisms and in symbiotic association (nodulation, signals between symbionts- *nod* and *nif* genes, structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by GS, GOGAT, GDH, seed storage proteins in legumes and cereals.

Unit III: Plant Growth Regulators No of Hours: 6

Discovery, basic structure and precursors, bioassays, physiological roles and commercial applications of auxins, gibberellins, cytokinins, abscisic acid and ethylene, Introduction to mode of action of hormones; General account of secondary metabolites, allelopathy.

Unit IV: Physiology of Flowering No of Hours: 6

Photoperiodism: SDPs, LDPs, DNPs, photoinductive cycle (perception of photoperiodic signal and florigen), phytochrome (discovery and structure), red and far-red light responses on photomorphogenesis, fluence response, vernalization.

Unit V: Signal transduction and stress physiology No of Hours: 8

Spatial and temporal aspects of signal transduction, signal perception at plasma membrane (characteristic features of membrane receptors, receptor kinases), signal transduction and amplification via second messengers (calcium, lipid signaling molecules, mitogen-activated protein (MAP) kinase cascade, cyclic nucleotides), Plant responses to abiotic stress through signaling pathways; developmental and physiological mechanisms that protect plants against environmental extremes; biotic stress (plant defense mechanisms, PAMP/MAMP triggered immunity (PTI), effector-triggered responses, SAR, pathogenesis-related proteins).

Unit VI: Environmental effects on plant physiological phenomena No of Hours: 3

Effect of increase in CO_2 on photosynthesis and nutritional status of plant and soil, CO_2 fertilization effect on plants, effect of climate change induced warming on enzymes of photosynthesis (Rubisco) and respiration, blockers of photosynthetic electron transport as potential herbicides.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. To determine the osmotic potential of plant cell sap by incipient plasmolytic method.
2. To determine the water potential by weight method.
3. To study the effect of two environmental factors on transpiration of an excised twig.
4. To calculate stomatal index and stomatal frequency of two surfaces of leaves of a mesophyte and a xerophyte.
5. To study the effect of light intensity and carbon dioxide on O_2 evolution in photosynthesis.
6. To demonstrate the activity of nitrate reductase in two plant sources.
7. To perform chemical separation of photosynthetic pigments using solvent extraction method.

Demonstrations

1. Suction due to transpiration
2. Rooting of cuttings
3. Bolting
4. Delay of senescence / fruit ripening
5. Respiration in roots
6. Effect of pH on anthocyanin pigments

3.3 REFERENCES

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 Sources

1. Bhatla, S.C. and Lal M.A. (2018).*Plant Physiology, Development and Metabolism*, Springer Nature, 1st edition.
2. Nobel, P.S. (2009).*Physicochemical and Environmental Plant Physiology*, Academic Press, 4th edition.
3. Uprety, D.C. and Reddy, V.R. (2016).*Crop response to global warming*, Springer.

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
I	Students will learn about the importance of turgor in plant growth, movement of water from the soil into the plant, within the plant body. Students will also learn about the essential elements transported into the plant by water and the mechanisms involved.	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. Practicals designed in such a way so as to reinforce the concepts learnt in theory.
II	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. Power point presentations may be used for explaining certain topics.	Class tests will be conducted for internal assessment. Oral questions will be asked in the class.
III	Students will be familiarized with important plant growth regulators, secondary metabolites and defense mechanism.	Teaching using chalk and board; Oral discussion sessions in the class; Theoretical concepts to be supplemented with projects	Assessment on the basis of practicals performed; Questions will be asked in the class
IV	Students will learn about the importance of light quality and cold conditions in flowering and other growth phenomena.	Teaching using chalk and board; computer animations of physiological phenomena; Power point presentations to augment the chalk and talk method	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
V	Students will gain insights into various stresses affecting plant growth and the signaling pathways involved.	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
VI	Students will learn about the effect of climate change on some plant physiological phenomena.	Visit to institutes to gain insight into the latest developments and actual methodologies; Relating the factual information with the recent progress in the field of climate change.	Worksheets to test the understanding of the unit; students will take up case studies followed by group discussions

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

5. Teaching Plan

Week 1: Water potential and its components (solute potential, pressure potential, gravimetric potential and matric potential); intercellular water transport (diffusion, mass flow and osmosis), short-distance transport (water absorption by roots), aquaporins, pathway of water movement (apoplast and symplast).

Week 2: Water and ion uptake from soil into roots, structural features of xylem which facilitate water and solute transport, root pressure, guttation, ascent of sap, cohesion-tension theory; Transpiration and its significance, factors affecting transpiration, antitranspirants; Mechanism of stomatal movement (starch-sugar hypothesis, proton transport theory).

Week 3: Source-sink relationship, experimental evidence in support of phloem as the site of sugar translocation (aphid technique, girdling experiment), features of phloem cells with reference to photoassimilate translocation (phloem sealing mechanism, P-proteins, sieve tube-companion cells interaction, composition of phloem sap), pressure flow model, mechanism of photoassimilate translocation (phloem loading and unloading); Biological Nitrogen fixation by free living organisms and in symbiotic association (nodulation, signals between symbionts- *nod* and *nif* genes.

Week 4: Structure and function of enzyme Nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by GS, GOGAT, GDH, seed storage proteins in legumes and cereals; Discovery, basic structure and precursors, bioassays, physiological roles and commercial applications of auxins.

Week 5: Discovery, basic structure and precursors, bioassays, physiological roles and commercial applications of gibberellins, cytokinins, abscisic acid and ethylene, Introduction to mode of action of hormones; General account of secondary metabolites, allelopathy.

Week 6: Photoperiodism: SDPs, LDPs, DNPs, photoinductive cycle (perception of photoperiodic signal and florigen), phytochrome (discovery and structure), red and far-red light responses on photomorphogenesis, fluence response, vernalization.

Week 7: Spatial and temporal aspects of signal transduction, signal perception at plasma membrane (characteristic features of membrane receptors, receptor kinases), signal transduction and amplification via second messengers (calcium, lipid signaling molecules, mitogen-activated protein (MAP) kinase cascade, cyclic nucleotides)

Week 8: Plant responses to abiotic stress through signaling pathways; developmental and physiological mechanisms that protect plants against environmental extremes

Week 9: biotic stress (plant defense mechanisms, PAMP/MAMP triggered immunity (PTI), effector-triggered responses, SAR, pathogenesis-related proteins).

Week 10: Effect of increase in CO_2 on photosynthesis and nutritional status of plant and soil, CO_2 fertilization effect on plants, effect of climate change induced warming on enzymes of photosynthesis (Rubisco) and respiration, blockers of photosynthetic electron transport as potential herbicides.

Week 11: Essential elements (macronutrients and micronutrients, criteria of essentiality, roles), methods of study and use of nutrient solutions (ash analysis, hydroponics and aeroponics), mineral deficiency symptoms.

Week 12: Soil cation exchange capacity, transport of ions across cell membrane-passive transport: simple (Fick's law) and facilitated diffusion (carrier and channel proteins), Donnan equilibrium, Nernst equation, active transport, proton ATPase pump, P-type ATPase and V-type ATPase, electrochemical gradient, ion flux, uniport, co-transport.

6. Keywords

Water potential, essential elements, photoassimilate, stress, signal transduction, climate change.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Animal Behaviour and Chronobiology (DSE-2)
SEMESTER – V

1. Course Objective

This course aims to provide an overview of scientific study of animal behavior: its underlying mechanisms and evolutionary relation, including neural, hormonal, and genetic basis of behaviour. Animal behavior is the bridge between the molecular and physiological aspects of biology. Chronobiology studies how natural rhythms affect living organisms.The related laboratory exercises will provide hands-on experience for many of these concepts. The knowledge gained from studying animal behavior and chronobiology has had a huge impact in the fields of medicine, psychology and the social sciences. The course will help the students to understand the huge importance of animal behavior and chronobiology and how can this knowledge be used in an applied way.

2. Course Learning Outcomes

- Students will be able to describe basic concepts of ethology.
- Students will learn the key concepts important to understand animal behaviour.
- Students will learn about the fascinating range and complexity of behaviour in animals.
- Students will understand the basic concepts of chronobiology and its application to human pathology.
- Students will be able design experiments to test hypotheses relating to animal behavior and learn the use of basic statistical analyses appropriate to the experiment's design.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Animal Behavior and Chronobiology No. of Hours: 2

Origin, history and significance of ethology: Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Franz Halberg.

Unit II: Mechanisms of Behavior No. of Hours: 6

Proximate and ultimate causes of behavior;Innate behavior: Instinct, FAP; Learning: Associative learning: Classical and Operant conditioning; Non-associative learning: Habituation, Imprinting; Stimulus filtering; Sign stimuli; Code breakers.

Unit III: Patterns of Behavior No. of Hours: 8

Reflexes: Types of reflexes, reflex path, characteristics of reflexes (latency, after discharge, summation, fatigue, inhibition) and its comparison with complex behavior. Orientation: Primary and secondary orientation; kinesis-orthokinesis, klinokinesis; taxis-tropotaxis and klinotaxis, menotaxis (light compass orientation).

Unit IV: Social Behavior and Sociobiology No. of Hours: 12

Concept of Society; Degree of sociality; Insects' society with Honey bee as example: Society organization and caste system, Haplodiploidy in honeybees; polyethism vs polymorphism; Dance as means of communication; Experiments to prove distance and direction component of dance, learning ability in honey bee, swarming and formation of new hive/queen, Altruism andReciprocal altruism, Hamilton's rule and inclusive fitness with suitable examples.

Unit V: Sexual Behavior No. of Hours: 8

Asymmetry of sex, Sexual dimorphism mate choice, Intra-sexual selection (male rivalry: competition, territoriality,infanticide), Inter-sexual selection (female choice), Consequences of mate choice for female fitness, Reproductive behaviour pattern (Courtship, mating system, Parental care).

Unit VI: Biological rhythms No. of Hours: 12

Types and properties of biological rhythms: Circadian rhythms, Tidal rhythms, Lunar rhythms;Role of zeitgebers in Entrainment, Role of melatonin, Relevanceof biological clocks, Sleep disorders: endogenous and exogenous; Chronotherapy.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. To study the nesting behaviour of birds and social insects.
2. To study the behavioral responses of wood lice to dry condition.
3. To study behavior responses of wood lice in response to humid condition.
4. To study habituation in snail/ earthworm/dog.
5. To study the phototaxis behavior in insect larvae.
6. Study and actogram construction of locomotor activity of suitable animal models.
7. To study the behavioral activities of animalsin field and prepare a short report.

3.3 REFERENCES

1. Alcock, J. (2013). Animal behavior: An evolutionary approach. Sunderland, Mass: Sinauer Associates.
2. Manning, A., & Dawkins, M. S. (2012). An Introduction to Animal Behaviour. Cambridge: Cambridge University Press.
3. McFarland, D. (2007). Animal Behaviour: Psychobiology, Ethology and Evolution. Harlow: Pearson/Prentice-Hall.

Additional Sources

1. Mandal, F.B. (2015).Textbook of Animal Behaviour. Delhi: PHI Pvt. Ltd.
2. Sherman, P. W., & Alcock, J. (2013).Exploring Animal Behavior, Sinauer Associate Inc., Massachusetts.

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
I	Students will learn about the concept of animal behavior and chronobiology and its relevance	The traditional chalk and talk method supplemented with power point presentations; discussion sessions in the class related to topic; Discussion of e-resources.	Class tests will be conducted for internal assessment. Assignments to enhance the learning and understanding.
II	Students will learn about the different behaviors displayed by animals such as instinct, conditioning, habituation and imprinting	The traditional chalk and talk method supplemented with power point presentations; Visit of students to a Forest/ Wild life Sanctuary/ Biodiversity Park/Zoological Park to help them understand field observations.	Problems will be assigned to encourage them to explore more about the concept. Report related to the visit giving an account of their field observations
III	Students will learn about the different patterns of behavior such as reflexes, orientation, kinesis and taxis.	The traditional chalk and talk method supplemented with power point presentations; Students will study the behavioral responses of wood lice to dry and humid conditions.Students will study the phototaxis behavior in insect larvae	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.Class tests will be conducted for internal assessment.
IV	Students will learn the concept of Society and concept of sociobiology with help of various examples.	The traditional chalk and talk method supplemented with power point presentations; Students will be shown videos to explain the concept.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
V	Students will learn about the concept of sexual behavior and reproductive behavior pattern	The traditional chalk and talk method supplemented with power point presentations; Students will be shown videos to explain the concept	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
VI	Students will learn about the biological rhythms and relevance of biological clock.	The traditional chalk and talk method. Students will do computer simulation of actogram construction of suitable animal models.	Students will be asked to give short presentations related to the subject.

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

5. Teaching Plan

Week 1: Origin, history and significance of ethology: Brief profiles of Karl von Frisch, Ivan Pavlov, Konrad Lorenz, Niko Tinbergen, Franz Halberg. Proximate and ultimate causes of behavior;Innate behavior: Instinct, FAP.

Week 2: Learning: Associative learning: Classical and Operant conditioning; Non-associative learning: Habituation, Imprinting; Stimulus filtering; Sign stimuli; Code breakers.

Week 3: Reflexes: Types of reflexes, reflex path, characteristics of reflexes (latency, after discharge, summation, fatigue, inhibition) and its comparison with complex behavior.

Week 4: Orientation: Primary and secondary orientation; kinesis-orthokinesis, klinokinesis; taxis-tropotaxis and klinotaxis, menotaxis (light compass orientation).

Week 5: Concept of Society; Degree of sociality; Insects' society with Honeybee as example: Society organization and caste system, Haplodiploidy in honeybees.

Week 6: polyethism v/s polymorphism; Dance as means of communication; Experiments to prove distance and direction component of dance, learning ability in honey bee, swarming and formation of new hive/queen.

Week 7: Altruism andReciprocal altruism, Hamilton's rule and inclusive fitness with suitable examples.

Week 8: Asymmetry of sex, Sexual dimorphism mate choice, Intra-sexual selection (male rivalry: competition, territoriality,infanticide).

Week 9: Inter-sexual selection (female choice), Consequences of mate choice for female fitness, Reproductive behaviour pattern (Courtship, mating system, Parental care).

Week 10: Types and properties of biological rhythms: Circadian rhythms, Tidal rhythms, Lunar rhythms; Role of zeitgebers in Entrainment.

Week 11: Role of melatonin, Relevanceof biological clocks.

Week 12: Sleep disorders: endogenous and exogenous; Chronotherapy.

6. Keywords

Animal behaviour, Ethology, Sexual selection, Altruism, Chronobiology, Biological rhythms, Biological clock, Circadian rhythms.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Biotechnology (DSE-3)
SEMESTER – V

1. Course Objective

The objective of the course is to introduce to the students the basic biotechnology techniques and fundamentals of recombinant DNA technology with an aim to develop an understanding of the use of various techniques like cell culture, cloning, polymerase chain reaction and sequencing and their applications in medicine and industry. The course has been designed to create awareness among students for ethical concerns related to genetically modified organisms/crops and impact of such biotechnological advancements on the individual and society.

2. Course Learning Outcomes

- Students will learn various techniques used in recombinant DNA technology.
- Students will learn about the biology of plasmids and phages and their uses in designing different cloning vectors.
- Students will learn about the designing and application of expression vectors.
- Students will get an insight into animal and plant biotechnology, creating transgenic animals and plants and its application in therapeutics.
- Students will appreciate the ethical concerns related to genetically modified organisms and impact of biotechnology on the society.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I Basic Recombinant DNA technology No of Hours: 14

Overview of recombinant DNA technology, Restriction-modification systems, Restriction endonucleases and other enzymes used in manipulating DNA molecules, Cloning vectors used in prokaryotes and eukaryotes, plasmid vectors (pBR322, pUC8, pGEM3Z), bacteriophage based vectors (M13 and lambda), high capacity vectors (BAC and cosmid), vectors for yeast, animals and plants, Joining DNA fragments, linkers and adaptors, introduction of DNA into bacterial cells and selection for recombinants, direct selection, colony and plaque hybridization, Polymerase chain reaction and DNA sequencing.

Unit II: Expression of Cloned Genes No of Hours: 6

Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions, Challenges in producing recombinant protein in *E. coli*, Production of recombinant protein by eukaryotic cells, Fusion tags and their role in purification of recombinant proteins,

Protein engineering.

Unit III: Plant Biotechnology No of Hours: 12

Introduction to cell and tissue culture, Plant tissue culture media (composition, types and preparation), plant hormones and growth regulators in tissue culture, Preparation of suitable explants for organogenesis, Micropropagation on large scale, somatic embryogenesis, protoplast culture and somatic hybridization, Anther, pollen and ovary culture for production of haploid plants and homozygous lines. Agrobacterium mediated gene transfer, Mechanisms of DNA transfer into animal cells, general features of Ti and their use as vectors, reporter genes,

Unit IV: Animal Biotechnology No of Hours: 6

Characteristics of cells in culture, Culture media – composition and preparation, Balanced salt solution - chemical, physical and metabolic functions of different constituents of culture medium-Role of CO_2.Culturing and maintenance of different animal cell lines (Primary and established cell lines), methods of gene transfer to animal cells, creating transgenic animals, Artificial Insemination.

Unit V: Applications in Plant and Animal Biotechnology No of Hours: 8

Transgenic plants, Crop improvement, herbicide resistance, insect resistance, production of recombinant gene products like Insulin and Factor VIII, Animal models for tackling human diseases (Gene knock out in mice models), Gene therapy, Recombinant vaccines.

Unit VI: Biosafety, Bioethics and Society No of Hours: 2

Biosafety, containment issues, emergence of antimicrobial resistance, Genetically modified organisms and plants, risks and controversies, Significance of patents.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. Isolation of plasmid DNA from *E. coli* cells
2. Digestion of plasmid DNA with restriction enzymes and agarose gel electrophoresis
3. Amplification of a DNA fragment by PCR
4. Transformation of *E. coli* cells with plasmid DNA
5. Selection of transformants by antibiotic resistance
6. Aseptic culture of explants on nutrient media

3.3 REFERENCES

1. Brown, T.A. (2010). Gene Cloning and DNA Analysis.Oxford, UK : Wiley-Blackwell.
2. Glick B.R., Pasternak, J.J. and Patten, C.L.,(2010). Molecular Biotechnology: Principles and Applications of Recombinant DNA. Washington DC. ASM Press.
3. Primrose, S.B., and Twyman, (2006). Principles of Gene Manipulation and Genomics.Oxford, UK:R. M., Blackwell.

Additional Sources

1. Green, M. R. and Sambrook, J. (2013). Molecular Cloning: A Laboratory Manual. New York: CSHL Press.

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
I	Students will learn about various enzymes used in RDT, and cloning vectors used in prokaryotes and eukaryotes. They will also gain insight into the techniques like PCR and DNA sequencing.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Practical will be designed in such a way so as to reinforce the concepts learnt bin theory.
II	Students will learn about designing and use of expression vectors for prokaryotic systems.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
III	Students will learn about different types of cell and plant tissue culture techniques.	Teaching using chalk and board; Power point presentations may be used for explaining certain topics	Oral questions will be asked in the class. Class tests will be conducted for internal assessment
IV	Students will learn about animal biotechnology and about the methods and techniques used in animal cell culture.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
V	Students will learn about the applications of biotechnology in creating transgenic animals and plants, and in therapeutics.	Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
VI	Students will learn about the importance of ethical concerns related to genetically modified organisms/crops and the impact of biotechnology on the society.	Teaching using chalk and board; Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Overview of recombinant DNA technology, Restriction-modification systems, Restriction endonucleases and other enzymes used in manipulating DNA molecules, Cloning vectors used in prokaryotes and eukaryotes, plasmid vectors (pBR322, pUC8, pGEM3Z).

Week 2: Bacteriophage based vectors (M13 and lambda), high capacity vectors (cosmid and BAC) Vectors for yeast, animals and plants.

Week 3: Joining DNA fragments, linkers and adaptors, introduction of DNA into bacterial cells and selection for recombinants. Direct selection, colony and plaque hybridization.

Week 4: Polymerase chain reaction and DNA sequencing. Vectors for expression of foreign genes in *E. coli*, cassettes and gene fusions.

Week 5: Challenges in producing recombinant protein in *E. coli*, Production of recombinant protein by eukaryotic cells, Fusion tags and their role in purification of recombinant proteins, Protein engineering.

Week 6: Introduction to cell and tissue culture, Plant tissue culture media (composition, types and preparation), plant hormones and growth regulators in tissue culture.

Week 7: Preparation of suitable explants for organogenesis Micropropagation on large scale, somatic embryogenesis, protoplast culture and somatic hybridization.

Week 8: Anther, pollen and ovary culture for production of haploid plants and homozygous lines Agrobacterium mediated gene transfer, general features of Ti and their use as vectors.

Week 9: Mechanisms of DNA transfer into animal cells, reporter genes.Characteristics of cells in culture, Culture media, composition and preparation, balanced salt solution, chemical, physical and metabolic functions of different constituents of culture medium.

Week 10: Role of CO_2, Culturing and maintenance of different animal cell lines (Primary and established cell lines). Methods of gene transfer to animal cells, creating transgenic animals. Artificial Insemination.

Week 11: Transgenic plants, Crop improvement, herbicide resistance, insect resistance, production of recombinant gene products like Insulin and Factor VIII, Animal models for tackling human diseases (Gene knock out in mice models).

Week 12: Gene therapy, Recombinant vaccines. Biosafety, containment issues, emergence of antimicrobial resistance. Risks and controversies linked with genetically modified organisms and plants. Significance of patents.

6. Keywords

Recombinant DNA Technology, Vectors, Transformation, Transgenic plants, Plant tissue culture, Bioethics.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Endocrinology (DSE-4)
SEMESTER – V

1. Course objectives

The course is designed to enable the students to understand and appreciate the delicate network and balance of hormones required for a healthy functioning of the body. The course emphasises on the different types of hormones along with their physiological action. The students will be taught the consequences of any hormonal imbalances (over and underproduction of hormones) with special emphasis on human diseases. The course is designed to help students understand the role of the endocrine system in maintaining homeostasis, integrating growth and development, responding to the environment and for successful reproduction.

2. Course Learning Outcomes

- Students will learn about the different classes of hormones, their structure, synthesis and mode of action.
- Students will learn about the regulation of hormone secretion and how hormones are transported in the blood.
- Students will learn about the roles of hormone receptors in hormone action including their location, type and signalling pathways.
- To compare and contrast the different mechanisms of action of hormones: i.e. those exerted by modulation of gene expressionto those that cause changes in protein activity.
- Students will appreciate the molecular, biochemical and physiological effects of hormones on cells and tissues and consequences of specific endocrine disorders.

3. Course Content

3.1THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Endocrinology No. of Hours: 4

History of endocrinology, characteristic of Hormones, Classification –Local and circulatinghormones, general classes of chemical of chemical messengers- peptide hormones, steroid hormones, neurotransmitters, neuropeptides, eicosanoids, pheramones. Cellular receptors and hormone action (nuclear receptors, cell surface receptors and coupled second messenger system).

Unit II:Hypothalamic-Pituitary system No. of Hours: 8

Hypothalamus; structure of hypothalamus, names and functions of important hypothalamicnuclei, neuroendocrine regulation of endocrine glands and feedback

mechanisms.PituitaryGland: structure of pituitary and its hormones.Secretion, transportation, storage, and functions of hormones.Hypothalamo- Hypophyseal axis. Pineal gland, secretions and theirfunctions in biological rhythms and reproduction.

Unit III: Thyroid-Parathyroid system No. of Hours: 10

Thyroid gland: structure of thyroid gland, synthesis and functions of thyroid hormones, mode of action, regulation of thyroid hormone secretion; thyrocalcitonin. Disorders of thyroid gland (hyperthyroidism, Hypothyroidism, Graves disease, Goiter)Parathyroid Glands: Secretion and action of parathyroid Hormones, role of parathyroid hormoneand calcitonin in calcium homeostasis, disorders of parathyroid gland (hyperparathyroidism).

Unit IV: Adrenal gland and its hormones No. of Hours: 10

Adrenal gland: structural of adrenal gland,synthesis of hormones of the adrenal cortexand medulla; Biological action of glucocorticoids, mineralocorticoids, adrenaline andnoradrenaline on carbohydrate and protein metabolism; Role of adrenal hormones on cardiovascular system,osmoregulation andstress (Flight and fight response).Diseases related to adrenal cortex and medulla (primary hyperaldosteronism, Cushing's syndrome, pheochromocytoma)

Unit V: Pancreas and Gastrointestinal hormones No. of Hours: 12

Structure of Pancreatic Islets of Langerhans. Insulin secretion,Glucagon secretion, mode of action of both hormones incontrolling the blood glucose level. Diabetes mellitus.A brief account of hormones of gastrointestinal tract (Gastrin, Secretin family of hormones) and kidney (erythropoietin). Regulation of appetite and satiety: Leptin and Grehlin hormones.

Unit VI: Reproductive endocrinology No. of Hours: 4

Male Reproductive system; hormonal control of testes; Biosynthesis of testosterone, functions of testosterone. Female Reproductive system: role of hormones inFemale ovarian (estrous/menstrual) cycle, placental hormones; parturition and lactation.

3.2 PRACTICALS

TOTAL HOURS: 48 CREDITS: 2

1. Study of the permanent slides of all the endocrine glands
2. Esrous cycle of rat.- Vaginal smear
3. Castration/ ovariectomy (subject to availability of rat).
4. Study of LH and HCG hormones through Ovulation and Pregnancy kits available in the market.
5. Tissue processing, microtomy and hematoxylin/eosin staining of endocrine glands: ovary, testis, thyroid and adrenal.
6. T3, T4 determination assays using ELISA.
   Estimation of blood glucose level using glucometer/ glucose kit.

3.3 REFERENCES

1. Guyton, A. C. (2005). *Textbook of Medical Physiology 11th Eleventh Edition* (111th, Eleventh Edition edition ed.). Saunders Co.
2. Jameson, J. (2010). *Harrison's Endocrinology, Second Edition* (2 edition). New York: McGraw-Hill Professional.
3. Turner, C. D. (1971). *General Endocrinology* (5th Revised edition edition; J. T. Bagnara, ed.). Philadelphia: W.B. Saunders Company.

Additional resources

1. https://www.endotext.org/A free clinical endocrinology internet resource.
   https://www.mooc-list.com/tags/endocrine-system
3. https://www.mooc-list.com/course/anatomy-gastrointestinal-reproductive-and-endocrine-systems-edx

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
I	The students will be able to explain the various types of hormones based on their chemical characteristics and their mode of action.	Projection of videos or short movies available on the subject will be used to enhance the understanding of the subject.Study of the permanent slides of all the endocrine glands will establish location and function of various hormones.	Group discussions, MCQ based tests, paper presentations on relevant topics. Assignments and Class tests will be conducted for internal assessment
II	The students will be able to describe the anatomy and histology of the endocrine systems particularly the hypothalamus, pituitary and the pineal gland along with mechanism of storage, transportation and secretion of various associated hormones.	Projection of videos or short movies available on the subject will be used. Cellular and hormonal features of pituitary gland will be highlighted with the study of various permanent histochemical stained slides.	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals.Assignments and Class tests will be conducted for internal assessment.
III	The students will be able to discuss the normal functioning of thyroid and parathyroid glands along and the understanding of diagnosis, treatment and prevention of thyroid and parathyroid disorders.	Projection of videos or short movies available on the subject will be used. Determine the serum concentration of T4 in a clinical sample and interpret the results with respect to hyper or hypo thyroidism.	Group discussions, MCQ based tests, paper presentations on relevant topics. Assignments and Class tests will be conducted for internal assessment.

IV	The students will be able to describe the anatomy and histology of adrenal gland. The students will also able to discuss the common endocrine disorders associated with adrenal glands.	Normal Cellular and hormonal features of Adrenal gland will be highlighted with the study of various histochemically stained slides. Diseases related to adrenal cortex and medulla will be understood with the help of photomicrographs.	Group discussions, MCQ based tests, paper presentations on relevant topics. Assignments and Class tests will be conducted for internal assessment
V	The students will be able to describe the anatomy and histology of pancreas.The students will be able to discuss the causes, diagnosis, investigation, treatment, complications and prevention of diabetes mellitus.	Estimation of blood glucose level using glucometer/ glucose kit will help students understand the basics investigation of diabetic conditions. Microscopic analysis of pancreas to understand cellular architecture of cells involved in insulin and glucagon production.	Group discussions, MCQ based tests, paper presentations on relevant topics.Mock practicals,assignments and Class tests will be conducted for internal assessment
VI	The students will be able to describe the anatomy and histology of testis and ovary and explain their role as endocrine glands.The students will be able to outline the biosynthesis of androgens and estrogens and their key role in ovarian cycle, gestation, parturition and lactation	Esrous cycle - will be studied through Vaginal smear preparation from rat. Study of LH and HCG hormones through Ovulation and Pregnancy kits. Castration/ ovariectomy (subject to availability of rat).	Group discussions, MCQ based tests, paper presentations on relevant topics. Mock practicals, assignments and class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: History of endocrinology, characteristic of Hormones, Classification –Local and circulating hormones, general classes of chemical of chemical messengers- peptide hormones, steroid hormones, neurotransmitters, neuropeptides, eicosanoids, pheramones. Cellular receptors and hormone action (nuclear receptors, cell surface receptors and coupled second messenger system).Hypothalamus; structure of hypothalamus.

Week 2: Names and functions of important hypothalamic nuclei, neuroendocrine regulation of endocrine glands and feedback mechanisms.

Week 3: Pituitary Gland: structure of pituitary and its hormones. Secretion, transportation, storage, and functions of hormones. Hypothalamo- Hypophyseal axis.Pineal gland, secretions and their functions in biological rhythms and reproduction.

Week 4: Thyroid gland: structure of thyroid gland. Synthesis and functions of thyroid hormones, mode of action, regulation of thyroid hormone secretion; thyrocalcitonin.

Week 5: Disorders of thyroid gland (hyperthyroidism, Hypothyroidism, Graves's disease, Goiter). Parathyroid Glands: Secretion and action of parathyroid Hormones, role of parathyroid hormone and calcitonin in calcium homeostasis

Week 6: Disorders of parathyroid gland (hyperparathyroidism).Adrenal gland: structural of adrenal gland, synthesis of hormones of the adrenal cortexand medulla (2 classes)

Week 7: Biological action of glucocorticoids, mineralocorticoids, adrenaline and noradrenaline on carbohydrate and protein metabolism.

Week 8: Role of adrenal hormones on cardiovascular system, osmoregulation and stress (Flight and fight response).

Week 9: Diseases related to adrenal cortex and medulla (primary hyperaldosteronism, Cushing's syndrome, pheochromocytoma) Structure of Pancreatic Islets of Langerhans. Insulin secretion

Week 10: Glucagon secretion.Mode of action of both hormones in controlling the blood glucose level.Diabetes mellitus.A brief account of hormones of gastrointestinal tract (Gastrin, Secretin family of hormones)

Week 11: Hormones of the kidney (erythropoietin). Regulation of appetite and satiety: Leptin and Grehlin hormones.

Week 12: Male Reproductive system; hormonal control of testes; Biosynthesis oftestosterone, functions of testosterone.Female Reproductive system: role of hormones in ovarian (estrous/menstrual) cycle, placental hormones; parturition and lactation

6. Keywords

Endocrine, Hormone, Diabetes, Hypothyroid, Hyperthyroid, Fight and Flight Response, Growth Hormone.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE(CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Natural Resource Management (DSE-5)
Semester – VI

1. Course Objective

The course will enable students to understand the role of natural resources in maintaining ecological balance.It will help them to appreciate different types of natural resources and the threats faced by them.The course covers basics concepts as well as applied aspects required in conservation and management of natural resources.

2. Course Learning Outcomes

- Students will be able to define and differentiate between biological and physical natural resources.
- Students will appreciate the role of natural resources in ecological, economic and socio-cultural activities.
- Students will understand the effect of anthropogenic interference on natural resources.
- Students will understand and appreciate the laws and policies associated with resource management and conservation.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Natural Resources and Sustainable Utilization No. of Hours: 8

Definition and types of Natural resources (physical and biological), Biodiversity register, Concept, Guiding principles of sustainable development, Brundtland commission, approaches to sustainable utilization (economic, ecological and socio-cultural)

Unit II: Land and Water No. of Hours: 8

Utilization of land (agricultural, pastoral, horticultural, silvicultural); Mining, Soil degradation, Reclamation and management, Utilization of water: Fresh (rivers, lakes, groundwater, aquifers, watershed) and Marine; Estuarine; Wetlands; Threats and management strategies.

Unit III: Biological Resources No. of Hours: 10

Biodiversity-definition, types and level; Significance; Categories of threats; climate change, Management strategies; Bioprospecting; Introduction to IPR; CBD; National Biodiversity Action Plan, Biodiversity Act 2002, Living planet index, Ecological footprint

Unit IV: Forests and Energy No. of Hours: 10

Definition and types, Cover and its significance (phytogeographical distribution with special reference to India); Agroforestry, Major and minor forest products (non-wood forest products); Depletion; Management (joint forest management), Renewable and non-renewable sources of energy (tidal energy, ocean thermal energy conversion)

Unit V: Contemporary practices in Resource Management No. of Hours: 12

EIA, GIS, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Types of waste and waste management strategies (solid waste, landfill sites, biogas, e-waste, vermicompost), National and international efforts in resource management and conservation.

3.2 PRACTICALS

TOTAL HOURS: 48 CREDITS: 2

1. Estimation of solid waste generated by a domestic system (biodegradable and non- biodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area and correlate it with conservation and socio economic practices.
3. Measurement of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological/ carbon footprint by using online calculators.
5. Ecological modelling (climate change models).
6. Estimation of soil organic carbon by Walkley and Black's method.
7. Visit to landfill sites/ mining area/sewage treatment plant.

3.3 REFERENCES

1. Rogers, P.P., Jalal, K. F., & Boyd, J. A. (2008).*Introduction to Sustainable Development*. New Delhi: Prentice Hall of India Private Limited
2. Singh, J. S., Singh, S. P., & Gupta, S. R. (2017).*Ecology and Environmental Science and Conservation*. New Delhi: S Chand and Company Ltd.
3. Singh, J.S., Singh, S.P., & Gupta, S. (2006). *Ecology, Environment and Resource Conservation*. New Delhi: Anamaya Publications.
4. Vasudevan, N. (2006). *Essentials of Environmental Science.* New Delhi: Narosa Publishing House.

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
I	Students will learn about the types of natural resources and principles of sustainable utilization.	Power point presentations; Teaching using chalk and board; Group discussions in the class.	Class tests will be conducted for internal assessment Questions will be asked in the class.

II	Students will learn about the different types of land and water resources and their conservation and management strategies.	Power point presentations; Teaching using chalk and board; Group discussion, Case studies.	Students will take up case studies and participate in group discussion (e.g. Case study of river Ganga etc.)
III	Students will be able to define biodiversity and enlist its types and appreciate the need to conserve biodiversity and understand various conventions associated with it.	Power point presentations; Teaching using chalk and board; role play, Case studies.	Students will be given worksheets / assignments to test their understanding of the subject.
IV	Students will be able to understand the role of different stakeholders in planning and implementing forest management	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Class tests will be conducted for internal assessment
V	Students will learn about different national and international policies in resource management and different types of wastes and their management.	Power point presentations; Teaching using chalk and board; discussion sessions in the class.	Students will be given worksheets / assignments to test their understanding of the subject.

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

5. Teaching Plan

Week 1: Definition and types of Natural resources (physical and biological), Biodiversity register.

Week 2: Concept, Guiding principles of sustainable development, Brundtland commission, approaches to sustainable utilization (economic, ecological and socio-cultural).

Week 3: Utilization of land (agricultural, pastoral, horticultural, silvicultural); Mining, Soil degradation, Reclamation and management.

Week 4: Utilization of water: Fresh (rivers, lakes, groundwater, aquifers, watershed) and Marine; Estuarine; Wetlands; Threats and management strategies.

Week 5: Biodiversity-definition, types and level; Significance; Categories of threats.

Week 6: Climate change, Management strategies; Bioprospecting; Introduction to IPR; CBD; National Biodiversity Action Plan, Biodiversity Act 2002.

Week 7: Living planet index, Ecological footprint, Definition and types of forests, Management (joint forest management).

Week 8: Cover and its significance (phytogeographical distribution with special reference to India); Agroforestry, Major and minor forest products (non-wood forest products).

Week 9: Depletion, Renewable and non-renewable sources of energy (tidal energy, ocean thermal energy conversion).

Week 10: EIA, Participatory Resource Appraisal, Ecological Footprint with emphasis on carbon footprint, Resource Accounting.

Week 11: Types of waste and waste management strategies (solid waste, landfill sites, biogas, e-waste, vermicompost).

Week 12: GIS, National and international efforts in resource management and conservation.

6. Keywords

Natural resources, sustainable development, waste management, climate change, agro forestry, ecological footprint.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Wildlife Biology and Conservation (DSE-6)
SEMESTER – VI

1. Course Objectives

The course aims to familiarize students with diverse aspects of wildlife and their conservation, including the significance of wildlife, major natural and anthropogenic threats as well as management of their population and habitats. The course also explores different techniques, perspectives, and approaches to both identify and achieve wildlife management goals. The main objective of this course is to develop interest and invoke a sense of responsibility among students towards wildlife conservation. This course will motivate students to pursue career in the field of wildlife conservation and management.

2. Course Learning Outcomes

- Students will learn about the importance of wildlife, its conservation and management.
- Students will learn about major causes of wildlife depletion and important *in-situ* and *ex-situ* strategies for the conservation of their genetic diversity.
- Students will learn about the management practices required to achieve a healthy ecosystem for wildlife population along with emphasis on conservation and restoration.
- Students will gain knowledge about the Protected Area Networks in India, Ecotourism, Human-animal conflict and other challenges in wildlife management.
- Students will be encouraged towards critical thinking, literature review; scientific writing as well as presentations and participation in citizen science initiatives with reference to wildlife.

3. Course Contents:

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction No. of Hours: 2

Values of wildlife; Ethics of wildlife conservation; Causes of depletion; Importance of Conservation.

Unit II: Evaluation and management of wild life habitat No. of Hours: 10
Physical parameters: Topography, geology and water; Biological Parameters food, cover; Setting back succession: Grazing, logging, Mechanical treatment; Advancing successional process: Cover construction.

Unit III: Population estimation No. of Hours: 10

Standard estimation procedures: Faecal analysis of ungulates and carnivores: Hair, antler, pug marks and hoof marks identification; Mortality, Natality, Population Size, Age Pyramids, Ecological and Crude Density; Survey Methods: Trail/transect monitoring, Quadrat method, Census method, Geographical Information System (GIS), GlobalPositioning System (GPS) and Remote Sensing (RS).

Unit IV: Modern Concepts and strategies of Wildlife Management No. of Hours: 13

Protected Area Network (PAN): Preservation of general genetic diversity: in-situ and ex-situ conservation strategies; National parks, sanctuaries, Biosphere reserves; Conservation and community reserve, Important features of protected areas in India; WWFN, IUCN, and CITES. Wild life Legislation – Wildlife Protection act (1972), its amendments and implementation. IUCN Red data book and red list categories (only names); Project Tiger: Tiger conservation - Tiger reserves in India; Management challenges in Tiger reserve; Objectives and activities of Project Elephant and Project Crocodile.

Unit V: Management of excess Population and Translocation No. of Hours: 8

Bio- telemetry; Common diseases of wild animal: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and mouth disease and Tuberculosis; Quarantine; Population Viability Analysis (PVA), rescue, rehabilitation and reintroduction.

Unit VI: Challenges in Wildlife Management No. of Hours: 5

Poaching, illegal trading, conflict management and shifting from extraction to preservation;effect of extinction of a species on ecosystem, Human-animal conflict; Eco tourism / wild life tourism in forests.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Identification and Study of five mammalian, avian and herpeto fauna through direct and indirect evidences seen on a field trip to a wildlife conservation site.
2. Demonstration of basic equipment needed in wildlife studies use, care and maintenance
3. (Compass, Binoculars, Spotting scope, Range Finders, Global Positioning System, Various
4. types of Cameras and lenses)
5. Familiarization and study of animal evidences in the field: Identification of animals through pug marks, hoof marks, scats, pellet groups, nest and antlers.
6. Demonstration of different field techniques for flora and fauna: PCQ, Quadrat method for diversity: Circular, Square & rectangular plots.
7. Trail / transect monitoring for abundance and diversity estimation of mammals and bird
8. (Direct and indirect evidences): Identification of Big Cats (Lion, Tiger, Panther, Cheetah, Leopard and Jaguar); Birds of Prey (Eagle, Kite, Vulture, Falcon, Hawk and Owl) and Poisonous snakes (Cobra, Krait, Viper).

A report based on a visit to a National Park/ Wildlife Sanctuary/ Biodiversity Park or any other wildlife conservation site.

3.3 REFERENCES

1. B. B. Hossetti (1997). *Concepts in wildlife management.* Daya Publishing House, Delhi.
2. R Woodroff, S Thirgood and A. Rabinowitz (2005). *People and Wildlife, Conflict or Coexistence?*.Cambridge University Press.
3. Saha, G. K. and Mazumdar, S. (2017). *Wildlife Biology: An Indian Perspective*. PHI Publishing.
4. T A Bookhout (1996)*Research and Management Techniques for Wildlife and Habitats*,5thEd. The Wildlife Society, Allen Press.
5. W J Sutherland, (2000). *The Conservation Handbook: Research, Management and Policy*.Blackwell Sciences.

Additional resources

1. https://papaco.org/mooc-on-species-conservation/
2. https://www.openlearning.com/umtmooc/courses/wildlife-management
3. https://www.zsl.org/united-for-wildlife-free-conservation-courses

5. 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 students will be made aware about the importance of wildlife, values of wildlife, ethics of wildlife conservation; causes of depletion as well asimportance of conservation and management.	The traditional chalk and talk method. Projection of videos or short movies available on the subject will enhance the understanding of the subject.	Paper presentations on relevant topics, Poster presentation, Powerpoint presentations, Assignments and Class tests will be conducted for internal assessment
II	Students will be able to understand the importance of preserving not just the wildlife, but their whole ecosystem. They will study the physical parameters as well asbiological parameters concerned with wildlife conservation.	The traditional chalk and talk method to be supplemented with LCD projection system and use of visualizer for theory classes.	Group discussions, Book reviews, MCQ based tests, Paper presentations on relevant topics, Poster presentation.

III	The students will understand the biology of wildlife as well as get familiar with the techniques for wildlife estimation.	**E-Museum**: Digital collection of pictures of pugmarks, hoof marks, birds nests, wild fauna and flora will facilitate observation of their characteristic features with ease. **Educational Visits**: Field visits to various conservation sites like Corbett National Park, Aravali Biodiversity Park and National Zoological Park will provide students a practical or hands on knowledge of the subject and allow them to interact with forest officers.	Group discussions, Book reviews, MCQ based tests, Paper presentations on relevant topics, Poster presentation, Powerpoint presentations, Report of the Educational visit. A write up of the hands-on field based activity performed with results. Assignments and Class tests will be conducted for internal assessment
IV	In this unit, the students will be able to comprehend the modern concepts and strategies of Wildlife Management within and outside their habitat. This unit will also provide the information about the ongoing governmental and intergovernmental efforts to conserve wildlife.	**Educational Visits**: Field visits to various conservation sites like Jim Corbett National Park, Aravali Biodiversity Park and National Zoological Park will provide students a practical or hands on knowledge of the subject and allow them to interact with forest officers. **Citizen Science Initiatives:** Students should participate in citizen science initiatives related to wildlife such as bird counts and uploading of the data on E-bird.org.	Group discussions, Book reviews, MCQ based tests, Paper presentations on relevant topics, Poster presentation, Powerpoint presentations, Assignments and Class tests will be conducted for internal assessment

V	In this unit the students will be made to understand the common diseases of wild animals and awareness about quarantine policies.	The traditional chalk and talk method to be supplemented with LCD projection system. Projection of videos or short movies available on the subject will enhance the understanding of the subject.	Group discussions, Book reviews, MCQ based tests, Paper presentations on relevant topics, Poster presentation, Powerpoint presentations.
VI	Students will be acquainted with the challenges in Wildlife Management such as poaching, illegal trading, conflict management and shifting from extraction to preservation.The students will be made to understand human-animal conflict and also about Eco tourism / wild life tourism in forests.	**Interaction with wildlife expert**: Lecture and real experience on Challenges in wildlife management by awildlife expert helpstudents to have a feeling of belonging with the course.	Paper presentations on relevant topics, Poster presentation, Powerpoint presentations, Assignments and Class tests will be conducted for internal assessment.

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

5. TeachingPlan

Week 1: Values of wildlife; Ethics of wildlife conservation; Causes of depletion; Importance of conservation.Introduction of Unit 2, Physical parameters.

Week 2: Physical parameters: Topography, geology and water; Biological Parameters food, cover.

Week 3: Setting back succession: Grazing, logging, Mechanical treatment; Advancing successional process: Cover construction.

Week 4: Standard estimation procedures: Faecal analysis of ungulates and carnivores: Hair, antler, pug marks and hoof marks identification.

Week 5: Survey Methods: Mortality, Natality, Population Size, Age Pyramids, Ecological and Crude Density.

Week 6: Geographical Information System (GIS), GlobalPositioning System (GPS), and Remote Sensing (RS). (2 classes)Protected Area Network (PAN): Preservation of general genetic diversity: in-situ and ex-situ conservation strategies.
Week 7: National parks, sanctuaries, Biosphere reserves; Conservation and community reserve, Important features of protected areas in India; WWFN, IUCN, and CITES.

Week 8: Wild life Legislation – Wildlife Protection act (1972), its amendments and implementation. IUCN Red data book and red list categories (only names); Project Tiger: Tiger conservation - Tiger reserves in India.

Week 9: Management challenges in Tiger reserve; Objectives and activities of Project Elephant and Project Crocodile.Introduction Bio- telemetry.

Week 10: Common diseases of wild animal: Zoonosis (Ebola and Salmonellosis), Rabies, Foot and mouth disease and Tuberculosis.

Week 11: Quarantine; Population Viability Analysis (PVA), rescue, rehabilitation and reintroduction.Poaching, illegal trading.

Week 12: Conflict management and shifting from extraction to preservation;effect of extinction of a species on ecosystem, Human-animal conflict; Eco tourism / wild life tourism in forests.

6. Keywords

Wildlife Habitat management, Pugmarks, Wildlife management, Project tiger, Protected Area Network, Red list.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Nutritional Biochemistry (DSE-7)
SEMESTER – VI

1. Course Objective

The objective of the course is to provide the students with an understanding of the nutrition based concepts of cellular metabolism. It focuses on the concept of energy metabolism and is a comprehensive study of the cellular and biochemical mechanisms that govern the digestion, assimilation and utilization of major and minor dietary components required to maintain health. It will allow the students to understand and appreciate the factors and biochemical events that cause ill-health due to malnutrition.

2. Course Learning Outcomes

- Students will understand the digestion, absorption and utilization of the major dietary components like carbohydrates, proteins and lipids.
- Students will comprehend and appreciate the importance of energy metabolism of the body in regulating body composition and health.
- Students will appreciate and understand the role of dietary fiber, essential fatty acids, and lipotropic factors in coordinating biochemical and cellular events that ensure good health.
- Students will get an understanding of the biochemical mechanism by which vitamins and minerals regulate cellular metabolism and health.
- Students will develop an inquisitive learning approach to seek answers regarding the role of the microbiome, food drug interactions and medicinal properties of food components that are essential for maintaining good health.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: Introduction to Nutrition and Energy Metabolism No. of Hours: 4

Defining nutrition, role of nutrients.Unit of energy, Biological oxidation of foodstuff.Physiological energy value of foods, SDA. Measurement of energy expenditure, BMR and RMR- factors affecting BMR. Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

Unit II: Macronutrients No. of Hours: 16

Food sources of carbohydrates, Review functions of carbohydrates. Factors affecting Digestion, absorption and utilization. Glycemic index and glycemic load. Dietary fiber and role of fiber in health. Role of gut microbiome in nutritive health.Role of Pre and probiotics in gut health.Essential Fatty Acids; Functions of EFA, RDA, –

excess and deficiency of EFA.Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA Factors affecting Digestion, absorption and utilization. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, Polyunsaturated and Saturated Fatty Acids. Review of functions of proteins in the body, Digestion and absorption. Essential and Nonessential amino acids. Complete protein, Amino Acid Availability, Antagonism, Toxicity and Imbalance. Amino acid complementation and Supplementation in foods.Effects of deficiency.Food source and Recommended Dietary Allowances for different age group.Amino acid pool.NPU, Biological Value, Nitrogen balance.PEM and Kwashiorkor.

Unit III: Micronutrients: Vitamins No. of Hours: 12

Vitamin A, D, E, K Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME),Deficiency.Role of Vitamin A as an antioxidant, in Visual cycle, dermatology and immunity.Role of Vitamin K in Gamma carboxylation.Role of Vitamin E as an antioxidant. Extra- skeletal role of Vitamin D and its effect on bone physiology. Hypervitaminosis.Vitamin C- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); role as cofactor in amino acid modifications. The B Complex vitamins- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); Thiamine-TPP roe in metabolism and deficiency disease; Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP; Vitamin B6-conversion to Pyridoxal Phosphate. Role in metabolism, Biochemical basis for deficiency symptoms; Vitamin B12 and folate-metabolic role, homocysteine cycle, Biochemical basis for deficiency symptoms.

Unit IV: Micro minerals and trace elements No. of Hours: 8

Calcium, Iron and Phosphorus- Distribution in the body digestion, Absorption, Utilization , Transport, Excretion, Balance, Deficiency, Toxicity, Sources, RDA. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum Distribution in the human body, Physiology, Function, deficiency, Toxicity and Sources.

Unit V: Assessment of nutritional status No. of Hours: 4

Direct methods of assessment-Anthropometric measurements; Biochemical assessment; clinical signs; dietary records and nutrient intake.ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

Unit VI: Food drug interaction and nutraceuticals No. of Hours: 4

Nutrient interactions affecting ADME of drugs. Drug induced nutrient deficiency: Alcohol, Antibiotics, Antimalarial drugs. Role of microbiome in maintaining Nutritive health. Neutraceuticals and Food as medicine: turmeric, garlic, ginger, cumin, asafoetida.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Anthropometric assessment for nutritional status of a healthy individual and in case studies of Kwashiorkor, Marasmus and/or Obesity.
2. Determination of lipid profile.
3. Determination of oxidative stress: TBARS, antioxidant enzymes in hemolysate.
4. Estimation of vitamin in drugs/food/serum.
5. Estimation of minerals in drugs/food/serum.
6. Estimation of glycosylated haemoglobin.
7. Determination of nutritive value of foods.

3.3 REFERENCES

1. Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations*.John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
2. G.F. Coombs Jr. (2008). *The vitamins, Fundamental aspects in Nutrition and Health*.Elsevier's Publications.ISBN-13- 978-0-12- 183493-7.
3. Mahan, L.K., Strings, S.E, Raymond, J. (2012). *Krause's Food and Nutrition Care process.*(2012); Elsevier's Publications.ISBN- 978-1-4377-2233-8.
4. Rosalind Gibson (2005). *Principles of Nutritional Assessment.*Oxford University Press. ISBN: 9780195171693.
5. Tom Brody (1999). *Nutritional Biochemistry (2nd ed.).* Harcourt Braces. ISBN: 9814033251, 9789814033251.

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
I.	Evaluate concepts in nutritional biochemistry that are important for an understanding of human nutrition.	Traditional chalk and board method with power-point presentations. Group discussions with examples.	Quiz and numerical problems on energy expenditure will be given.
II.	To understand the basis and nutritional importance of macronutrients and gut biome in human health.	Chalk and board teaching and power point presentation on essential macronutrients.	Internal assessment, test and case study evaluations.
III.	Understand the ADME and the importance of fat and water soluble vitamins and biochemical basis of symptoms of vitamin deficiencies and excesses.	Presentation on essential vitamins and their deficiency disorders, historical perspective on nutritional deficiencies. . Practical diagnosis of any one vitamin deficiency.	Test/quiz. Case study analysis.

IV	Appreciating the importance of mineral macronutrients with special emphasis on calcium and iron.	Chalk and board teaching of the basic concepts and presentations on regulation of micromineral homeostasis. Practical diagnosis of any one mineral deficiency.	Test and assignment Case study analysis. Power point presentations on chemistry of vitamins.
V.	To be acquainted with the techniques used in the assessment of Nutritional status and nutritional disorders.	Chalk and board teaching and discussion on case studies based on anthropometry and biochemical estimations.	Assessment test and Case study evaluation.
VI.	To understand drug nutrient interactions. Learn about Nutraceuticals and medicinal importance of certain food items.	Power point presentation and chalk and board teaching.	Test/quiz on various groups of drugs and their effect on nutrient availability. Power point presentations on Nutraceuticals.

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

5. Teaching Plan

Week 1: Defining nutrition, role of nutrients. Unit of energy, Biological oxidation of food stuff. Physiological energy value of foods, SDA. Measurement of energy expenditure, BMR and RMR- factors affecting BMR. Recommended Nutrient Intakes (RNI) and Recommended Dietary Allowances for different age groups.

Week 2: Food sources of carbohydrates, review functions of carbohydrates. Factors affecting digestion, absorption and utilization. Glycemic index and glycemic load. Dietary fiber and role of fiber in health.

Week 3: Role of gut microbiome in maintaining health. Role of pre and probiotics in nutritive health.Essential Fatty Acids; Functions of EFA, RDA, – excess and deficiency of EFA.Dietary implications of fats and oils, Combination ratios of n6 and n3, MUFA, PUFA and SFA -factors affecting.

Week 4: Digestion, absorption and utilization. Importance of the following: a) Omega – fatty acids. Omega 3/ omega 6 ratio b) Phospholipids c) Cholesterol in the body d) Mono, polyunsaturated and saturated fatty acids. Review of functions of proteins in the body-digestion and absorption. Essential and Nonessential amino acids.

Week 5: Complete protein, amino acid availability, antagonism, toxicity, imbalance, amino acid complementation and supplementation in foods. Effects of deficiency.Food source and Recommended Dietary Allowances for different age group.Amino acid pool.NPU, biological value, nitrogen balance.PEM and Kwashiorkor.

Week 6: Vitamin A, D, E, K- dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME), deficiency. Role of Vitamin A as an antioxidant, in

Visual cycle, dermatology and immunity.

Week 7: Role of Vitamin K in Gamma carboxylation. Role of Vitamin E as an antioxidant.Extraskeletal role of Vitamin D and its effect on bone physiology.Hypervitaminosis.Vitamin C- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); role as cofactor in amino acid modifications.

Week 8: The B Complex vitamins- Dietary sources, RDA, Adsorption, Distribution, Metabolism and excretion (ADME); Thiamine-TPP roe in metabolism and deficiency disease; Niacin- Metabolic interrelation between tryptophan, Niacin and NAD/ NADP. Vitamin B6-conversion to Pyridoxal Phosphate.Role in metabolism, Biochemical basis for deficiency symptoms; Vitamin B12 and folate- metabolic role, homocysteine cycle, Biochemical basis of deficiency symptoms.

Week 9: Calcium, Iron and Phosphorus- Distribution in the body digestion, absorption, utilization , transport, excretion, balance, deficiency, toxicity, sources and RDA.

Week 10: Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium, Molybdenum-distribution in the human body, physiology, function, deficiency, toxicity and sources.

Week 11: Direct methods of assessment-Anthropometric measurements; Biochemical assessment; clinical signs; dietary records and nutrient intake. ROS assessment, GTT and glycosylated Hb, Differential diagnosis of B12 and folate.

Week 12: Nutrient interactions affecting ADME of drugs. Drug induced nutrient deficiency: alcohol, antibiotics, antimalarial drugs. Food as medicine: turmeric, garlic, ginger, cumin, asafetida.

6. Keywords

Nutrition, Energy Metabolism, Macronutrients, Vitamins, Minerals, Nutraceuticals, Nutritional status

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE
Microbiology (DSE-8)
SEMESTER – VI

1. Course Objective

The objective of the course is to describe the historical perspectives that are important in the development of microbiology and make students aware of the diversity, distribution and characteristic features of various microorganisms. The course also aims to make students aware of the indispensable role of microorganisms in the environment, biotechnology, fermentation, medicine and other industries important to human welfare. In addition to this the course shall also prepare students for higher education in microbiology related disciplines.

2. Course Learning Outcomes

- Students will learn about general characterscs and structural details of various microbes.
- Students will learn about various microbiological techniques including sterilization, media preparation, maintenance of microbial culture and staining.
- Students will understand the pathogenesis of various diseases caused by microbes and learn about the techniques to assess antimicrobial activity of various drugs.
- Students will learn about various commercial applications of microbiological techniques.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 48 **CREDITS: 4**

Unit I: History of Microbiology No. of Hours : 4

History of development of microbiology as a discipline, Spontaneous generation versus biogenesis, contributions of Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Richard Petri, Charles Chamberland, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei Winogradsky, Alexander Fleming, Elie Metchnikoff and Emil von Behring.

Unit II: Diversity of Microbial world and Microbial Cell organization No. of Hours : 12

Difference between prokaryotic and eukaryotic microorganisms. General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Bacteria, Archaea, Algae, Fungi and Protozoa) with emphasis on distribution, occurrence and morphology. Cell-wall: Composition and detailed structure of Gram positive and Gram negative cell walls, mechanism of Gram's staining. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

Unit III: Microbial Nutrition and Growth No. of Hours : 12

Nutritional types of microorganisms, growth factors, culture media- synthetic and complex, types of media; isolation of pure cultures, growth curves, mean growth rate constant, generation time; influence of environmental factors on growth of microbes: effect of pH, temperature, solute, oxygen concentration, pressure and radiations. Sterilization, disinfection and antiseptics.Use of physical methods (heat, low temperature, filtration, radiation) and chemical agents (phenolics, halogens, heavy metals, sterilizing gases) in microbial control.

Unit IV: Pathogenicity of Microorganisms and Antimicrobial Chemotherapy.

No. of Hours: 8

Characteristics of cells in culture, Culture media – composition and preparation, Balanced salt solution - chemical, physical and metabolic functions of different constituents of culture medium-Role of CO_2.Culturing and maintenance of different animal cell lines (Primary and established cell lines), methods of gene transfer to animal cells, creating transgenic animals, Artificial Insemination.

Unit V: Applications of Microbiology No. of Hours : 12

Importance of microbiology in food and industries.Basic design of fermenter, continuous and discontinuous culture.Preparation of fermented food products such as yoghurt, curd and cheese.Preparation of alcoholic beverages like wine and beer.Single cell proteins.Treatment of waste water (Municipal treatment plant) and sewage.bioremediation and biodegradation.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. To prepare and sterilize the culture media for the growth of microorganisms.
2. To perform various culture transfer techniques: Solid to solid (streaking), liquid to solid (spreading), liquid to liquid, solid to liquid and determine CFU/ml.
3. To stain bacteria using methylene blue.
4. To perform Gram staining.
5. To prepare temporary mount of algae (spirogyra)/fungi (penicillium).
6. To study the growth curve of E.coli.
7. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs.

3.3 REFERENCES

1. J. Willey, L. Sherwood & C. Woolverton. (2017). Prescott's Microbiology.McGraw Hill international.
2. M. J Chan, ECS Krieg & NR Pelczar.(2004). Microbiology, McGraw Hill International.

Additional Sources

1. J. G. Cappuccino, and N. Sherman. (2013). Microbiology: A Laboratory manual, Benajamin/Cummings.
2. M. T. Madigan, J. M. Martinko & D. A. Stahl, Brock. (2010). Biology of Microorganisms, Pearson Education International.

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**
I	Students will learn about the historical developments in the field of Microbiology.	Teaching using chalk and board; Power point presentations;Oral discussions in the class.	Oral questions will be asked in the class.
II	Students will learn about general characterscs and structural details of various microbes.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
III	Students will learn about various parameters required for optimum growth of microbes.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
IV	Students will learn about the pathogenesis of diseases caused by microbes and the techniques to assess antimicrobial activity of various drugs.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
V	Students will learn about various commercial applications of microbiological techniques.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class.	Problems will be assigned to test student's analytical ability. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: History of development of microbiology as a discipline, Spontaneous generation versus biogenesis, contributions of Anton von Leeuwenhoek, Joseph Lister, Paul Ehrlich, Richard Petri, Charles Chamberland, Edward Jenner, Louis Pasteur, Robert Koch, Martinus W. Beijerinck, Sergei Winogradsky, Alexander Fleming, Elie Metchnikoff and Emil von Behring.

Week 2: Difference between prokaryotic and eukaryotic microorganisms. General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) with emphasis on distribution, occurrence and morphology.

Week 3: General characteristics of Cellular microorganisms (Bacteria, Archaea, Algae, Fungi and Protozoa) with emphasis on distribution, occurrence and morphology.

Week 4: Cell-wall: Composition and detailed structure of Gram positive and Gram negative cell walls, mechanism of Gram's staining. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

Week 5:Nutritional types of microorganisms, growth factors, culture media- synthetic and complex, types of media; isolation of pure cultures, growth curves, mean growth rate constant, generation time.

Week 6:Influence of environmental factors on growth of microbes: effect of pH, temperature, solute, oxygen concentration, pressure and radiations. Sterilization, disinfection and antiseptics.

Week 7: Use of physical methods (heat, low temperature, filtration, radiation) and chemical agents (phenolics, halogens, heavy metals, sterilizing gases) in microbial control.

Week 8:Introduction to pathogenic microbes; disease, pathogenesis, diagnosis, vaccine, treatment and symptoms (TB, HIV, Malaria)

Week 9: General Characteristics of antimicrobial drugs.Determining the level of antimicrobial activity: dilution susceptibility test and disc diffusion test.Mechanism of action of penicillins, vancomycin and tetracycline.

Week 10: Importance of microbiology in food and industries.Basic design of fermenter, continuous and discontinuous culture.

Week 11: Preparation of fermented food products such as yoghurt, curd and cheese.Preparation of alcoholic beverages like wine and beer.Single cell proteins.

Week 12: Treatment of waste water (Municipal treatment plant) and sewage.bioremediation and biodegradation.

6. Keywords

Microorganisms, Diversity, Culture, Pathogenicity, Industrial microbiology

B.Sc. (HONOURS) BIOLOGICAL SCIENCE
(CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Medicinal Botany (SEC-1)
SEMESTER – III

1. Course Objective

Plants are imperative to mankind with almost all plants known to possess medicinal values. There is an increased emphasis on indigenous system of medicine which has lent prime focus on medicinal plants. Keeping the therapeutic importance of medicinal plants in mind this course is designed to provide education and training on diverse perspectives of medicinal plants. The course also offers comprehensive knowledge about understanding the difference between ancient wisdom and modern system of medicine.

2. Course Learning Outcomes

- Students will be able to identify the common medicinal plants in their vicinity.
- Students will learn about the traditional healing sciences namely Ayurveda, Siddha and Unani, which have been used since the ancient times.
- Students will appreciate the importance of conservation strategies for medicinal plants.
- Students will be able to understand the importance of medicinal plants, significance of ethnobotany, role of ethnic groups in the conservation of medicinal plants.

3. Course Contents

3.1 THEORY

TOTALHOURS: 24 **CREDITS: 2**

Unit I: History, Scope and Importance of Medicinal Plants No. of Hours: 10

Introduction to indigenous systems of medicines- Ayurveda, Unani and Siddha system of medicine.) -Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Siddha: Origin of Siddha medicinal systems, Basis of Siddha system,. Unani: History, concept: Umoor-e- tabiya. Plants used in Ayurveda, siddha and unani medicine with special reference to *Carum carvi, Allium cepa, Allium sativum, Asparagus racemosus, Vitis vinifera, Linum usitatissimum, Amaranthus paniculatus* Polyherbal formulations (with special reference to Safi, Chyawanprash, Trifala, swalin, amukkara choorna, gandhak rasayana). Natural products – Compounds responsible for biological activity of medicinal plants: their biology, and pharmacology (*Curcumin, vinblastine, vincristine, Ecliptine, Cinchonine, Azadirachtin, Artemisinin*).

Unit II: Conservation of Endangered and Endemic Medicinal Plant No. of Hours: 6

Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanical Gardens, herbal gardens, Ethnomedicinal plant gardens. Germplasm conservation, cryopreservation (Cryo banks and DNA banks), Propagation of Medicinal Plants: *In vitro* and *In vivo* strategies.

Unit III: Ethnobotany and Folk Medicines No. of Hours: 8

Introduction, concept, scope and objectives; Ethnobotany in India: Methods to study ethnobotany; Folk medicines of ethnobotany, Role of ethnobotany in modern medicine with special reference to *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia, Withania* Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, blood pressure and skin diseases. Role of ethnic groups in conservation of plant genetic resources; Brief account of biopiracy and IPR.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. To locate any ten common medicinal plants in the surrounding area (Description, diagram, medicinally important plant part, characteristic feature, therapeutic uses).
2. To extract the active principle from any four medicinal plants. (*Aloe vera, Ocimum, Azadirachta, Catharanthus, Adhatoda, Withania*)
3. Write the details of any two commonly used medicines from the indigenous system of medicine (Ayurveda,Siddha and Unani)
4. Field trip (Industries/Institutes) / e-presentations (System of medicine, Conservation strategies, propagation of medicinal plants, folk medicines, application of natural products to certain diseases listed in the syllabus)
5. Herbarium preparation for any two medicinal plants.
6. To compare the total phenolic content of few locally available medicinal plants
7. Laboratory records

3.3 REFERENCES

1. Abdin, M. Z. and Abrol, Y. P., (2006). *Traditional Systems of Medicine.* Narosa Publishing House, New Delhi.
2. Kumar, S., (2018). *Ethnobotany*. Kojo press, New Delhi.
3. Purohit and Vyas, (2008). *Medicinal Plant Cultivation: A Scientific Approach,* Agrobios.
4. Trivedi, P. C. (2006). *Medicinal Plants: Ethnobotanical Approach.* Agrobios.

Additional Resources

1. Colton, C. M., (1997). *Ethnobotany: Principles and Applications*. John Wiley and Sons.
2. Jain, S. K., (1990). *Contributions to Indian Ethnobotany*. Scientific publishers, Jodhpur.
3. Jain, S. K., (1995). *Manual of Ethnobotany.* Scientific Publishers, Jodhpur.

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
I	Students will learn about the traditional healing sciences- Ayurveda, Siddha and Unani, which have been used since the ancient times.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Oral questions will be asked in the class. Students will be assessed based on the concept related class presentations.
II	Students will learn about the importance of conservation strategies for medicinal plants and identify the common medicinal plants in their vicinity.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Concept based knowledge will be tested though Quiz. Class tests will be conducted for internal assessment.
III	Students will learn about the importance of medicinal plants, significance of ethnobotany, role of ethnic groups in the conservation of medicinal plants.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Students will be assessed based on the assignment given to them to identify common medicinal plants.

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

5. Teaching Plan

Week 1: Introduction to indigenous systems of medicines- Ayurveda, Unani and Siddha system of medicine. Ayurveda: History and origin.

Week 2: Panchamahabhutas, saptadhatu and tridosha concepts, Siddha, Origin of Siddha medicinal systems.

Week 3: Basis of Siddha system,Unani: History, concept: Umoor-e- tabiya.

Week 4: Plants used in Ayurveda, siddha and unani medicine with special reference to *Carum carvi, Allium cepa, Allium sativum, Asparagus racemosus, Vitis vinifera, Linum usitatissimum, Amaranthus paniculatus* Polyherbal formulations (with special reference to Safi, Chyawanprash, Trifala, swalin, amukkara choorna, gandhak rasayana).

Week 5: Natural products – Compounds responsible for biological activity of medicinal plants: their biology, and pharmacology (*Curcumin, Vinblastine, Vincristine, Ecliptine, Cinchonine, Artemisim).*

Week 6: Definition: endemic and endangered medicinal plants, Red list criteria; In situ conservation: Biosphere reserves, sacred groves, National Parks.

Week 7: Ex situ conservation: Botanical Gardens, herbal gardens, Ethnomedicinal plant gardens Germplasm conservation.

Week 8: Cryopreservation (Cryo banks and DNA banks), Propagation of Medicinal Plants: *In vitro* and *In vivo* strategies.

Week 9: Introduction, concept, scope and objectives; Ethnobotany in India: Methods to study ethnobotany.

Week 10: Folk medicines of ethnobotany, Role of ethnobotany in modern medicine with special reference to *Rauvolfia serpentina, Trichopus zeylanicus, Artemisia, Withania.*

Week 11: Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, blood pressure and skin diseases.

Week 12: Role of ethnic groups in conservation of plant genetic resources; Brief account of biopiracy and IPR.

6. Keywords

Ayurveda, Siddha, Unani, Ethnobotany, Conservation, Folk medicine, Biopiracy, Germplasm conservation, Cryopreservation.

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Medical Diagnostics (SEC-2)
SEMESTER – IV

1. Course Objective

The course is designed to provide students a unique opportunity to study how doctors and clinicians come to a conclusion regarding disease prediction, prevention, diagnosis and optimal treatment regimens. The students will learn about importance of technology in healthcare and study the various medical diagnostic tools, techniques and technologies frequently used in medical practice. The related laboratory exercises will provide hands-on experience for many of these concepts in clinical context. The course will help the students to understand the biomedical basis of various diseases, the skills required to understand the common signs and symptoms related to diseases, the scientific approach to make a differential diagnosis and the use of technology in healthcare diagnosis and management.

2. Course Learning Outcomes

- Students will be able to correlate the various symptoms associated with early diagnosis of common diseases.
- Students will be able to understand the key concepts related to categorization of diseases (infectious/non-infectious diseases, lifestyle/genetic basis).
- Students will learn the basis of common diseases and the biochemistry underlying the various diagnostic tests.
- Students will develop basic skills that are commonly used for clinical diagnosis.

3. Course Contents

3.1 THEORY

TOTAL HOURS: 24 **CREDITS: 2**

Unit I: Biomedical Basis of Diseases No. of Hours: 8

Study of disease burden: India and global perspective; brief pathophysiology and diagnosis/ study of specific biomarkers of some prevalent diseases and disorders:complex disorders (diabetes, cardiovascular diseases, obesity, polycystic ovarian syndrome, autism spectrum disorder); infectious (amoebic dysentery, sepsis, pulmonary and extra-pulmonary tuberculosis, malaria, dengue, pneumonia, AIDS, swine flu, hepatitis, Japanese encephalitis, chikungunya, hantavirus, Nipah and Zika); autoimmune diseases (rheumatoid arthritis); Cancer-types and staging; How pathogenesis is related to symptoms

Unit II: Analytical Technology No. of Hours: 6

Brief description of the following analytical techniques: liquid chromatography (LC/HPLC); gas chromatography-mass spectrometry (GC-MS); nuclear magnetic

resonance spectroscopy (NMR); atomic force and scanning electron microscopy (AFM and SEM); electrochemistry; immunohistochemistry; molecular diagnosis of genetic diseases

Unit III: Diagnostic Methodology No. of Hours: 10

Outline the diverse methodology used in hospitals: histopathology, biochemistry, haematology (enzymatic and protein markers in blood: alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), creatinine, creatine kinase (CK), lactate dehydrogenase (LDH), serum GGT {Gamma glutamyl transaminase (γ-GT)}, myoglobin (Mb), troponin T (cTNT), C-reactive Protein (US-CRP), HbA1c) and microbiology laboratories; Basic concepts of X-ray, CT, MRI, Ultrasound, ECG, Echo; Latest advancements in the field of medical diagnostics: embedded sensors and wearables, biomedical informatics.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. ABO Blood typing
2. Analysis of urine for abnormal constituents
3. Body temperature and blood pressure under normal condition and condition of stress
4. Estimation of blood glucose/cholesterol by kit
5. Interpretation of ECG
6. Medical imaging: X-rays of bone fracture; Ultrasound, MRI; CT-Scan; PET-Scan
7. A visit to pathology laboratory/ related research laboratory and submission of report.

3.3 REFERENCES

1. Godkar, P. B., & Godkar, D. P. (2014). *Textbook of Medical Laboratory Technology*. Mumbai: Bhalani Publishing House.
2. Guyton, A.C. &Hall, J.E. (2011). *Textbook of Medical Physiology*. Harcourt Asia Pvt. Ltd/ W.B. Saunders Company.
3. Kumar, V., Abbas, A. K., Fausto, N., and Aster, J. C. (2009). *Robbins and Cotran Pathologic Basis of Disease*. Philadelphia, PA: Elsevier/Saunders.

Additional Sources

1. Prakash, G., (2012). *Lab Manual on Blood Analysis and Medical Diagnostics.* S. Chand and Co. Ltd.
2. Walker, B.R., Colledge, N.R., Ralston, S., and Penman, I.D. (2014). *Davidson's Principles & Practice of Medicine*. Edinburgh: Churchill Livingstone/Elsevier.

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
I	Students will learn about the biomedical basis of common diseases and the various symptoms associated with early diagnosis of common diseases.	The traditional chalk and talk method supplemented with power point presentations. Students will be taught to do ABO typing and relevance of blood grouping	Students will be asked to gather information about prevalence of disease as per category in their area.
II	Students will learn about the analytical biochemistry related to diagnostic tests and their clinical significance.	The traditional chalk and talk method and power point presentations. Students will be taught to perform estimation of blood glucose, analysis of urine and interpret results.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.
III	Students will learn about the diverse methodology used in hospitals for diagnosis of diseases and the various tests/ technology available to help in this diagnosis.	Students will be taught to interpret ECG, PET-Scan and ultrasound reports.Visit of students to a pathology laboratory/ research laboratory/Mohalla clinics.	Oral questions will be asked in the class. Students will be asked to discuss some clinical case-studies by giving short presentations.

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

5. Teaching Plan

Week 1: Study of disease burden: India and global perspective; brief pathophysiology of some prevalent diseases and disorders.

Week 2: Diagnosis/ study of specific biomarkers of some prevalent diseases and disorders: complex disorders (diabetes, cardiovascular diseases, obesity, polycystic ovarian syndrome, autism spectrum disorder).

Week 3: Diagnosis/ study of specific biomarkers of some prevalent diseases and disorders: infectious (amoebic dysentery, sepsis, pulmonary and extra-pulmonary tuberculosis, malaria, dengue, pneumonia, AIDS, swine flu, hepatitis, Japanese encephalitis, chikungunya, hantavirus, Nipah and Zika).

Week 4: Diagnosis/ study of specific biomarkers of some prevalent diseases and disorders: autoimmune diseases (rheumatoid arthritis); Cancer-types and staging; How pathogenesis is related to symptoms.

Week 5: Brief description of the following analytical techniques: liquid chromatography (LC/HPLC); gas chromatography-mass spectrometry (GC-MS).

Week 6: Brief description of the following analytical techniques: nuclear magnetic resonance spectroscopy (NMR); atomic force and scanning electron microscopy (AFM and SEM).

Week 7: Brief description of the following analytical techniques: electrochemistry; immunohistochemistry; molecular diagnosis of genetic diseases.

Week 8: Outline the diverse methodology used in hospitals.

Week 9: Histopathology, biochemistry, haematology (enzymatic and protein markers in blood: alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), creatinine, creatine kinase (CK).

Week 10: Haematology (lactate dehydrogenase (LDH), serum GGT {Gamma glutamyl transaminase (γ-GT)}, myoglobin (Mb), troponin T (cTNT), C - reactive protein (US-CRP), HbA1c) and microbiology laboratories.

Week 11: Basic concepts of X-ray, CT, MRI, Ultrasound, ECG, Echo.

Week 12: Latest advancements in the field of medical diagnostics: embedded sensors and wearables, biomedical informatics.

6. Keywords

Disease, Prognosis, Diagnosis, Health management, Medical imaging

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Bioinformatics (SEC-3)
SEMESTER – III

1. Course Objectives

The objective of this course is to impart basic understanding of bioinformatics and computational biology. 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. Students will be trained in the basic theory and application of programs used for database searching, protein and DNA sequence analysis and prediction of protein structures.

2. Course 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.

3. Course Contents

3.1 THEORY

TOTALHOURS: 24 **CREDITS: 2**

Unit-I: Introduction to Bioinformatics No. of Hours: 2

Introduction to Bioinformatics, Historical background. Scope of bioinformatics. Genomics, Proteomics, Computer aided drug design (CADD) and Systems Biology.

Unit-II: Biological Databases and Data Retrieval No. of Hours: 8

Introduction to biological databases, primary, secondary and composite databases, NCBI, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot, TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc, and MetaCyc), small molecule databases (PubChem, Drug Bank, ZINC, CSD). Organism specific databases (E. coli, yeast, Arabidopsis, Mouse, Drosophila Melanogaster). Structure viewers (Ras Mol, J mol) and File formats.

Unit-III: Sequence Alignment & Phylogeny No. of Hours: 8

Similarity, identity and homology. Concept of Alignment, local and global alignment, pairwise and multiple sequence alignments, BLAST and CLUSTALW. Phylogeny and its importance, methods of phylogeny, software for phylogenetic analyses.

Unit-IV: Genomics No. of Hours: 2

Introduction to genomics, comparative and functional genomics, gene structure in prokaryotes and eukaryotes, Genome annotation, gene prediction approaches and tools.

Unit-V: Applications of Bioinformatics No. of Hours: 4

Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Applications in Microbial Genomics, Crop improvement and Health Care.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Sequence retrieval (protein and gene) from NCBI and Molecular file formats - FASTA, GenBank/Genpept.
2. Structure download (protein and DNA) from PDB and Molecular viewer by visualization software (Pymol / Rasmol/Jmol)
3. BLAST suite of tools for pairwise alignment
4. Multiple sequence alignment (CLUSTALW/TCoffee) and construction of phylogenetic trees
5. Secondary structure prediction of RNA/Protein
6. Tertiary structure prediction (SWISSMODEL) and Protein structure evaluation - Ramachandran map (PROCHECK
7. Design probe and primers for a given gene sequence
8. Gene Prediction Tools (GLIMMER/GENSCAN)

3.3 REFERENCES

1. Ghosh, Z., and Mallick, B. (2014). *Bioinformatics: Principles and applications*. ISBN: 9780195692303.
2. Pevsner, J. (2005). *Bioinformatics and functional genomics*. Hoboken, N.J: Wiley-Liss. ISBN: 0-47121004-8.

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
I	Students will be familiarized with the concept of Bioinformatics and Computational biology.	Teaching through power point presentations and chalk and board method.	Research review articles discussion and class presentations.

II	Students will learn about Biological Databases and the types of databases and various file formats used for sequence and structure analysis.	Traditional chalk and board method with powerpoint presentations on biological databases.	Computer assisted quizzes, assignments.
III	Students will learn about sequence alignment methods. Pairwise and multiple sequence alignment will be discussed in detail with examples of BLAST and CLUSTALw. They will also learn methods for phylogeny.	Chalk and board and notes; Power point presentations for images for clarity of concepts; Research papers will be discussed.	Class presentations and assignments will be given to students to understand phylogeny.
IV	Students will understand different applications of genomics in gene prediction. Functional Genomics & Comparative Genomics will be discussed	Power point presentations; Chalk and board; Student interaction in class.	Assignments and Quiz
V	Students will learn the applications of bioinformatics in drug discovery, agriculture and healthcare.	Chalk and board method, research articles and powerpoint presentations.	Assignments and Class presentations.

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

5. Teaching Plan

Week 1: Overview of Bioinformatics and its applications in biology.

Week 2: Databases & types of biological databases.

Week 3: Structure and Sequence Databases with examples.

Week 4: Sequence Alignment & its applications in study of phylogeny.

Week 5: BLAST and Multiple Sequence Alignment.

Week 6: Phylogenetic Analysis, Rooted & Unrooted Trees.

Week 7: Genomics & its application.

Week 8: Genome Annotation.

Week 9: Gene prediction methods.

Week 10: Applications of Bioinformatics in Drug Discovery. CADD.

Week 11: Microbial Genomics.

Week 12: Applications of Bioinformatics in Agriculture.

6. Keywords

Biological Databases, NCBI, PDB, Sequence Alignment, BLAST, Phylogeny, Gene Prediction

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Organic Farming (SEC-4)
SEMESTER – IV

1. Course Objective

The objective of the course is to introduce the concept of organic farming and its eco-friendly practices which are gaining momentum to counteract the adverse effects of chemical fertilizers and pesticides. Biofertilizers being essential components of organic farming play vital role in maintaining long term soil fertility and sustainability. The use of biofertilizers helps in sustainable agriculture by fixing atmospheric nitrogen, mobilizing fixed macro and micro nutrients or converting insoluble phosphorus in the soil to soluble forms to be available to plants. The course aims to familiarize the students with eco-friendly, low-tech and knowledge-rich approaches to farming.

2. Course Learning Outcomes

- Students will learn the importance of biofertilizers and organic farming over chemical inputs in agriculture system.
- Students will learn techniques for the identification, isolation and mass multiplication of various micro-organisms.
- Students will develop entrepreneurship skills and gain awareness in production of organic inputs.
- Students will be able to design resource efficient farming system for small and marginal farmers for improving their economy while meeting the quality food demand in a sustainable environment.

3. Course Contents

3.1THEORY

TOTAL HOURS: 24 **CREDITS: 2**

Unit I: Introduction No. of Hours: 3

Types and importance of biofertilizers, organic farming system, history of biofertilizer production, classification of microorganisms used in biofertilizer production.

Unit II:*Rhizobium*, *Azospirillum* and *Azotobacter* No. of Hours: 5

General characteristics, isolation, identification, mass multiplication and carrier-based inoculants; Biofertilizers available in the market.

Unit III: Cyanobacteria (blue green algae) No. of Hours: 4

Role of Algal biofertilizers in sustainable agriculture; Characteristics of *Azolla-Anabaena azollae* (BGA) association and their role in rice cultivation; Role of Algal Bio-Fertilizers in reducing greenhouse gases.

Unit IV: Mycorrhizal association No. of Hours: 5

Types of mycorrhizal association, occurrence and distribution, phosphorus nutrition, growth and yield – colonization of VAM – isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit V: Biological Control of Plant diseases No. of Hours: 3

Use of microbial inoculants as potential biopesticides for sustainable agriculture and integrated pest management.

Unit VI: Organic Farming No. of Hours: 4

Conventional farming, organic farming, importance of organic farming, status and scope of organic farming in India; Green manure and organic fertilizers, biocompost methods and types; and method of vermicomposting – field Application.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. a) Isolation of *Rhizobium* from root nodules by pour plate technique
   (b) Temporary mount preparation to study *Rhizobium* by gram staining method
2. Isolation and study of Blue-green algae (BGA) from *Azolla* leaves
3. (a) Isolation of Arbuscular Mycorrhizal fungal spores from rhizospheric soil
   (b) *In vivo* mass multiplication of isolated fungal spores using *Sorghum* roots
   (c) Study of arbuscules and vesicles in colonized roots by temporary mount preparation
4. Test for pH, NO_3, Cl^- and Organic matter of different compost / landfill leachate
5. Study of earthworm (*Eisenia foetida*), bio-control agents (pheromones traps, *Trichoderma*, *Pseudomonas*, Neem) through specimen/ photographs

3.3 REFERENCES

1. Dubey, R.C. (2005). *A Text book of Biotechnology*. S. Chand and Co, New Delhi.
2. John Jothi Prakash, E. (2004). *Outlines of Plant Biotechnology*. Emkay -Publication, New Delhi.
3. Kumaresan, V. (2005). *Biotechnology*. Saras Publications, New Delhi.
4. Palaniappan S. P., Annadurai K. (2018). *Organic Farming: Theory & Practice.* Scientific Publisher.
5. Sathe, T.V. (2004). *Vermiculture and Organic Farming*. Daya publishers.

Additional Reading

1. Subba Rao, N.S. (2000). *Soil Microbiology*, Oxford& IBH Publishers, New Delhi.
2. Vayas,S.C, Vayas, S. and Modi, H.A. (1998). *Bio-fertilizers and organic Farming*. Akta Prakashan, Nadiad.

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
I.	Students will learn about the importance of biofertilizers and organic farming in crop productivity and identify the microorganisms used as biofertilizers	Traditional chalk and board method with power-point presentations. Group Discussions with examples.	Problems will be assigned to the students for their better understanding. Assignments to enhance the learning and understanding.
II.	Students will learn about the mass multiplication of identified bacterial / fungal biofertilizers	Traditional chalk and board method with power-point presentations. Group Discussions with examples.	Regular question- answer sessions in the class. Class tests will be conducted for internal assessment
III.	The student will learn about algal biofertilizers, *Azolla-Anabaena* association and its importance in rice cultivation	Traditional chalk and board method with power-point presentations. Group discussions.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment
IV	The students will learn about importance of mycorrhizal association and their role in improving crop plants.	Traditional chalk & board method with power-point presentations.	Oral questions will be asked in the class. Students will be assessed based on the concept related class presentations.
V.	Students will learn about the use of microbial inoculants in combating stress in increasing crop productivity, integrated pest management.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class	Students will be assessed based on the assignment given to them to identify common medicinal plants.
VI.	The students will learn about conventional farming, organic farming, green manure, biocompost and method of vermicomposting.	Traditional chalk & board method with power-point presentations.	Problems will be assigned to test student's analytical ability. Assignments to enhance the learning and understanding.

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

5. Teaching Plan

Week 1: Introduction on biofertilizers and organic farming, its types and importance in agriculture.

Week 2: History of biofertilizer production, Classification of microorganisms used in biofertilizer production.

Week 3: General characteristics of *Rhizobium*, *Azospirrilium* and *Azotobacter*, isolation and their identification.

Week 4: Mass multiplication of isolated spores and study of their carrier-based inoculants; Biofertilizers available in the market.

Week 5: Role of Algal biofertilizers in sustainable agriculture; Characteristics of *Azolla-Anabaena azollae* (BGA) association and their role in rice cultivation.

Week 6: Role of Algal Bio-Fertilizers in reducing greenhouse gases.

Week 7: Types of mycorrhizal association, occurrence and their distribution, colonization of VAM – isolation and inoculum production.

Week 8: Role of mycorrhizal in the uptake of nutrition especially phosphorus, effect on growth and yield of crop plants.

Week 9: Use of microbial inoculants as potential biopesticides for sustainable agriculture and integrated pest management.

Week 10: Conventional farming, organic farming, importance of organic farming, status and scope of organic farming in India.

Week 11: Green manure and organic fertilizers, biocompost methods and its types.

Week 12: Method of vermicomposting, field Application.

6. Keywords

Rhizobium, Blue green algae, Mycorrhizal associations, Compost, Recycling

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Public Health Management (SEC-5)
SEMESTER – III

1. Course Objective

The course aims to provide the students a thorough understanding of the basics of public health and management of health and health hazards. The course will help the students understand the various environmental hazards and the fate of the hazardous toxins in the environment along with the dose response evaluation and exposure assessment. The students would gain awareness to various types of pollution and their impact on the health of living beings. This course will also help the students to understand the types and characteristics of waste handling and disposing with special emphasis on biomedical waste, nuclear waste and thermal power plant waste.

2. Course Learning Outcomes

- Students will learn about major causes of environment and human health hazards.
- Students will get familiar with various public health management strategies.
- Students will be made aware about the increased pollution levels in the environment and its effect on human health.
- Students will gain knowledge about social and economic factors for different types of diseases.
- Students will be encouraged for scientific writing as well as presentations and participation in citizen science initiatives with reference to human health.

3. Course Contents

3.1 THEORY

TOTALHOURS: 24 **CREDITS: 2**

Unit I: Pollution No. of Hours: 4

Air, water, Noise Pollution and Light pollution sources and effects

Unit II: Waste Management and Hazards No. of Hours: 8

Types and Characteristics of Wastes, Biomedical waste handling and disposal, Nuclear waste handling and disposal, Waste from thermal power plants. Case histories on Bhopal gas tragedy, Chernobyl disaster and Seveso disaster and Three Mile Island accident and their aftermath, Government awareness programs.

Unit III: Infectious Diseases No. of Hours: 6

Social and Economic factors of diseases, roles of health services and other organizations: diseases: Hepatitis, Dengue, Chikungunia, Zika, Nepa, Ebola, Bird flu, Sexually transmitted diseases.

Unit IV: Non-infectious diseases No. of Hours: 6

Lifestyle and Inherited (Obesity, Diabetes and Hypertension) /Genetic diseases (Autism, Down syndrome and Thalassemia/ Sickle cell anaemia), Nutritional deficiency: Vitamin deficiency, Iron deficiency and Protein deficiency.

3.2 PRACTICALS

TOTALHOURS: 48 **CREDIT: 2**

1. To study the following medically important organisms- Mosquito, Housefly, Cockroach, Ants and Rats.
2. Estimate the blood glucose level by enzymatic method/ Glucometer
3. Testing potability of water for human consumption by MPN method.
4. Calculate the BMI of students analyse the results with suitable statistical tools.
5. Measure the blood pressure using sphygmomanometer, analyze and correlate with lifestyle.
6. Data collection case study or interview of the individuals suffering from diseases (eg. Hypertension, Diabetes, Tuberculosis, PCOD etc.)
7. A visit to water purification/ Sewage treatment/ Sulabh International/ Effluent treatment plant/ CPCB/ NIMR etc. and submission of report.

3.3 REFERENCES

1. Cutter, S.L. (1999). *Environmental Risk and Hazards*. Prentice-Hall, India.
2. Goel S., Gupta P. (2012). *Food Nutrition and Health*. 1st ed.,ISBN: 81-219-4092-3.
3. Kolluru R., Bartell S., Pitblado R. and Stricoff, S., (1996). *Risk Assessment and Management Handbook*. McGraw Hill Inc., New York.

Additional Sources

1. Annual report, National Institute of Nutrition Council of Medical Research, Hyderabad.

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
I	Students will learn about different types of pollution, their sources and effects on human health.	Teaching using chalk and board; Power point presentations. Oral discussions in the class.	Oral questions will be asked in the class.Class tests will be conducted for internal assessment.

II	Students will learn about types and characteristics of wastes and its management. Few case histories like Bhopal gas tragedy and Chemobyl disaster will be discussed.	Group discussions, book reviews, paper presentations, videos, animations will be employed .Power point presentations may be used for explaining certain topics.	Problems will be assigned to test student's analytical ability. Practical will be designed in such a way so as to reinforce the concepts learnt in theory.
III	Students will learn about different types of infectious diseases and sexually transmitted diseases.	Teaching using chalk and board; Oral discussion sessions in the class. Power point presentations may be used.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.
IV	Students will learn about non-infectious diseases. Lifestyle and Inherited and nutritional deficiency related diseases.	Oral discussion sessions in the class. Power point presentations may be used for explaining certain topics.	Oral questions will be asked in the class. Class tests will be conducted for internal assessment.

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

5. Teaching Plan

Week 1: Overview of Air, water pollution, its sources and effects.

Week 2: Noise Pollution and Light pollution sources and effects.

Week 3: Types and Characteristics of Wastes, Biomedical waste handling and disposal.

Week 4: Nuclear waste handling and disposal, Waste from thermal power plants.

Week 5: Case histories on Bhopal gas tragedy and Chernobyl disaster, their aftermath.

Week 6: Case histories on Seveso disaster and Three Mile Island accident and their aftermath, Government awareness programs.

Week 7: Social and Economic factors of diseases, roles of health services and other organizations. Infectious diseases: Hepatitis.

Week 8: Infectious diseases: Dengue, Chikungunia, Zika, Nepa,

Week 9: Infectious diseases: Ebola, Bird flu, Sexually transmitted diseases.

Week 10: Non-infectious diseases: Lifestyle and Inherited (Obesity, Diabetes and Hypertension).

Week 11: Non-infectious diseases: Genetic diseases (Autism, Down syndrome and Thalassemia/ Sickle cell anaemia).

Week 12: Non-infectious diseases: Nutritional deficiency: Vitamin deficiency, Iron deficiency and Protein deficiency.

6. Keywords

Pollution, Biomedical waste, Health Hazards, Infectious diseases, Lifestyle diseases, Nutritional deficiency

B.Sc. (HONOURS) BIOLOGICAL SCIENCE (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC)
Biochemical Techniques (SEC-6)
SEMESTER – IV

1. Course Objective

The objective of the course is to introduce various biochemical techniques to the students and to provide them with an understanding of the principle underlying these techniques. The aim of the course is to empower the students in various laboratory skills which they will acquire in the form of practical exercises. The knowledge and skill acquired by the students will enable them to improve their understanding of the techniques which they can apply for various qualitative and quantitative applications in biological science.

2. Course Learning Outcomes

- Students will acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques.
- Students will learn about the principle and application of electrophoresis and centrifugation techniques.
- It will also give them an opportunity to get hands on experience to develop their laboratory skills expected of any biochemist working in a research lab.

3. Course Contents

3.1THEORY

TOTAL HOURS: 24 **CREDITS: 2**

Unit I: Spectroscopic Techniques No. of Hours: 4

Electromagnetic radiation, interaction of radiation with biomolecules, principle of UV visible absorption spectrophotometry, Lambert's Law, Beer's Law, working of a spectrophotometer.Applications of UV-visible absorption spectrophotometry in biochemistry.Flourescence spectrophotometry and its applications in biochemistry.

Unit II: Chromatography No. of Hours: 8

Introduction to chromatography. Principle and applications of Paper Chromatography, Thin Layer Chromatography, Ion Exchange Chromatography, Gel filtration and Affinity Chromatography. HPLC.

Unit III: Electrophoresis No. of Hours: 8

Principle of electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native and denaturing gels.Buffer systems in electrophoresis.Agarose gel electrophoresis.Electrophoresis of proteins and nucleic acids,

detection and identification.Molecular weight determination, Isoelectric Focusing of proteins.

Unit IV: Centrifugation No. of Hours: 4

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient.Various types of centrifuges, types of rotors. Application of centrifugation, differential centrifugation, density gradient centrifugation, zonal and isopycnic.

3.2 PRACTICALS

TOTAL HOURS: 48 **CREDITS: 2**

1. Verification of Beer's Law
2. Protein estimation by Biuret/Lowry's method
3. Separation of amino acids by Thin layer chromatography (TLC)
4. Separation of sugars/bases using paper chromatography
5. Separation by Ion Exchange/Gel filteration Chromatography
6. To perform agarose gel electrophoresis
7. Isolation of mitochondria and assay of its marker enzyme SDH

3.3 REFERENCES

1. Boyer, R.F., (2012). *Biochemistry Laboratory: Modern Theory and Techniques.* (6th ed.) Boston, Mass: Prentice Hall. ISBN-13: 978-0136043027.
2. Plummer D. T. (1998). *An Introduction to Practical Biochemistry* (3rd ed.). Tata McGraw Hill Education Pvt. Ltd. (New Delhi). ISBN: 13: 978-0-07-099487-4 / ISBN: 10: 0-07-099487-0.
3. Wilson K. and Walker J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology* (7th ed.). Cambridge University Press. ISBN 978-0-521-51635-8.

Additional Reading

1. Cooper T. G. (2011). *The Tools of Biochemistry* (2nd ed.). Wiley-Interscience Publication (New Delhi). ISBN: 13:9788126530168.
2. Freifelder, D. (1982). *Physical Biochemistry: Applications to Biochemistry and Molecular Biology* (2nd ed.). W.H. Freeman and Company (New York). ISBN: 0-7167-1315-2 / ISBN:0-716714442.

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
I	Students will learn about the principle and applications of	Teaching using chalk and board; Oral discussion	Problems will be assigned related to

	spectrophotometry and flourimetry.	sessions in the class. Powerpoint presentations.	Beer's Law and Lambert's Law to test the understanding of students.
II	Students will learn the principle of various chromatographic techniques like gel filteration, ion exchange and affinity chromatography.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Practical exercises are designed whereby the students get hands on experience with these chromatography techniques.
III	Students will learn about electrophoretic techniques, their principle and applications.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class.	Various analytical problems will be assigned to students related to electrophoretic separation.
IV	Students will learn about the basic rules of sedimentation, various types of centrifuges and rotors.	Teaching using chalk and board; Power point presentations; Oral discussions in the class.	Demonstration with the help of centrifuges and rotors to improve their understanding.

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

5. Teaching Plan

Week 1: Electromagnetic radiation, interaction of radiation with biomolecules, principle of UV-visible absorption spectrophotometry, Lambert's Law, Beer's Law, working of a spectrophotometer.

Week 2: Applications of UV-visible absorption spectrophotometry in biochemistry. Flourescence spectrophotometry and its applications in biochemistry.

Week 3: Introduction to chromatography. Principle and applications of Paper Chromatography and Thin Layer Chromatography.

Week 4: Principle and applications of Ion Exchange Chromatography.

Week 5: Principle and applications of Gel filtration Chromatography.

Week 6: Principle and applications of affinity Chromatography. HPLC.

Week 7: Principle of electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE.

Week 8: Native and denaturing gels. Agarose gel electrophoresis, buffer systems in electrophoresis.

Week 9: Electrophoresis of proteins and nucleic acids, detection and identification.

Week 10: Molecular weight determination, Isoelectric Focusing of proteins.

Week 11: Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient. Various types of centrifuges, types of rotors.

Week 12: Application of centrifugation, differential centrifugation, density gradient centrifugation (zonal and isopycnic).

6. Keywords

Spectrophotometry, Chromatography, SDS-PAGE, Isoelectric focussing, Centrifugation, Electrophoresis