दिल्ली विश्वविद्यालय
UNIVERSITY OF DELHI

Bachelor of Science (Hons) Biochemistry

(Effective from Academic Year 2019-20)

Revised Syllabus as approved by

Academic Council

Date: No:

Executive Council

Date: No:

Applicable for students registered with Regular Colleges, Non Collegiate Women's Education Board and School of Open Learning

Syllabus
For
B.Sc. (Honours) Biochemistry
(Three Year Full Time Programme)

Under

Choice Based Credit System (CBCS)
Learning Outcome Based Curriculum Framework
(LOCF)

1st Meeting of Teachers / Faculties (13th Feb 2019)
Course Revision Committee (18th February 2019)
DRAFT 1 (15th March 2019)
DRAFT 2 (22nd April 2019)
1st COC Meeting: 24th April 2019
Draft 3 : (3rd June 2019)
2nd COC Meeting: 4th June 2019
Faculty Meeting : 11th June 2019
Standing Committee : 11th July 2019

(Syllabus applicable for students seeking admission in the B.Sc. (Hons) Biochemistry Course from the academic year 2019-20)

Department of Biochemistry
Faculty of Interdisciplinary and Applied Sciences
University of Delhi South Campus
New Delhi-110021

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PREAMBLE

Biochemistry is the branch of science that explores the chemical processes within and related to living organisms. It is a laboratory based science programme that brings together biology and chemistry and focuses on processes happening at the cellular and molecular level. Biochemistry is the study of the components and composition of living things and their assembly and interactions important in sustaining life. By using chemical knowledge and techniques, biochemists attempt to investigate and solve biological problems pertaining to the understanding of physiological processes, their malfunction leading to diseases and subsequent disease diagnostics, prevention, therapy and prognostics. Bachelor's degree in Biochemistry at University of Delhi endeavors to train students in this classical art of life sciences to create a knowledge pool and skilled manpower to take on the challenges that modern biological sciences poses in understanding the emerging dynamics of life processes and the myriads of diseases that threaten mankind.

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.

For multi-faceted development of a student, the curriculum includes courses to gain specialization in biochemistry while at the same time obtain sufficient exposure to related and varied subjects and skills. The curriculum emphasizes on several "core" courses (C) that will train students with the basic as well as advanced concepts of the discipline of biochemistry. All students pursuing the Bachelor's degree with Honours shall study fourteen such core papers across the six semesters. Students pursuing the programme shall also study four Discipline-Specific Elective (DSE) courses in the fifth and sixth semesters, which they will select from a list of such courses based on their individual preferences. These DSE courses will include diverse papers in other areas of life sciences (like Microbiology and Plant Biochemistry) or specialized research oriented courses (like Molecular Basis of Infectious Diseases) or advanced courses of Biochemistry (like Advanced Cell Biology and Advanced Methodologies), which will provide students with wholesome knowledge and requisite skills preparing them for higher studies across the globe. The content of each paper (C and DSE papers) is based on the premise that the fundamental principles and ideas must come across in a clear, easy and concise manner. The course seeks to be diverse and yet will present the essence of biochemistry in a very elegant and focused manner that will build competitive edge not only for professional development in a related area but prepare students for academic pursuits like research and teaching.

The Skill Enhancement Courses (SEC), offered in the third and fourth semesters, emphasizes on hands-on-training and supplements the discipline courses in an appropriate manner to impart students the confidence and required skills in practical aspects of biochemistry to help them choose a future path in either industrial or academic setting. The

SEC courses also include a paper on research methodology that will prepare students appropriately for a future in research.

The Generic Elective Courses (GE) offer inter- and trans-disciplinary students an opportunity to obtain a flavour of Biochemistry in simple and concise terms. It will also help them to switch over to this discipline of study in the future, should they choose to do so. Students opting for these courses learn the basic concepts of Biochemistry right from the first semester onwards, with one paper in each of the first, second, third and fourth semester. . Students who join for Honours degree in Biochemistry will opt for Generic Elective courses from other related/unrelated disciplines.

Two value-based courses (Ability Enhancement Compulsory Courses - AECC) in the first and second semester will enable students to improve their knowledge and communication skills.

B.Sc. (Hons) Biochemistry

1. Introduction

Biochemistry is the branch of dynamic science that explores the chemical processes within living organisms/ systems. The study of Biochemistry aims to understand how all the molecules that constitute living organisms interact, to maintain and perpetuate life. It deals with the complexity of living organisms, the microscopic and macroscopic structures within organisms that have specific functions and their systems for extracting and transforming energy from the environment. Biochemistry also explains how organisms adapt to their changing environments and gradually evolve.

The teaching of such a dynamic and evolving course is best achieved through **Choice-based Credit System (CBCS)** since it offers opportunities to provide solid foundation in the core discipline, while allowing freedom to students to select discipline specific courses that augment the learning in core courses. This freedom is further reiterated through flexibility in opting courses that enhance specific skills in the discipline as well as selection of courses from other disciplines / departments that widen the scope for higher education and employability. The **Learning Outcome-based Curriculum Framework (LOCF)** built into the CBCS offers focus and purpose to the programme providing a platform for self-evaluation by students and teachers in addition to global assessment by all stakeholders. The combination of LOCF and CBCS also allows for lateral movement of students between institutes of higher learning and offers a level playing field for them across the nation.

1a. Nature and Extent of the B.Sc. (Honours) Programme in Biochemistry

Biochemistry is an interdisciplinary science with areas of overlap with Chemistry, Physics and Mathematics. It is a laboratory based science that acts as a bridge between Biology and Chemistry. It also shares boundaries with other interdisciplinary subjects such as Microbiology, Genetics and Biophysics. This course is designed so as to enable the students to gain theoretical knowledge and hands- on-experience in the laboratory. The course content is aimed at encouraging students to cultivate keen observational skills and to develop the ability to analyze and interpret experimental data, making them suitable for future careers in higher education and employment in industry and research institutes.

1b. Aims of the Programme

The overall objective of the Bachelors (Honours) Programme in Biochemistry is to enable students to learn and integrate foundational knowledge in Biology and Chemistry that is relevant to Biochemistry and thus prepare them for post-graduate education and /or careers as researchers in academia or related industries.

The program aims to:

- Provide students with scholarly experiences, both theoretical and hands-on, that help instil deep interests in learning the chemistry underlying the working of biological systems while developing broad and balanced knowledge and understanding of key biological concepts, principles and theories. The idea is to equip students with

appropriate tools of analysis so that they can independently tackle issues and problems in the field of biology and chemistry.

- 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.
- Develop in students an inquisitive learning approach to seek answers regarding the complex workings of various physiological systems, cellular multiplication and differentiation and communication within and between cells and organs, and the chemical bases of inheritance and disease.
- Empower students to apply the knowledge and skills they have acquired to the solution of specific theoretical and applied problems in Biochemistry.
- Build concepts in biochemistry that would enable them to undertake further studies in Biochemistry and related areas or in multidisciplinary areas and help develop a range of generic skills that are relevant to wage employment, self-employment and entrepreneurship.

1c. Program Duration, Design and Structure

Duration of the Program:

The BSc Biochemistry course is a three-year degree programme divided into six semesters. Each academic year (July - May) will consist of two semesters. Each semester will be of fifteen weeks duration with one week designated for teaching break to promote co-curricular and co-scholastic activities.

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 paper will carry a maximum of 100 marks, with 25% marks allotted for internal assessment and 75% for end-semester examination. Each practical paper will carry a maximum of 50 marks including experimentation, viva-voce and practical notebook assessment.

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 mandatory 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, four Generic Elective 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 148 credits to get a degree in B.Sc. (H) Biochemistry.

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).

Six courses of Discipline-Specific Electives (DSE) are offered in the programme, of which students will opt 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 elect 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). The Department of Biochemistry will offer seven GE courses for students of other departments in the respective colleges.

From a list of six Skill Enhancement (SE) courses provided, students will undertake 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 / MIL communication), will be of two credits each (theory only). Students will undertake one each in Semesters I and II.

2. Learning Outcome-based Approach to Curriculum Planning

The learning outcomes-based curriculum framework (LOCF) for a B.Sc. degree in Biochemistry is intended to provide a broad framework within which the biochemistry programme is designed such that it enables students to acquire a skill set that helps them understand and appreciate the field of biochemistry. The structure or design of this framework shall ensure a high standard of the Honours degree in Biochemistry in the University. It shall subsequently pave the way for periodic updation and review of the programme, all within the boundaries of the set framework. This programme specification, as outline in individual courses, is intended as a reference point for prospective students, current students, examiners

and academic and support staff involved in delivering the programme and enabling student development and achievement.

Program learning outcomes are the central organizing features of student learning. They are developed from the complex interaction of a range of competing and complementary factors. Since program learning outcomes can only be achieved and demonstrated through component courses, course learning outcomes and their assessment are integrally related to program learning outcomes. The expected programme learning outcomes are described below while the course learning outcomes are included along with course contents. The LOCF in Biochemistry aims to achieve this important aspect of a modern teaching programme.

3. Characteristic Attributes of a Graduate in Biochemistry

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

- **Disciplinary knowledge and skills:** Capable of demonstrating (i) comprehensive knowledge and understanding of major concepts, theoretical principles and experimental findings in Biochemistry and other related fields of study, including interdisciplinary subfields such as life science in general, medicine and clinical biology, plant sciences, biotechnology, microbiology, nutrition, forensics, bioinformatics and environmental science; (ii) ability to use modern instrumentation for chemical and physical analysis of biological samples.
- **Critical thinker and problem solver**: Ability to employ critical thinking and efficient problem solving skills in the various areas of biochemistry and related disciplines.
- **Sense of inquiry:** Biochemistry being the foundation for understanding all biological processes, a graduate in this discipline is expected to seek deeper knowledge by asking relevant/appropriate questions relating to issues and problems in the field of Biochemistry and related areas. It is also envisaged that the course will empower them with the ability to plan, execute and report the results of an experiment or investigation.
- **Research skills:** Capable of identifying a scientific problem, preparing/mobilising appropriate resources required for the project, and execute the project through to completion, while observing responsible and ethical scientific conduct; and biosafety and chemical hygiene regulations and practices.
- **Skilled communicator:** Ability to transmit complex technical information relating to biochemistry in a clear and concise manner in both oral and written formats.
- **Team player/worker:** Capable of working effectively in diverse teams in both classroom, laboratory and in industry and field-based situations.
- **Digitally literate:** Capable of using computers for mining scientific information using modern library search tools from various open source platforms or journals and the ability to use technique specific software to conduct experiments and analyze data. The graduates are expected to be proficient in using computational & visualization tools to study bio-molecular structures, graphing and statistical software to analyze statistical significance of data and report data in the form of graphs, tables or figures.
- **Ethical awareness:** The graduates of this programme will be able to avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism. They will learn to appreciate environmental and sustainability issues and their societal relevance.

- **Lifelong learners:** Capable of self-paced and self-directed learning aimed at personal development and for improving knowledge/skill development and acquiring fresh skills.

4. Qualification Description

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

- A student should demonstrate (i) a comprehensive and coherent understanding of the field of Biochemistry, its applications and links to related disciplinary areas of study; (ii) practical knowledge that enables different types of professions related to the discipline, 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 Biochemistry and an ability to use established techniques of analysis.
- Demonstration of a comprehensive knowledge of study material, including current research articles, books and e-books relating to basic and advanced concepts.
- 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.
- Application of disciplinary knowledge and transferable skills to new or unfamiliar problems and issues and the ability to seek solutions to real-life problems.
- Imbibing the ability to function effectively either independently or as a constituent of a team.

5. Programme Learning Outcomes (PO)

The curriculum is designed to achieve the following outcomes:

PO1: Inculcate the basic concepts of biochemistry including an understanding of the fundamental biochemical principles and their applications in a systematic, methodical, scientific, evidence-based process. The programme will also provide a general understanding of the related disciplines with a holistic knowledge generation in biological sciences.
PO2: Develop problem solving and analytical skills through case studies, research papers and hands-on-experience, especially integrated into skill enhancement courses.
PO3: Students will gain proficiency in basic laboratory techniques and be able to apply the scientific method to the processes of experimentation, hypothesis testing, data interpretation and logical conclusions.
PO4: Provide requisite knowledge of laboratory safety, data replication and quality control, record keeping and other aspects of "responsible conduct of research".
PO5: Ability to employ modern library search tools to locate and retrieve primary literature on a topic and critically evaluate the literature.
PO6: Students will be able to apply and effectively communicate scientific reasoning and data analysis in both written and oral forms. They will be able to communicate effectively with

well-designed posters and slides in talks aimed at scientific audiences as well as the general public.
PO7: Students will learn to work collaboratively in a team.
PO8: 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.
PO9: Graduates will be able to apply the major theories and research procedures to contemporary societal issues.
P10: The programme will prepare students to plunge into various fields of higher education or related profession in various disciplines, armed with plethora of knowledge, hands-on-experience and scientific attitude, at national and global levels.

6. Teaching-learning processes

The foremost effort of teaching is to impart knowledge to students, factual as well as hypothetical. The manner in which this is communicated to the students determines the success of the teaching process. To be able to see tangible results, it is imperative that the teaching-learning process be bilateral. There are three critical components to the teaching learning process, namely content writing, content delivery and engaging the students to complete the course. A passive flow of information from the teacher to the taught should make way for a vibrant atmosphere of active participation from the students. Teachers participating in the programme would have a well-structured and well-planned lecture ready for the class that should compel the students to concentrate, understand and enjoy the discourse. Students would be encouraged to think independently and ask pertinent questions cultivating out-of-the-box thinking. The link between theory and practical would be made evident, as working with their hands reinforces the concepts first introduced in theory classes.

The traditional chalk and talk method of teaching is simple but very effective. Diagrams or additional material may be shown as slides but with minimum text-rich content. For concepts that are difficult to explain, power point presentations or videos would be used. Some laboratory experiments will be open ended. Students will be divided into small groups to encourage teamwork, healthy competition and to be able to complete the task in stipulated time frames. Students will be taken out of the classroom and into the world of research institutions as well as industries in the form of simple visits or internships or educational tours for maximum benefit. It will help them to correlate what they learn in the classroom with the real world. Additionally, teachers will use MOODLE platform to create lessons and interact with students to create an open and effective two-way communication channel. Digital initiatives such as the Swayam portal, National digital library and open education resources will be used to greatly facilitate blended learning and flipped class rooms encouraging students to be responsible for learning. Group discussions, debates and scientific talks by external experts will be arranged for facile learning. Students will be encouraged to write comprehensive reviews of papers in a particular topic, reports, essays and short projects to augment their writing skills. Students will also be motivated to deliver seminars to strengthen their oratory skills.

7. Assessment methods

Assessment methods are the strategies, techniques, tools and instruments for collecting information to determine the extent to which students demonstrate desired learning outcomes.

Student learning outcomes cannot be ascertained by single evaluation criteria. A combination of direct and indirect assessments would thus be used. Direct methods of assessment will be used for students to demonstrate their learning while indirect methods will be used to observe students reflect on their learning. Written tests, essays, quiz, presentations and seminars will be used as direct methods of assessment, and indirect methods will include surveys, discussions, debates, participation in scientific meetings and festivals. Embedded assessments, in other words "classroom-based" or "continuous" assessments will be utilized as both a grading instrument as well as data for assessing student learning outcomes. Some examples of assessment methods that will be used are given below:

Method	**Description**	**Direct or Indirect Assessment**
Attendance	Regular participation in class activities (Theory and Practicals)	Indirect
Observations	Information can be collected while observing "events" such as classes, group work, and study sessions.	Indirect
Performance	Students can be evaluated on participation in practicals, events, presentations, projects. Encourages public speaking skills.	Direct
Portfolio	Students' work is collected throughout the program which is assessed by faculty using a common scoring guide. Portfolios may contain assignments, reports, class tests, exams, case studies, presentations, practical file record etc.	Direct
Viva Voce or External Review	An interview conducted by external faculty to gauge the depth of theoretical knowledge, clarity, visualization and hands on practical skills of the student. Instills self-confidence to face interviews in their future careers.	Indirect
Internally developed class tests	These are shorter tests held periodically through the semester to assess how well the students have grasped the concepts and skills. Also encourages regular attendance.	Direct
Course Exam	A comprehensive written exam given near the end of every 2 semesters to determine a student's acquisition and application of a particular type of knowledge or skill, as well as the ability to integrate knowledge.	Direct

Structure of B.Sc. (Honours) Biochemistry under CBCS

Core Course

BCH C-1: Molecules of Life
BCH C-2: Cell Biology
BCH C-3: Proteins
BCH C-4: Enzymes
BCH C-5: Metabolism of Carbohydrates and Lipids
BCH C-6: Membrane Biology and Bioenergetics
BCH C-7: Hormone: Biochemistry and Function
BCH C-8: Human Physiology
BCH C-9: Gene Organization, Replication and Repair
BCH C-10: Metabolism of Amino Acids and Nucleotides
BCH C-11: Concepts in Genetics
BCH C-12: Gene Expression and Regulation
BCH C-13: Genetic Engineering and Biotechnology
BCH C-14: Immunology

Discipline Specific Elective (*Any four*)

BCH DSE-1: Nutritional Biochemistry
BCH DSE-2: Advanced Cell Biology
BCH DSE-3: Microbiology
BCH DSE-4: Molecular Basis of Infectious Diseases
BCH DSE-5: Plant Biochemistry
BCH DSE-6: Advanced Methodologies

Generic Elective (*Any four*)

BCH GE-1: Biomolecules
BCH GE-2: Techniques in Biochemistry
BCH GE-3: Proteins and Enzymes
BCH GE-4: Biochemical Correlation of Diseases
BCH GE-5: Intermediary Metabolism
BCH GE-6: Biochemical Applications in Forensics
BCH GE-7: Recombinant DNA Technology

Ability Enhancement Compulsory Course

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

Skill Enhancement Elective Course (*Any two*)

BCH SEC-1: Biochemical Techniques
BCH SEC-2: Biostatistics
BCH SEC-3: Research Methodology
BCH SEC-4: Bioinformatics
BCH SEC-5: Microbial Techniques

SEMESTER-WISE COURSE STRUCTURE of B.Sc. (Honours) Biochemistry

SEMESTER I		SEMESTER II	
C1	Molecules of Life	**C3**	Proteins
C2	Cell Biology	**C4**	Enzymes
AECC1	English/MIL Communication or EVS	**AECC2**	English/MIL Communication or EVS
GE-I	Generic Elective (*Any one*)	**GE-II**	Generic Elective (*Any one*)
	I. Biomolecules (GE-1)		I. Proteins and Enzymes (GE-3)
	II. Techniques in Biochemistry (GE-2)		II. Techniques in Biochemistry (GE-2A)
			III. Biochemical Correlation of Diseases (GE-4)
SEMESTER III		**SEMESTER IV**	
C5	Metabolism of Carbohydrates and Lipids	**C8**	Human Physiology
C6	Membrane Biology and Bioenergetics	**C9**	Gene Organization, Replication and Repair
C7	Hormone: Biochemistry and Function	**C10**	Metabolism of Amino Acids and Nucleotides
SEC-I	Skill Enhancement Course (*Any one*)	**SEC-II**	Skill Enhancement Course (*Any one*)
	I. Biochemical Techniques (SEC-1)		I. Bioinformatics (SEC-4)
	II. Biostatistics (SEC-2)		II. Microbial Techniques (SEC-5)
	III. Research Methodology (SEC-3)		III. Research Methodology (SEC-3A)
GE-III	Generic Elective (*Any one*)	**GE-IV**	Generic Elective (*Any one*)
	I. Intermediary Metabolism (GE-5)		I. Biochemical Correlation of Diseases (GE-4A)
	II. Proteins and Enzymes (GE-3A)		II. Recombinant DNA Technology (GE-7)
	III. Biochemical Applications in Forensics (GE-6)		III. Biochemical Applications in Forensics (GE-6A)
SEMESTER V		**SEMESTER VI**	
C11	Concepts in Genetics	**C13**	Genetic Engineering and Biotechnology
C12	Gene Expression and Regulation	**C14**	Immunology
DSE-I	Discipline Specific Elective (*Any two*)	**DSE-II**	Discipline Specific Elective (*Any two*)
	I. Nutritional Biochemistry (DSE-1)		I. Molecular Basis of Infectious Diseases (DSE-4)
	II. Advanced Cell Biology (DSE-2)		II. Plant Biochemistry (DSE-5)
	III. Microbiology (DSE-3)		III. Advanced Methodologies (DSE-6)

C: Core Courses (14); **GE**: Generic Elective (04); **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 offered in each category.**

Courses containing "A" in their course code are repeated in different semesters.

SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. HONOURS BIOCHEMISTRY

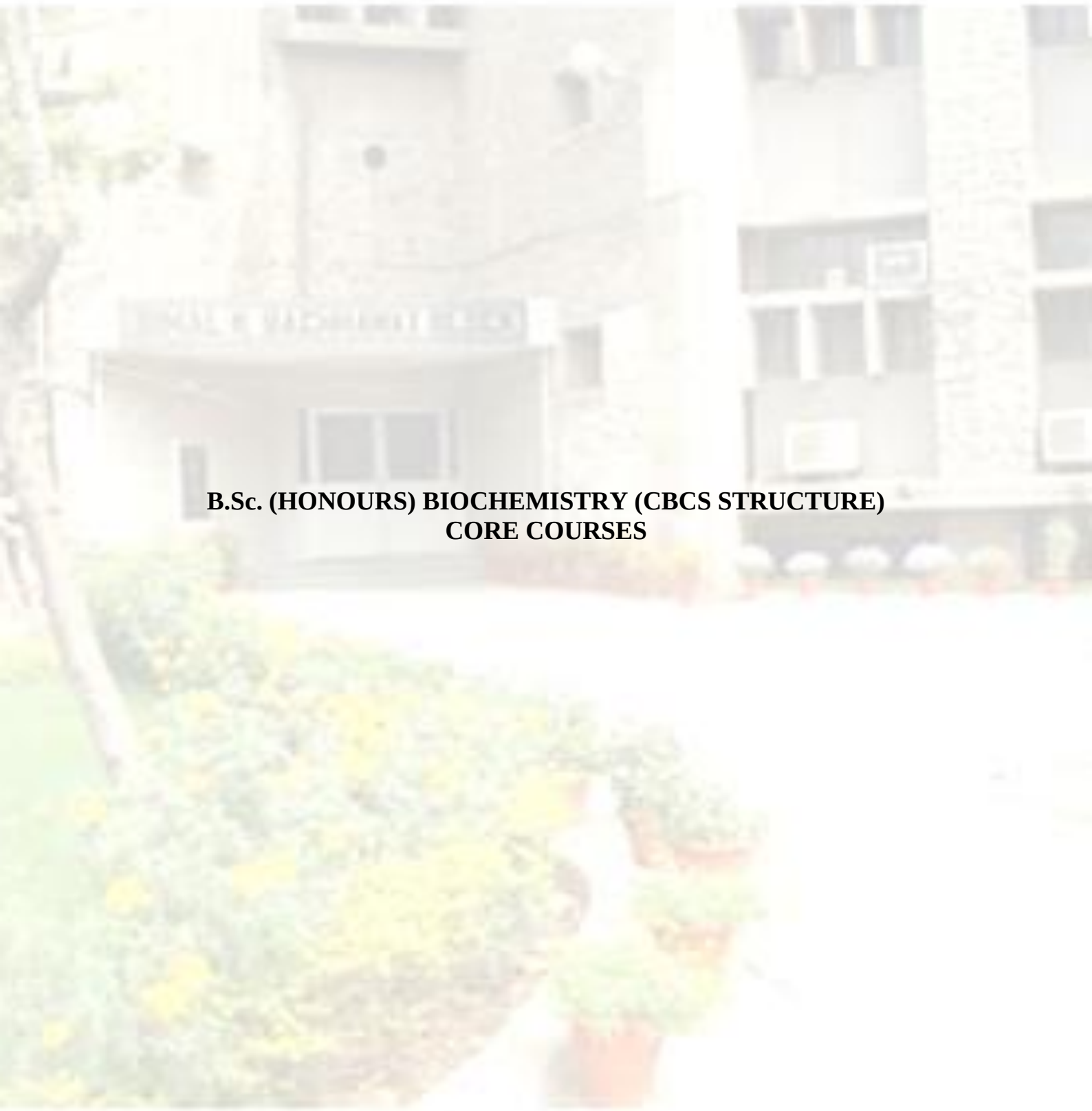
SEMESTER	COURSES OFFERED	COURSE NAME	CREDITS
I	Ability Enhancement Compulsory Course 1	English / MIL communication / Environmental Science	4
	Core course 1 Theory (C1)	Molecules of Life	4
	Core course 1 Practical	Molecules of Life	2
	Core course 2 Theory (C2)	Cell Biology	4
	Core course 2 Practical	Cell Biology	2
	Generic Elective 1 Theory (GE-1)	Biomolecules	4
	Generic Elective 1 Practical	Biomolecules	2
	Generic Elective 2 Theory (GE-2)	Techniques in Biochemistry	4
	Generic Elective 2 Practical	Technique in Biochemistry	2
II	Ability Enhancement Compulsory Course 2	English / MIL communication / Environmental Science	4
	Core course 3 Theory (C3)	Proteins	4
	Core course 3 Practical	Proteins	2
	Core course 4 Theory (C4)	Enzymes	4
	Core course 4 Practical	Enzymes	2
	Generic Elective 3 Theory (GE-3)	Proteins and Enzymes	4
	Generic Elective 3 Practical	Proteins and Enzymes	2
	Generic Elective 4 Theory (GE-4)	Biochemical Correlation of Diseases	4
	Generic Elective 4 Practical	Biochemical Correlation of Diseases	2
III	Core course 5 Theory (C5)	Metabolism of Carbohydrates and Lipids	4
	Core course 5 Practical	Metabolism of Carbohydrates and Lipids	2
	Core course 6 Theory (C6)	Membrane Biology and Bioenergetics	4
	Core course 6 Practical	Membrane Biology and Bioenergetics	2

	Core course 7 Theory (C7)	Hormone: Biochemistry and Function	4
	Core course 7 Practical	Hormone: Biochemistry and Function	2
	Skill Enhancement Course -1 Theory (SEC-1)	Biochemical Techniques	2
	Skill Enhancement Course -1 Practical	Biochemical Techniques	2
	Skill Enhancement Course -2 Theory (SEC-2)	Biostatistics	2
	Skill Enhancement Course -2 Practical	Biostatistics	2
	Skill Enhancement Course -3 Theory (SEC-3)	Research Methodology	2
	Skill Enhancement Course -3 Practical	Research Methodology	2
	Generic Elective – 5 Theory (GE-5)	Intermediary Metabolism	4
	Generic Elective – 5 Practical	Intermediary Metabolism	2
	Generic Elective – 6 Theory (GE-6)	Biochemical Applications in Forensics	4
	Generic Elective – 6 Practical	Biochemical Applications in Forensics	2
IV	Core course 8 Theory (C8)	Human Physiology	4
	Core course 8 Practical	Human Physiology	2
	Core course 9 Theory (C9)	Gene organization, replication and repair	4
	Core course 9 Practical	Gene organization, replication and repair	2
	Core course 10 Theory (C10)	Metabolism of Amino Acids and Nucleotides	4
	Core course 10 Practical	Metabolism of Amino Acids and Nucleotides	2
	Skill Enhancement Course – 4 Theory (SEC-4)	Bioinformatics	2
	Skill Enhancement Course – 4 Practical	Bioinformatics	2
	Skill Enhancement Course – 5 Theory (SEC-5)	Microbial Techniques	2
	Skill Enhancement Course – 5 Practical	Microbial Techniques	2

	Generic Elective – 7 Theory (GE-7)	Recombinant DNA Technology	4
	Generic Elective - 7 Practical	Recombinant DNA Technology	2
V	Core course 11 Theory (C11)	Concepts in Genetics	4
	Core course 11 Practical	Concepts in Genetics	2
	Core course 12 Theory (C12)	Gene expression and regulation	4
	Core course 12 Practical	Gene expression and regulation	2
	Discipline Specific Elective-1 Theory (DSE-1)	Nutritional Biochemistry	4
	Discipline Specific Elective-1 Practical	Nutritional Biochemistry	2
	Discipline Specific Elective-2 Theory (DSE-2)	Advanced Cell Biology	4
	Discipline Specific Elective – 2 Practical	Advanced Cell Biology	2
	Discipline Specific Elective – 3 Theory (DSE-3)	Microbiology	4
	Discipline Specific Elective – 3 Practical	Microbiology	2
VI	Core course 13 Theory (C13)	Genetic Engineering and Biotechnology	4
	Core course 13 Practical	Genetic Engineering and Biotechnology	2
	Core course 14 Theory (C14)	Immunology	4
	Core course 14 Practical	Immunology	2
	Discipline Specific Elective-4 Theory (DSE-4)	Molecular basis of infectious diseases	4
	Discipline Specific Elective-4 Practical	Molecular basis of infectious diseases	2
	Discipline Specific Elective-5 Theory (DSE-5)	Plant Biochemistry	4
	Discipline Specific Elective-5 Practical	Plant Biochemistry	2
	Discipline Specific Elective – 6 Theory (DSE-6)	Advanced Methodologies	4
	Discipline Specific Elective – 6 Practical	Advanced Methodologies	2

Total : 148 credits

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



B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Molecules of Life (BCH C-1)
Semester - I

1. Course Objectives

The course aims to provide students with an understanding of biomolecules, the basic building blocks of living organisms, focusing on their structural underpinnings, unique properties, biological roles and functions and inter relations. The course will outline the importance of water as a biological solvent and vitamins as vital ingredients of life. Emphasis will be on the association between structure and function of various biomolecules at a chemical level with a biological perspective as well as hands on approach and laboratory techniques.

2.1 Course Learning Outcomes

On successful completion of the course students will be:

- Acquainted with chemical and molecular foundations of life and appreciate the role of water in biological systems.
- Able to comprehend the structure, function and acid base properties of amino acids.
- Introduced to the structure, properties and roles of carbohydrates, lipids and nucleic acids.
- Aware of the importance of vitamins in biological systems.
- Able to independently identify various biomolecules in the laboratory.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I : The foundations of biochemistry **No. of hours : 6**

Cellular and chemical foundations of life, Water: unique properties, weak interactions in aqueous systems, ionization of water, buffering action in biological system, water as a reactant and fitness of the aqueous environment.

UNIT II: Amino Acids **No. of hours : 8**

Structural features and classification; Physical properties, optical properties (Stereoisomerism); Chemical properties (acid base properties, titration curve) of amino acids; Uncommon amino acids and their functions

UNIT III: Carbohydrates and Glycobiology **No. of hours : 16**

Monosaccharides - structure of aldoses and ketoses; Ring structure of sugars, conformations of sugars, mutarotation, anomers, epimers and enantiomers; Structure of biologically important

sugar derivatives, oxidation and reduction of sugars; Formation of disaccharides, reducing and non-reducing disaccharides; Polysaccharides – homo- and heteropolysaccharides, structural and storage polysaccharides; Structure and role of glycoconjugates - proteoglycans, glycoproteins and glycolipids (gangliosides and lipopolysaccharides); Carbohydrates as informational molecules.

UNIT IV: Lipids **No. of hours : 14**

Building blocks of lipids - fatty acids, glycerol, ceramide; Storage lipids - triacyl glycerol and waxes; Structural lipids in membranes – glycerophospholipids; Galactolipids and sulpholipids, etherlipids, sphingolipids and sterols, structure, distribution and role of membrane lipids. Plant steroids; Lipids as signals, cofactors and pigments. Qualitative tests for lipids.

UNIT V: Nucleic Acids **No. of hours : 10**

Nucleotides - structure and properties of bases, pentoses, nucleosides; Nucleic acid structure – Watson-Crick model of DNA, forms of DNA; Structure of major species of RNA - mRNA, tRNA and rRNA; Nucleic acid chemistry - UV absorption, effect of acid and alkali on DNA; Other functions of nucleotides - source of energy, component of coenzymes and second messengers.

Unit VI: Vitamins **No. of hours : 6**

Structure and active forms of water soluble and fat soluble vitamins; Deficiency diseases and symptoms, hypervitaminosis

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Safety measures in laboratories.
2. Preparation of normal and molar solutions.
3. Preparation of buffers, phosphate and acetate buffers.
4. Determination of pKa of acetic acid and glycine.
5. Qualitative tests for carbohydrates.
6. Qualitative tests for amino acids, proteins.
7. Qualitative tests for nucleic acids.
8. Separation of amino acids/ sugars/ bases by thin layer chromatography/paper chromatography.
9. Estimation of vitamin C.

2.3 References

1. Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations* (7th ed.). New York, John Wiley & Sons, Inc. ISBN:978-0-470-28173-4.
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Appreciation of the role of water in biological system.	Traditional chalk and board teaching and hands-on-experiments with buffers	Unit assessment by multiple choice questions (MCQ)
II.	Ability to comprehend the structure, function and acid base properties of amino acids.	Classroom teaching of structures and properties of amino acids and laboratory experiments on titration curves and identification of functional groups	Quiz on amino acid properties and structure. Students will be shown three-dimensional structures of amino acids in power points, which they will identify and relate to properties
III.	Introduction to the structure, properties and roles of carbohydrates.	Traditional chalk and board teaching; learning properties of carbohydrates through laboratory based identification	Test on structure and functions of carbohydrates
IV	Appreciation of the varied roles of lipids including distribution in different biological membranes	Traditional teaching of structures of lipids and video presentation of membrane lipids: learning structure and function of lipids and membranes through discussion and power point presentations	Test and MCQ on lipids
V.	Understanding nucleic acid chemistry and structure.	Chalk and board teaching and presentation on double helix model of nucleic acid structure.	Test and quiz on nucleic acids. Discussion on the history of discovery of double helix of DNA
VI.	Understanding of the biochemical importance of vitamins and their active forms	Classroom teaching of vitamin structures and their active forms and estimation of vitamin-C in laboratory	Quiz on vitamins, their active forms and deficiency diseases. Revision of the entire course

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

4. Keywords

Carbohydrates; Lipids; Nucleic acids; Amino acids; Vitamins; Water; Buffers

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Cell Biology (BCH C-2)
Semester I

1. Course Objectives

The objective of this paper is to offer insights into the basic structure and function of a cell and cellular organelles. The course also aims to impart understanding of cell cycle, cell death, cell renewal processes and various techniques of cell biology.

2.1 Course Learning Outcomes

The objective of this paper is to offer insights into the basic structure and function of a cell and cellular organelles. Students will:

- Learn about cell theory and basic cell structure
- Be introduced to cell fractionation and cell visualization techniques
- Gain knowledge about the structure and function of various cell organelles in a eukaryotic cell
- Acquire knowledge about the composition of cytoskeleton and extracellular matrix
- Acquire insight into cell division and cell death mechanisms

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Cell Biology **No. of hours: 5**

Cell theory, Structure of prokaryotic and eukaryotic cell, exceptions to cell theory, mycoplasma, viruses, viroids, prions, cells as experimental models

UNIT II: Tools of Cell Biology **No. of hours: 10**

Cell Fractionation techniques: Principle of centrifugation, Sedimentation Coefficient, Differential and Density Gradient (isopycnic and rate zonal) centrifugation. Cell Visualization techniques: Principle of Light microscope, Phase Contrast microscope, Fluorescence microscope, Confocal microscope and Electron microscope; Sample preparation and staining techniques for different kinds of microscopy. Basic principles of identification of sub cellular organelles.

UNIT III: Cell Organelles (structure and function) **No. of hours: 17**

Nucleus: Structure of nuclear envelope, nuclear pore complex nucleolus and chromatin Endoplasmic Reticulum: RER - Brief overview of cotranslational and post-translational transport of proteins; SER – Lipid synthesis, brief overview of export of proteins from ER; Golgi apparatus: organization, brief overview of glycosylation of proteins within Golgi, lipid and polysaccharide metabolism in Golgi apparatus.

Lysosomes: Development of different forms of lysosomes, role in cellular digestion, lysosomal storage diseases Peroxisomes: assembly, functions (H_2O_2 metabolism, fatty acid oxidation), glyoxysomes Mitochondria: structure, endosymbiont theory, genome Chloroplast: structure, endosymbiont theory, genome

UNIT IV: Cell Wall, Extracellular Matrix and Cell Junctions No. of hours: 10

Prokaryotic and eukaryotic cell wall structure; ECM components – proteins, polysaccharides and adhesion molecules; basic concept of anchoring junctions, tight junctions and communication junctions (gap junctions and plasmodesmata)

UNIT V: Cytoskeleton No. of hours: 08

Structure, assembly and function of Microtubules: Axonemal and cytoplasmic microtubules (cilia, flagella, centrioles, basal bodies) Microfilaments: Actin and Myosin Intermediate Filaments: different classes. Role of cytoskeletal elements in the entry of infectious agents

UNIT VI: Cell Cycle, Cell Death and Cell Renewal No. of hours: 10

Eukaryotic Cell Cycle, Checkpoints, Cell Division (mitosis and meiosis); Brief overview of apoptosis and necrosis; Types and potency of Stem Cells, Cancer – types, salient features of a transformed cell, causes of cancer. Apoptotic death in relation to cell cycle

PRACTICALS

CREDIT : 2 TOTAL HOURS: 60

1. To study the parts of a microscope
2. Cytochemical staining of proteins by Methylene Blue
3. Cytochemical staining of RNA by Methyl Green Pyronin
4. Cytochemical staining of polysaccharides by PAS
5. To study different stages of mitosis by temporary preparation in onion root tip
6. To study different stages of meiosis by temporary preparation in onion flower buds/ grasshopper testes
7. To study cell organelles by using electron micrographs
8. To study the effect of isotonic, hypotonic and hypertonic solution on cells

2. References

1. Cooper, G.M., Hausman, R.E. (2013). *The Cell: A Molecular Approach* (6th ed.). Washington, DC: ASM Press & Sunderland, Sinauer Associates, MA. ISBN:978-0-87893-300-6.

Additional Resources:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., Walter, P. (2008) *Molecular Biology of the Cell* (5th ed.). New York: Garland Science (Princeton). ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.
2. Karp, G. (2013). *Cell and Molecular Biology: Concepts and Experiments* (7th ed.). John Wiley and Sons. Inc. ISBN: 978-1-118-65322-7

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the cell theory and basics of cell structure	Milestones of the development in cell biology will be discussed, Models of cell structure will be shown	Students will be asked to research on this topic. Assignments will be conducted
II.	Students will be introduced to cell fractionation and cell visualization techniques	Students will be taught by use of video tutorial. They will be taken to various institutes for demonstration of some of the tools taught in class	Quiz will be organized. They will be shown various pictures to identify the various microscopy techniques. Assignment and tests.
III.	Students will gain knowledge about the structure and function of various cell organelles in a eukaryotic cell	Will be taught by chalk and board method. Students will be shown various power point presentations and videos for concept building	They will be asked to label various parts of organelles. Assignment and tests will be conducted.
IV.	Students will gain knowledge about the structure of cell wall, components of extracellular matrix and basics of cell junctions	Teaching will be imparted by chalk and board method and by videos.	Students will be assigned the task of retrieving information on the differences in cell wall in various kingdom of life and enlist the components of extracellular matrix.
V.	Students will acquire knowledge about the structure, composition and significance of cytoskeleton	Chalk and board method of teaching to be employed along with power point presentations and videos.	Students will be assigned the task of retrieving information on cytoskeleton elements and their relation to diseases
VI.	Students will acquire insight into cell division and cell death mechanisms	Power point presentations, video tutorials and traditional teaching will be utilized. Current research in this area will be discussed in groups	Assignment and tests; identification of different stages of cell division and cell death will be assigned

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

4. Keywords

Cell organelles, Cell wall, Cell-Cell Interactions, Cancerous Cells, Cell-Pathogen interactions, Cell Theory, Cell cycle, Transformed cell

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Proteins (BCH C-3)
SEMESTER –II

1. Course Objectives

The course aims to introduce "proteins" and their importance to modern biochemistry, highlighting their structural features and unique characteristics that help them participate in every physiological process in life, thus also playing important role in disease manifestation and their interventions.

2.1 Course Learning Outcomes

After completion of the course, a student will

- Understand the diverse functions of proteins in a cell
- Understand the hierarchy of protein architecture – primary, secondary, tertiary & quaternary structure, with the ability to distinguish features of globular & fibrous proteins
- Be able to comprehend the fundamental mechanisms of protein folding and stability and their relation to conformational diseases
- Be able to describe and discuss the separation and purification techniques used in protein chemistry
- Learn to access and use the databases related to protein sequence and structure
- Understand specialized proteins like membrane proteins, defense proteins and motor proteins
- Gain comprehension of structure-function relationship of proteins and their significance in physiology, diseases and applications in industry and medicine.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to amino acids, peptides and proteins **No. of hours: 4**

Amino acids and their properties - hydrophobic, polar and charged. Multimeric proteins, Conjugated proteins and Metallo-proteins. Diversity of peptide and protein function and their applications. Solid phase peptide synthesis.

UNIT II: Hierarchy of protein structure **No. of hours: 18**

Organization of protein structure into primary, secondary, tertiary and quaternary structures. N-terminal and C-terminal amino acid analysis. Sequencing techniques - Edman degradation. Generation of overlap peptides using different enzymes and chemical reagents. Disulfide bonds and their location. Forces stabilizing the protein structure - covalent and non-covalent. Importance of primary structure in protein folding. The peptide bond, dihedral angles psi and

phi, helices, sheets and turns, Ramachandran map. Motifs and domains. Structures of myoglobin and haemoglobin, α-keratin, silk fibroin, collagen.

UNIT III: Protein folding and conformational diseases No. of hours: 6

Denaturation and renaturation of Ribonuclease A – discovery of protein folding. Introduction to thermodynamics of folding and molten globule. Assisted folding by molecular chaperones, chaperonins and PDI. Defects in protein folding. Diseases associated with misfolding – Alzheimer's and Prion based.

UNIT IV: Specialized proteins No. of hours: 10

Transport protein: Haemoglobin - Oxygen binding curves, influence of 2,3-BPG, CO_2 and H^+, Hill plot, Cooperativity between subunits and models to explain the phenomena - concerted and sequential models. Haemoglobin disorders-sickle cell anemia, thalassemias. Motor proteins- Actin and myosin. Defense proteins- Antibodies, Membrane proteins- Integral and membrane associated proteins. Hydropathy plots to predict transmembrane domains.

UNIT V: Extraction, purification and characterization of proteins No. of hours: 18

Solubilization of proteins from their cellular and extracellular locations. Use of mechanical and chemical methods, homogenization, ultrasonication, French press and centrifugation. Ammonium sulphate fractionation, solvent fractionation, dialysis and lyophilization Ion-exchange chromatography, molecular sieve chromatography, hydrophobic interaction/reverse phase chromatography, affinity chromatography, HPLC and FPLC. Determination of purity, molecular weight, extinction coefficient and sedimentation coefficient. IEF, SDS-PAGE and 2-D gel electrophoresis.

UNIT VI: Introduction to Protein Databases No. of hours: 4

Introduction to protein sequence and structure databases (UNIPROT, SWISS-PROT & PDB), Protein sequence file Format (FASTA) and Visualization softwares.

PRACTICALS

CREDITS: 2 TOTAL HOURS: 60

1. Estimation of proteins using UV-absorbance and Biuret method.
2. Estimation of proteins using Lowry/Bradford method.
3. Determination of isoelectric pH of casein.
4. Ammonium sulphate fractionation of proteins.
5. Separation of proteins using anion-exchange chromatography (demonstration).
6. SDS-PAGE analysis of proteins (demonstration).
7. Molecular Visualization Softwares: Pymol and Rasmol for protein structures from PDB

2.3 References

1. Cooper, T.G. (2011). *The Tools of Biochemistry.* Wiley India Pvt. Ltd
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN13: 9781464126116, ISBN10: 1464126119

3. Schulz**,** G.E., Schirmer**,** R.H. (1979). *Principles of protein structure*. Springer, ISBN 978-1-4612-6137-7
4. Scopes, R.K. (1994) *Protein Purification. Principles and Practice* (3rd ed). Springer, ISBN 978-1-4737-2333-5
5. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). *Biochemistry* (9th ed.). New York, WH: Freeman. ISBN-13: 9781319114671
6. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN : 978-1-11809244-6.

Additional Resources

1. Whitford, D. (2004). *Protein Structure and function*. Southern Gate, Chichester, West Sussex: John Wiley & Sons, Inc. ISBN-13: 978-047149894 ISBN-10: 0471498947

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Appreciation of the significance of proteins in life; Understanding of the classification and diversity of functions of proteins; Knowledge of amino acids as building blocks of proteins, their classification and structures	Outlining history of development of proteins through power point presentations and landmark publications; Classification and diversity will be taught by chalk and board method; Stereochemistry models for amino acids structures and power point presentations and videos	Numerical problems related to codes in amino acids, numerical problems relating to the pKa and pI of amino acids.
II.	Knowledge of hierarchy of protein structures and various aspects of structures and sequencing methods; concepts of subunits with reference to hemoglobin structure	Traditional chalk and board method will be employed along with powerpoint presentations on 3D structures, Ramachandran Map and hierarchy of protein structures; Videos will be shown	Numerical problems on Sequencing will be assigned; Students will download 3D structures from PDB and visualize several aspects of structures using softwares.
III.	Basic concepts as to how proteins fold and what challenges they face during folding; Knowledge about chaperones that help in protein folding and diseases caused due to protein misfolding	Appropriate mix of chalk and board teaching as well as use of Power point presentations for clarity of concepts with images; Research papers will be discussed	Class presentations and case studies will help students understand misfolding diseases; They will be asked to match a few proteins with the diseases they cause due to misfolding. Each student will review a paper on the biotechnological

			importance of refolding of proteins *in vitro*
IV	Students will learn about the structural features and differences between fibrous and globular proteins with examples; Structural aspects of membrane proteins and their relation to function	Power point presentations; Chalk and board; Student interaction in class; Case studies with examples of each protein structural class	Images of proteins to identify globular and fibrous proteins will be provided. Transmembrane protein prediction tools will be used by students, Hydropathy plots will be discussed.
V.	Development of understanding of the rationale, basic principles, types of biochemical and biophysical methods for extraction and characterization of proteins	Chalk & board method of teaching followed by class discussions with examples.	Numerical methods to discuss enzyme activity, specific activity will assigned; Practical problems in protein purification will be discussed and assigned in groups
VI.	Students will learn about protein databases and tools available in public domain.	Power point presentations on various databases, protein sequence and structure retrieval to be utilized.	Assignments and quiz on databases and tools used in protein sequence and structure analysis; Students will be assigned the task of identifying new databases and tools by browsing papers and internet.

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

4. Keywords

Amino acids, Peptides; Globular and Fibrous proteins; Protein structure; Denaturation and Renaturation; Purification of proteins; Protein Folding & Diseases; Protein Databases

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Enzymes (BCH C-4)
Semester - II

1. Course Objectives

The objective of the course is to provide detailed knowledge about enzymes, the biological catalysts with remarkable properties that sustain life, so as to develop an understanding of enzyme kinetics, mechanism of enzyme action and their regulation. The course also aims to outline the diverse applications of enzymes in disease diagnosis and therapy as well as in industry.

2.1 Course Learning Outcomes

- Students will learn the nature and importance of enzymes in living systems
- Students will gain insight into the thermodynamic and molecular basis of catalysis by enzymes and the underlying basis of their specificity
- Students will understand the mechanisms of enzyme action, kinetics of enzyme catalyzed reactions and clinical importance of enzyme inhibitors
- Students will also learn to appreciate how enzymes are regulated and the physiological importance of enzyme regulation in the cell
- The course will introduce students to the applications of enzymes in research and medicine as well as in industry, which will bolster their foray into industrial and biomedical research.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to enzymes and features of catalysis **No. of hours: 8**

General characteristics of enzymes; nature of enzymes - protein and non-protein (ribozymes – RNaseP, self-splicing introns, abzymes). Co-factor and prosthetic group, apoenzyme, holoenzyme. Classification and nomenclature of enzymes. Enzyme assays-discontinuous, continuous, coupled assays; Enzyme activity, specific activity, units to express enzyme activity. Features of enzyme catalysis, factors affecting the rate of chemical reactions, collision theory, activation energy and transition state theory. Catalysis, reaction rates and thermodynamics of reaction. Catalytic power and specificity of enzymes (concept of active site), Fischer's lock and key hypothesis, Koshland's induced fit hypothesis.

UNIT II: Enzyme kinetics **No. of hours: 12**

Relationship between initial velocity and substrate concentration, equilibrium constant, steady state kinetics, mono-substrate reactions. Michaelis-Menten equation, Lineweaver-Burk plot,

Eadie-Hofstee and Hanes plot. Determination of K_M and V_{max}, K_{cat}, specificity constant. Effect of pH and temperature on the activity of enzymes. Types of bisubstrate reactions (sequential – ordered and random, ping pong reactions), examples. Differentiating bi-substrate mechanisms (diagnostic plots, isotope exchange).

UNIT III: Enzyme inhibition **No. of hours: 8**

Reversible inhibition (competitive, uncompetitive, non-competitive and mixed) and irreversible inhibition. Substrate inhibition. Structural analogs (allopurinol, methotrexate and trimethoprim). Mechanism based inhibitors (β-lactam antibiotics, difluoromethyl ornithine), clinical importance of enzyme inhibitors.

UNIT IV: Mechanism of action of enzymes **No. of hours: 12**

General features - proximity and orientation, strain and distortion, acid-base and covalent catalysis (chymotrypsin, lysozyme). Metal activated enzymes and metalloenzymes, transition state analogues. Coenzymes in enzyme catalyzed reactions. Structure, vitamin precursors, types of reaction involved in: TPP, FAD, NAD, pyridoxal phosphate, biotin, coenzyme A, tetrahydrofolate and lipoic acid.

UNIT V: Regulation of enzyme activity **No. of hours: 10**

Control of activities of single enzymes and metabolic pathways, feedback inhibition, allosteric modulation (aspartate transcarbamoylase), regulation by reversible covalent modification (glycogen phosphorylase and glycogen synthase). Proteolytic cleavage (zymogens-chymotrypsinogen, trypsinogen, procaspases). Regulation of multi-enzyme complex, properties (pyruvate dehydrogenase). Isoenzymes - properties and physiological significance (lactate dehydrogenase, hexokinase and glucokinase).

UNIT VI: Applications of enzymes **No. of hours: 10**

Enzymes as reagents (glucose oxidase, cholesterol oxidase);Marker enzymes in diagnostics (SGPT, SGOT, creatine kinase, alkaline and acid phosphatases);Enzyme linked immunoassay (ALP and HRP);Enzyme therapy (streptokinase);Enzymes in research (Taq polymerase, restriction endonucleases). Immobilized enzymes and industrial applications of enzymes.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Partial purification of an enzyme using bulk methods or chromatography
2. Assay to determine activity and specific activity of an enzyme
3. Progress curve for an enzyme
4. Effect of pH/temperature on enzyme activity
5. Determination of K_M and V_{max} of an enzyme using Lineweaver-Burk plot
6. Calculation of inhibitory constant (K_i) for an enzyme
7. Continuous assay of an enzyme

2.3 References

1. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
2. Nicholas, C.P., Lewis, S. (1999). *Fundamentals of Enzymology* (3rd ed.). New York , Oxford University Press Inc. ISBN:0 19 850229 X.
3. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). *Biochemistry* (9th ed.). New York, WH: Freeman. ISBN-13: 9781319114671

Additional Resources:

1. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN : 978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Knowledge about the basic properties and characteristics of enzymes and their action; insights into the factors affecting enzyme activity.	Historical perspectives; Power point presentations; Teaching using chalk and board method.	Oral questions will be asked in the class. Assignments to classify enzymes, determine specific activity and reaction rates.
II	Students will learn about the kinetics of enzyme catalyzed reactions and bisubstrate reactions	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class; Recent papers will be discussed	Class test will be conducted for internal assessment; Numerical problems assigned for enzyme kinetics.
III	Outline of the inhibitors of enzymes and their clinical importance.	Significance of inhibitors will be discussed with use of research papers; Classical chalk and board teaching and power point presentations	Various analytical problems will be assigned to students related to enzyme inhibition. Students will identify examples of inhibitors of various kinds.
IV	Understanding of the mechanism of enzyme action and the role of coenzymes in catalysis.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Demonstration by students with the help of models to test their understanding.

V	Students will learn how enzymes are regulated and the importance of enzyme regulation in the cellular context.	Teaching using chalk and board method along with power point presentations and video tutorials.	Problems will be assigned to test student's analytical ability. Class tests will be conducted for internal assessment. Students will discuss methods of regulation in groups.
VI	Detailed knowledge of the various applications of enzymes in medicine and research.	Teaching using chalk and board; Oral discussion sessions in the class; Videos. Special lecture will be arranged on current status of applications of enzymes	Assignment of a small project on identifying a specific application of any enzyme and tracings its development and current use.

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

4. Keyword

Enzymes, Catalysis, Specific activity, Mechanism of action, Vitamins, Isoenzymes

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Metabolism of Carbohydrates and Lipids (BCH C-5)
Semester - III

1. Course Objective

The objective of this course is to provide an understanding of metabolism of carbohydrates and lipids, the enzymes involved in various metabolic pathways and regulation of metabolism in cells. The course also aims to outline the importance of such pathways in relation to metabolic defects.

2.1 Course Learning Outcomes

The learners will be able to:

- Understand the concepts of metabolism, characteristics of metabolic pathways and strategies used to study these pathways.
- Gain a detailed knowledge of various catabolic and anabolic pathways
- Understand the regulation of various pathways
- Gain knowledge about the diseases caused by defects in metabolism with emphasis on the metabolic control

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Glycolysis, and pentose phosphate pathway **No of hours: 12**

Autotrophs, Heterotrophs, catabolism, anabolism, metabolic pathways, ATP as energy currency, experimental approaches to study metabolism, High energy compounds. Glycolysis: overview, reactions, regulations including hormones, fates of pyruvate, feeder pathways for glycolysis, galactosemia. Lactose intolerance. Cori and Cori cycle. Pentose phosphate pathway and its importance, Relationship between glycolysis and pentose phosphate pathway. Anaerobic ATP production, fermentation.

UNIT II: Additional pathways in carbohydrate metabolism **No of hours: 12**

Glycogen synthesis, glycogen breakdown, regulation of glycogen metabolism, gluconeogenesis. Glycogen storage diseases; Von Gierke, Pompe, Cori and McArdle. Gluconeogenesis. Photosynthesis dark reaction: Calvin cycle, regulation, Photo respiration, C4 and CAM pathways in plants.

UNIT III: Citric acid cycle **No of hours: 10**

Overview of citric acid cycle, synthesis of acetyl Coenzyme A, enzymes of citric acid cycle, regulation of citric acid cycle, anaplerotic reactions, amphibolic nature, Malate aspartate shuttle, Glyceraldehyde-3-phosphate dehydrogenase shuttle, Glyoxylate cycle in plants. Signaling pathways, regulation of carbohydrate metabolism by hormones, diseases associated with metabolic irregularities.

UNIT IV: Degradation of lipids **No of hours: 10**

Lipid digestion, absorption and transport. Fatty acid oxidation: transport to mitochondria, activation of fatty acids, β oxidation of saturated, unsaturated, odd and even numbered and branched chain fatty acids, regulation of fatty acid oxidation, peroxisomal β oxidation, ω oxidation and α oxidation. Ketone-body metabolism.

UNIT V: Synthesis of lipids **No of hours: 10**

Transport of mitochondrial Acetyl Co A to cytosol, Fatty acid synthase complex enzyme. Synthesis of saturated, unsaturated, odd and even chain fatty acids, regulation of fatty acid metabolism. Synthesis of glycerophospholipids and sphingolipids. Cholesterol metabolism, diseases associated with abnormal lipid metabolism.

UNIT VI: Regulation of metabolism **No of hours: 06**

Well-fed state, early fasting state, fasting state, early re-fed state, energy requirements, reserves and caloric homeostasis.

PRACTICALS

CREDIT : 2 **TOTAL HOURS : 60**

1. Estimation of blood glucose in serum using ortho toluidine method/ GOD-PxD method
2. Sugar fermentation by microorganisms.
3. Assay of salivary amylase.
4. Isolation of lipids from egg yolk and separation by TLC.
5. Cholesterol estimation.

2.3 References

1. Devlin, T.M. (2011). *Textbook of Biochemistry with Clinical Correlations* (7th ed.). New York, John Wiley & Sons, Inc. ISBN:978-0-470-28173-4.
2. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
3. Voet, D., Voet. J. G. (2013). *Biochemistry* (4th ed.). New Jersey, John Wiley & Sons Asia Pvt. Ltd. ISBN:978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn the concepts of metabolism with an emphasis on glycolysis and gluconeogenesis	Traditional chalk and black board method, Audio visual presentation. Class room discussion	Assignment, unit -test and practical assessment through experiment
II.	Students will learn about glycogen synthesis, breakdown, glycogen storage diseases, Calvin cycle C3 and C4 pathways in plants	Traditional chalk and black board method with examples and reactions and experiments	MCQ based assignments, unit –test and practical assessment through experiment
III.	The students will learn about overview, enzymes and regulation of citric acid cycle and glyoxylate cycle in plants. They will also learn about hormonal regulation of carbohydrate metabolism and diseases associated with metabolic irregularities.	Revision of the previous classes will be conducted. Traditional chalk and black board method, Audio visual presentation	Internal assessment tests will be conducted, – presentations will be assessed along with practical assessment
IV	The students will learn about lipid digestion, Fatty acid oxidation, and Ketone-body metabolism.	Chalk and board teaching along with presentations. Class discussions on syllabus topics will be performed.	Assessment through midterm examination and internal assessment test
V.	The students will learn about synthesis of saturated, unsaturated, odd and even chain fatty acids and regulation of fatty acid metabolism. They will also learn about the synthesis of	Presentations will be delivered along with traditional chalk board method. Class room revisions will be conducted before each class.	MCQ based internal assessment test will be held, quiz will be conducted and end term examination.

	glycerophospholipids and sphingolipids. Cholesterol metabolism, diseases associated with abnormal lipid metabolism		
VI.	The students will learn Well-fed state, early fasting state, fasting state, early re-fed state in metabolism.	Traditional chalk and black board method, students will be asked to deliver seminars to enhance their understanding and presentation skills.	End term examination evaluation, class room quiz will be held, unit - test and practical assessment through experiment.

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

4. Keywords

Metabolism, Carbohydrates, Lipids, Glycolysis, Citric acid cycle, Allosteric regulation, Fatty acid oxidation, Ketone bodies, Starve feed cycle, Blood glucose regulation

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Membrane Biology and Bioenergetics (BCH C-6)
Semester III

1. Course Objective

The objective of the course is to provide students with the basic understanding of membrane composition, structure-function relationship and properties of membranes. The course will also provide an understanding of the various types of membrane transporters and their molecular mechanisms. The course will introduce students to the basic tenets of Bioenergetics and detail out the molecular mechanisms of oxidative phosphorylation and photophosphorylation.

2.1 Course Learning Outcomes

On successful completion of the course, students will:

- Understand the general composition and structure of biomembranes.
- Gain knowledge of the basic properties of membranes such as membrane fluidity.
- Have knowledge about the various types of membrane transport mechanisms.
- Understand the basic tenets of Bioenergetics.
- Be able to imbibe the concept of chemi-osmotic theory and the mechanism of oxidative phosphorylation and ATP synthesis.
- Understand the basic mechanisms of photophosphorylation in plants and microbes.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Membrane composition and structure **No. of hours: 12**

Historical background and various membrane models. Overview of membrane functions. Composition of membranes: Lipids -Phospholipids, Glycolipids, sterols; Proteins - Peripheral Proteins, Integral Membrane Proteins and Lipid-Anchored proteins, and carbohydrates. Comparison of the composition of various cellular and subcellular membranes. Lateral and transverse asymmetry in membranes. Role of Flippase, Floppase and Scramblase. Model systems to study membranes - Lipid Monolayers, Planar Bilayer and Liposome, and their application. Polymorphic Lipid-Water Systems. The various determinants of polymorphic phases: CMC, lipid shape, critical packing parameter.

UNIT II: Membrane dynamics **No. of hours: 8**

Membrane fluidity: lateral, transverse and rotational motion of lipids and proteins. Factors affecting membrane fluidity- composition, barriers (tight junctions), cytoskeleton interactions, microdomains – rafts, caveolae. Fence and gate model. Study of RBC membrane architecture. Homeoviscous Adaptation. Techniques to study membrane dynamics: FRAP, TNBS, SPT.

UNIT III: Membrane transport **No. of hours: 12**

Thermodynamics of transport. Simple diffusion and facilitated diffusion. Passive transport-glucose transporter and anion transporter. Primary active transporters- P type ATPases, V type ATPases, F type ATPases. Secondary active transporters - lactose permease, Na+ -glucose symporter. ABC family of transporters – MDR and CFTR. Group translocation and bacteriorhodopsin. Ion channels: voltage-gated ion channels (Na+ /K+ voltage-gated channel) and ligand-gated ion channels (acetyl choline receptor), and aquaporins. Ionophores: valinomycin, gramicidin. Relationship of membrane transport and diseases.

UNIT IV: Introduction to Bioenergetics **No. of hours: 8**

Laws of thermodynamics. Concept of state functions, free energy change, equilibrium constant, coupled reactions, energy charge, ATP cycle, phosphorylation potential, and phosphoryl group transfers. Chemical basis of high standard energy of hydrolysis of ATP, PEP, 1,3 BPG and thioesters. Redox reactions, standard redox potentials and Nernst equation. Universal electron carriers.

UNIT V: Oxidative phosphorylation **No. of hours: 10**

The electron transport chain - its organization and function. Peter Mitchell's chemiosmotic hypothesis and Proton motive force. F_oF_1 ATP synthase, structure and mechanism of ATP synthesis. Metabolite transporters in mitochondria. Regulation of oxidative phosphorylation. ROS production and antioxidant mechanisms. Thermogenesis Alternative respiratory pathways in plants.

UNIT VI: Photophosphorylation **No. of hours: 10**

General features of photophosphorylation, historical background and Hill's reaction. Role of photosynthetic pigments and light harvesting systems in plants and microbes. Bacterial photophosphorylation in purple bacteria and Green sulfur bacteria. Photophosphorylation in plants. Molecular architecture of Photosystem I and Photosystem II. The Z-scheme of photosynthetic electron flow. Cyclic photophosphorylation and its significance.

PRACTICALS

CREDIT: 2 **TOTAL HOURS: 60**

1. Effect of lipid composition on the permeability of a lipid monolayer.
2. Determination of CMC of detergents.
3. Preparation of RBC ghost cell.
4. Study the photosynthetic O_2 evolution in hydrilla plant.
5. Isolation of chloroplast from spinach leaves and estimation of chlorophyll content.
6. Study the Hill reaction by using artificial electron acceptor.
7. Separation of photosynthetic pigments by TLC.
8. Separation of RBC membrane proteins by SDS-PAGE.
9. Isolation of mitochondria from liver and assay of marker enzyme SDH.

2.3 References

1. Garret, R.H., Grisham, C.M. (2016). *Biochemistry* (6th ed.). Boston, Cengage Learning. ISBN-10: 1133106293, ISBN-13: 978-1133106296
2. Lodish, H., Berk, A., Kaiser, C.A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Scott, M.P. (2016). *Molecular Cell Biology* (8th ed.). New York, WH: Freeman & Company. ISBN-13: 978-1-4641-0981-2.
3. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-6412611-9.
4. Voet, D.J., Voet, J.G., Pratt, C.W. (2008). *Principles of Biochemistry* (3rd ed.). New York, John Wiley & Sons, Inc. ISBN:13: 978-0470-23396-2

Additional Resources:

1. Wardhan, R., Mudgal, P. (2017). *Text Book on Membrane Biology* (1st ed.). Singapore, Springer. ISBN-10: 9811071004, ISBN-13: 978-9811071003

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understand the general composition and structure of biomembranes. To study various membrane model systems and their application.	Traditional chalk & board method with powerpoint presentations. Students to do comparative study of various cellular and subcellular membranes.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
II.	Understand membrane fluidity, and various techniques used to study membrane fluidity.	Traditional chalk & board method with powerpoint presentations	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
III.	Have knowledge about the various types of membrane transport mechanisms.	Traditional chalk & board method with powerpoint presentations.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture. Mid-term exam.

IV	Understand the basic tenets of Bioenergetics.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to free energy change, entropy, etc., to be done in class to explain spontaneous, endothermic, exothermic reactions.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
V.	Understand the concept of chemiosmotic theory and the mechanism of Oxidative phosphorylation and ATP synthesis.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to standard redox potential, proton motive force done in class. Videos of rotational catalysis shown.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture.
VI.	Understand the basic mechanisms of photophosphorylation in plants and microbes.	Traditional chalk & board method with powerpoint presentations. Numerical problems relating to photophoshorylation efficiency done.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts. Prelecture quiz to evaluate students understanding of previous lecture. Power point presentation by students.

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

4. Keywords

Membrane asymmetry, Membrane fluidity, ATPase, Ion channels, Ionophores, PMF, Oxidative phosphorylation, Photophosphorylation.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Hormone : Biochemistry and Function (BCH C-7)
Semester - III

1. Course Objectives

The course is designed to provide an understanding of the process of cellular communication including signal reception, transduction, amplification and response. The course will enable students to understand and appreciate the delicate network and balance of hormones required for the healthy functioning of the human body. It will provide an understanding of the different endocrine factors that regulate metabolism, growth, ionic homeostasis, glucose homeostasis and reproductive function. It outlines the consequences of hormonal imbalances with special emphasis on human diseases. The course will also prepare a student for postgraduate studies in any course related to molecular medicine.

2.1 Course Learning Outcomes

On successful completion of the course, a student will:

- Understand and appreciate the different cognate and non-cognate modes of communication between cells in a multi-cellular organism
- Understand the role of endocrine system in maintaining ionic and glucose homeostasis
- Be able to describe molecular, biochemical and physiological effects of all hormones and factors on cells and tissues.
- Understand the integrative communications that regulate, growth, appetite, metabolism and reproduction\
- Be prepared for interpreting clinical parameters in a real life situation

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Endocrinology and Cellular signaling **No of hours: 17**

Functions of hormones and their regulation. Chemical signaling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, transport of hormones in the circulation and their half-lives. Hormone therapy. General introduction to Endocrine methodology. Hormone receptors - extracellular and intracellular. Receptor - hormone binding, Scatchard analysis. G protein coupled receptors, G proteins, second messengers - cAMP, cGMP, IP3, DAG, Ca^{2+}, Effector systems - adenylyl cyclase, guanylyl cyclase, PDE, PLC. Protein kinases (PKA, PKB, PKC, PKG). Receptor tyrosine kinases - EGF, insulin and Ras - MAP kinase cascade. Non receptor tyrosine kinase-erythropoietin receptor JAK - STAT pathway. Steroid hormone Receptor. Receptor regulation and cross talk.

UNIT II: Hypothalamic- Hypophysial system: **No. of hours: 5**

Hypothalamic - Pituitary axis: anatomy, histology, vasculature and secretions. Physiological and biochemical actions of hypothalamic hormones and anterior pituitary hormones; Hormone feed- back regulatory cascade. Posterior pituitary hormones –structure, physiology and biochemical actions of AVP and Oxytocin; Diabetes insipidus.

UNIT III: Hormones regulating Metabolism, Calcium homeostasis and Growth:
No. of hours: 14

Thyroid gland - Histology; Biosynthesis of thyroid hormone and its regulation: Role of TRH and TSH in T4 synthesis and response. Physiological and biochemical action of Thyroxine. Pathophysiology of thyroxine secretion: Hyper and hypothyroidism, Goiter, Graves' disease, Cretinism, Myxoedema.
Regulation of calcium homeostasis: PTH, Vitamin D and calcitonin. Mechanism of Ca^{2+} regulation and pathways involving bone, skin, liver, gut and kidneys. Pathophysiology - rickets, osteomalacia, osteoporosis.
Regulation of Growth: growth hormone and somatomedin, Endocrine disorders - gigantism, acromegaly, dwarfism, pygmies. Physiology and biochemical actions of Growth factors- EGF, PDGF and Erythropoietin.

UNIT IV: Hormones of the Adrenals: **No. of hours: 8**

Histology of Adrenal Gland. Physiology and action of Aldosterone; the Renin Angiotensin System. Physiology and Biochemical actions of Cortisol. Regulation of cortisol synthesis: POMC and CRH. Adrenal medullary Hormones: Epinephrine and Norepinephrine. The Fight or flight response; Dual receptor hypothesis. General adaptation syndrome: acute and chronic stress response. Pathophysiology – Addison's disease, Conn's syndrome, Cushing syndrome.

UNIT V: Pancreatic and GI Tract Hormones: **No. of hours: 10**

Cells involved in the release of gastrointestinal hormones; the gastrin family of hormones and CCK: the secretin family of hormones; Incretins; Ghrelin; Summary of hormone metabolite control of GI function. Hormones of the Pancreas: Structure, synthesis, physiology and biochemical actions of insulin and glucagon. Adipocyte hormones: Adiponectin and leptin; Appetite and satiety control. Pathophysiology - Type I and type II Diabetes mellitus.

UNIT VI: Reproductive Hormones: **No. of hours: 6**

Male and female sex hormones. Interplay of hormones during ovarian and uterine phases of menstrual cycle; Placental hormones; role of hormones during parturition and lactation. Hormone based contraception and hormone therapy.

PRACTICALS

CREDIT: 2 **TOTAL HOURS : 60**

1. Determination of oral Glucose tolerance test as a confirmatory test for Diabetes Mellitus.

2. Estimation of serum Ca^{2+}.
3. Estimation of serum T4
4. HCG based pregnancy detection test.
5. Estimation of serum electrolytes.
6. Case studies on hormone disorders.

2.3 References

1. Cooper, G.M., Hausman, R.E. (2009). The Cell: A Molecular Approach (5th ed.). Washington, DC: ASM Press & Sunderland, Sinauer Associates. ISBN:978-0-87893-300
2. Hadley, M.C., Levine, J.E. (2007). *Endocrinology* (6th ed.). New Delhi, Pearson Education, Inc. ISBN: 978-81-317-2610-5.
3. Nelson, D.L., Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). New York, WH: Freeman and Company. ISBN: 13: 978-1-4641-2611-6 / ISBN:10:1-46412611-9.
4. Widmaier, E.P., Raff, H., Strang, K.T. (2019). *Vander's Human Physiology* (15th ed.). USA, McGraw Hill International Publications. ISBN: 978-0-07-128366-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to hormones, various types of cellular signaling, classical and modern endocrine methodologies. They will understand the concept of signal, reception, transduction, amplification and response, Scatchard analysis, signal transduction and steroid receptors.	Teaching will be conducted both through black board mode and power point presentation mode.	Students will be given questions that are application based and require analytical skills. Quizzes will be held to gauge their conceptual understanding.
II.	They will also gain insight into significance of the hypothalamic pituitary axis, secretions of the hypothalamus, anterior and posterior pituitary, concept of hormonal feedback regulation.	Powerpoint presentations and black board and oral discussions will be used for teaching	Oral questions will be asked in the class. Students will be given to prepare power point presentation on the assigned topics related to the class teachings.
III.	Knowledge about the synthesis, structure and biochemical functions of the thyroid gland secretions, factors that monitor calcium homeostasis in the human	Classical chalk and board teaching, oral discussions and power point presentation whenever needed.	Students will be asked to analyze case studies. Open book tests will be held to promote self-learning. Practical related oral

	body and hormonal networks that regulate growth and repair.	Practical analysis of serum samples for understanding diagnosis of thyroid hormone pathophysiology and imbalances in calcium homeostasis.	questions will be asked.
IV	Appreciate the significance of the adrenal histology with respect to synthesis of cortical and medullary hormones. The concept of blood pressure regulation and electrolyte balance will be understood. Role of medullary hormone epinephrine in fight and flight response, general adaptation syndrome and the biochemical changes during acute and chronic stress will be learned.	Both black board mode and power point presentation mode will be used.	Regular class question-answer sessions. Students will be asked to prepare PowerPoint presentation on any topic of interest relating to hormone biochemistry. Internal assessment tests will be conducted.
V.	Gain knowledge about histology of gastrointestinal tract with respect to regulation secretion of gastrointestinal hormones, regulation of satiety and appetite. Other topics include glucose homeostasis and role of hormones and other factors in the same. Students will get an insight into dysregulations that lead to pathophysiologies like anorexia, bulimia, diabetes, obesity and metabolic syndrome.	Teaching will be conducted both through black board mode and power point presentation mode. Practical assessment of glucose homeostasis by RBG and GTT.	Internal assessment tests will be conducted Discussions using case studies will be conducted.
VI.	Understand the role of sex hormones, hormonal regulation of menstrual cycle, gestation, parturition and lactation and hormonal contraception.	Teaching will be conducted through black board and power point presentation. Useful video clips will be shown for better clarity.	Regular oral evaluation will be done. Internal assessment tests will be conducted

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

4. Keywords

Cellular communication, signal transduction, hypothalamic-hypophysial axis, hormones, calcium and glucose homeostasis, hormonal disorders.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPERS
Human Physiology (BCH C-8)
Semester – IV

1. Course Objectives

The objective of the course in human physiology is to provide a comprehensive study of the molecular and cellular mechanisms that govern the integrative working and regulation of the various organ systems in the human body. The course will provide a foundation of the physiological principles and the application of the same in real-life situations. It also outlines the factors and biochemical events that disrupt homeostasis leading to pathophysiology. The course will prepare students for higher education in any field related to molecular medicine.

2.1 Course Learning Outcomes

On successful completion of this core paper, students should be able to:

- Understand the basic organization and homeostatic control of the human body from the cell itself to organ systems and the functioning of the whole body.
- Comprehend and appreciate the importance of the fluid components of the body in regulating and connecting the various organ systems; particularly the heart and vascular system.
- Appreciate and understand the biochemical, molecular and cellular events that orchestrate the coordinate working of the organ systems that regulate life processes.
- Get a holistic understanding of the different organ systems with respect to their basic functioning, which involves both integrative learning and the regulatory roles of the Nervous and Endocrine system.
- Develop in students an inquisitive learning approach to seek answers regarding the complex workings of brain.
- Understand the factors that cause an imbalance to the Homeostatic control in the body and how these lead to disorders and diseases.
- Perform and analyze various physiological tests that examine the function of various systems of the human body.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Human body and Understanding Homeostasis No. of hours: 3

Physiology: overview and definition, levels of structural organization, organ system. Body fluid compartments: intracellular, extracellular and interstitial fluid. Homeostasis: definition and control mechanisms (negative and positive feedback mechanisms).

UNIT II: Blood, Heart and Circulation: **No. of hours: 16**

Components of blood: Plasma - Composition, SPE - electrophoretic pattern of serum proteins, major plasma proteins and their role, Erythrocytes- erythropoiesis, function and metabolism, Leukocytes, Platelets- structure and function; Hemostasis and its molecular mechanism, role of platelets in coagulation, role of vitamin K in coagulation, Anticlotting and fibrinolytic systems. Anemias: definition and types (Hemolytic, hemorrhagic, megaloblast, pernicious, iron deficiency and aplastic anemia), polycythemia, Hemophilia and Thrombosis.

Anatomy of heart. Automacity of the cardiac muscle conducting fibres; Physiology of cardiac contracting muscle fibres, Relationship between cardiac cycle, heart sound, ventricular volumes and the ECG. Control of Heart rate and stroke volume. The vascular system: Arteries, arterial blood pressure and its measurement, Capillaries and bulk flow across the capillary walls, Veins and determination of venous pressure. Regulation of systemic arterial pressure. Long term and short-term regulation of cardiac efficiency and blood pressure. Hypertension, congestive heart disease, atherosclerosis, Heart failure and myocardial infarction.

UNIT III: Life Processes: **No. of hours: 22**

Respiratory physiology - Organization of the pulmonary system, site of gas exchange, Ventilation and lung mechanics. Inspiration, Expiration, Lung compliance and its determinants. Lung Volumes and Capacities. Transport of oxygen and carbon dioxide in blood. Haldane and Bohr's effect. Transport of hydrogen ions between tissues and lungs. Control of respiration. Hering-Breuer reflex. Asthma, Chronic Obstructive Pulmonary Disease (COPD), Hypoxia, Emphysema. *Renal physiology* - Anatomy of the kidney and the nephron. Regulation of renal blood flow. Cell biology of the Bowmans' capsule. Physiology of glomerular filtration and GFR. Tubular processing of the glomerular filtrate. Micturition. Regulation of ion and water balance. Urine concentration: The counter current multiplier system. Blood buffer systems, renal responses to acidosis and alkalosis. Assessment of kidney function. Glomerular nephritis. Dialysis: Hemodialysis and peritoneal dialysis. Diuretics. *Gastrointestinal and hepatic physiology* - Histology of the gastrointestinal tract. Propulsion and motility of food and digested material. Enteric reflexes. Secretory functions of the gastrointestinal tract, digestion and absorption of macronutrients and micronutrients. Peptic ulcer, Sprue, Celiac disease, IBD, regurgitation. Anatomy of the hepatic lobule and blood flow into the liver. Formation and secretion of bile. Enterohepatic cycle, detoxification in liver. Jaundice, liver cirrhosis and fatty liver.

UNIT IV: Muscle **No. of hours: 04**

Structure of Skeletal, smooth and cardiac muscle, Molecular mechanisms of skeletal muscle contraction: role of troponin, tropomyosin, and calcium in contraction, excitation-contraction coupling. Smooth muscle contraction and its control. Excitation-contraction coupling in cardiac muscle.

UNIT V: Reproductive Physiology: **No. of hours: 06**

Sex determination and differentiation. Development of female and male genital tracts. Oogenesis, Spermatogenesis, capacitation and transport of sperm, blood-testis barrier. Fertilization. Early development, Implantation. Placentation and Parturition.

UNIT VI: Neurophysiology: **No. of hours: 09**

Central Nervous system. Peripheral Nervous system. Blood brain barrier and CSF. Structure and maintenance of neurons. Functional classes of neurons. Membrane potentials: Resting Membrane Potential, Graded potentials, Action potential. Synapse: excitatory and inhibitory. Temporal and spatial summation. Neurotransmitters and neuromodulators (definition with examples). Somatic sensation: definition and cellular pathways of pain transmission and modulation. Physiology of EEG, sleep.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Hematology:
    a. Determination of Packed Cell Volume, Bleeding Time and Clotting time.
    b. Preparation of blood smear and estimation of differential leucocyte count.
    c. Enumeration of Blood cells: RBC and WBC counting, Calculation of blood Indices.
    d. Estimation of hemoglobin
2. Determination of total iron binding capacity.
3. Pulmonary function tests, spirometry and measurement of blood pressure.
4. Separation of isoenzymes of LDH by electrophoresis.
5. Case studies: Renal clearance, ECG, LFT, EEG (any two)

2.3 References

1. Fox, S.I. (2018) Human Physiology 15th ed., McGraw Hill International Publications, (New York) ISBN 978-1259864629.
2. Widmaier, E.P., Raff, H. and Strang, K.T. (2019) Vander's Human Physiology 15th ed., McGraw Hill International Publications (New York), ISBN: 978-1259903885

Additional Resources

1. Guyton, A.C. and Hall, J.E., (2016) Reed Textbook of Medical Physiology 13th ed., Elseviers India Pvt. Ltd. (New Delhi). ISBN: 978-1455770052
2. Sherwood, L. (2012) Introduction to Human Physiology 8th edition; Brooks/Cole, Cengage Learning. ISBN-13: 978-1133104544.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding the concept of homeostasis and the mechanism for maintaining it; Learning the importance of different fluid components in	Teaching will be conducted both through black board mode and power point presentation mode; Using online data to discuss the	Internal assessment tests; Students will be given questions that are application based

	the human body; Comparing the different extracellular fluids with respect to composition and function.	importance of fluid compositions in diagnosis.	and require analytical skills
II.	Learning the importance of plasma compositional variations as an important diagnostic tool. Understanding the biochemistry and physiological role of RBC. Learning the biochemistry of blood coagulation and the factors that lead to bleeding and coagulation pathopysiologies. Understand the anatomy, physiology and biochemistry of cardiac function. Understand the biophysics of movement of blood through the vasculature. Discuss and appreciate the factors that lead to pathophysiology of the cardiovascular system.	Teaching will be conducted both through black board mode and power point presentation mode. Hematological practical's as an important diagnostic tool for anemias, infections and bleeding disorders.	Conduct of Internal assessment tests Case study with hematological reports.
III.	Learning the anatomy, physiology and biochemistry of pulmonary respiration and transport of oxygen for cellular utilization. Understand the importance of renal excretion of nitrogenous wasted by learning the process of urine formation. Understand the process of ingestion, digestion and assimilation of food. Learn to correlate biochemical mechanism to the manifestation of symptoms associated with the pathophysiologies related with the three important life processes- respiration, digestion and excretion.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions with case studies and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	Internal assessment tests will be conducted Analyzing case studies. Open book tests to promote self-learning.
IV	Understanding the biochemical mechanism that underlie the contraction of skeletal muscles. Comparing the differences in smooth, skeletal and cardiac muscle with respect to anatomy mechanism of contraction and regulation.	Teaching will be conducted both through black board mode and power point presentation mode.	Internal assessment tests will be conducted .

V.	Comparing the cell biology and physiology of spermatogenesis versus oogenesis. Understanding the mechanism that define, spermatogenesis, spermiogenesis, semen composition and capacitation. Learning the process of cellular development that support and regulate oogenesis. Understanding acrosomal reaction, cortical response and polyspermy that ensure proper fertilization. Understanding the physiological processes involved in implantation, placentation and parturition	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using case studies will be conducted.	Internal assessment tests will be conducted. Analysis of case studies.
VI.	Understand the cellular composition and anatomy of the central and peripheral nervous system. Learning the process of synthesis, composition and function of CSF. Understand the mechanism of generation, propogation and regulation of action potentials. Learning about the neurophysiology and chemistry of sensory perception, learning and memory and sleep.	Teaching will be conducted both through black board mode and power point presentation mode.	Internal assessment tests will be conducted A PowerPoint presentation on any topic of interest relating to Neurophysiology and chemistry.

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

4. Key words

Physiology, Homeostasis, life processes, heart, neurophysiology, reproduction

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Gene Organization, Replication and Repair (BCH C-9)
Semester - IV

1. Course Objectives

The objective of the course is to introduce to the students, the basic concepts of genome, DNA structure, genes, chromatin and chromosomes. It provides comprehensive understanding of DNA replication, recombination, mutations and repair processes in a way that students can apply this knowledge in understanding the life processes and develop an interest to pursue high quality research.

2.1 Course Learning Outcomes

- Students will acquire basic information about the structure of DNA and various forms of DNA, about organization of genome in various life forms, supercoiling of DNA and its significance
- Students will learn about the molecular basis of processes like DNA replication, recombination and transposition and understand the significance of these processes
- 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

2.2 Course Contents

THEORY

CREDIT : 4 **TOTAL HOURS: 60**

UNIT I: Structure of DNA **No. of hours: 10**

Building blocks of DNA structure, Watson and Crick model, features of the double helix, various forms of DNA, denaturation and renaturation of DNA, hyperchromicity, melting temperature, factors affecting T_m of DNA molecules. Supercoiling of DNA, linking number, topoisomerases and their classification. Topoisomerase inhibitors and their clinical importance.

UNIT II: Genes and genomic organization **No. of hours: 10**

Definition of a gene, organization of genes in viruses, bacteria and eukaryotes, concept of split genes, introns, exons, satellite DNA, highly repetitive DNA, centromere and telomere sequences. Nucleosome structure and packaging of DNA into higher order structures.

UNIT III: Replication of DNA **No. of hours: 16**

General features of 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, relationship between replication and cell division, replication in eukaryotes, end replication problem, telomerase,

various modes of replication. Comparison of replication in prokaryotes and eukaryotes. Inhibitors of DNA replication and applications in medicine.

UNIT IV: Recombination and transposition of DNA **No. of hours: 12**

Homologous recombination, biological role and models for homologous recombination, proteins and enzymes in homologous recombination, site-specific recombination, serine and tyrosine recombinases. Transposition, the three classes of transposable elements-DNA transposons, virus-like retrotransposons and poly-A retrotransposons. DNA transposition by cut and paste and replicative mechanism.

UNIT V: Molecular basis of mutations **No. of hours : 6**

Importance of mutations in evolution of species. 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.

UNIT VI: Various modes of DNA repair **No. of hours : 6**

Replication errors and their repair, mismatch repair system. Repair of DNA damage-direct reversal of DNA damage, base excision repair, nucleotide excision repair, recombination repair, trans-lesion DNA synthesis. DNA repair and diseases.

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. To hydrolyze DNA and separate nucleotide bases by paper chromatography
2. To plot ultraviolet absorption spectrum of DNA
3. Determination of DNA concentration by A_{260nm}
4. DNA estimation by Diphenylamine (DPA) method
5. Determination of the melting temperature of DNA
6. Isolation of chromosomal DNA from *E coli* cells

2.3 References

1. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7^{th} ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7^{th} ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN-13: 9780321762436

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the complexity of DNA double helix structure, nature of nuclotides, melting of DNA and understand the importance of supercoiling of DNA.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class Practical learning of hydrolysis of DNA, separation of nucleotide bases using paper chromatography, melting temperature of DNA.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability. Asking practical related questions.
II.	Gain insight into the organization of DNA and how a long DNA molecule gets packaged in a small cell.	Power point presentations will be used to teach levels of DNA packaging ; Oral discussion sessions in the class	Regular question-answer sessions in the class. Class tests will be conducted for internal assessment
III.	Understand the details of DNA replication and importance of various proteins and enzymes involved in replication and application of inhibitors	Teaching will be carried out by displaying colourful models for steps of replication using slides and the rest using chalk and board method; Discussion sessions in the class	Students will be challenged with analytical problems, puzzles and assignments related to replication of DNA.
IV	Learn to appreciate the mechanism and importance of homologous and site specific recombination and transposition.	Power point presentations will be used to explain recombination process; Interactive discussion sessions in the class	Regular question-answer and quiz sessions in the class, demonstration by students with the help of models to test and improve their understanding.
V	Know about DNA mutations and understand how DNA can be damaged by chemical mutagens and radiation.	Teaching using chalk and board; Power point presentations; Oral discussion sessions in the class	Regular class interaction and analytical problem solving in the class. Class tests will be conducted for internal assessment
VI.	Will be familiarized with various strategies of DNA repair and diseases associated with DNA repair problems.	Power point presentations as well as chalk and board method will be used for teaching, Oral discussion about repair and its problems along with movie display.	Various analytical problems will be assigned to students related to DNA repair and related disorders.

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

4. Keywords

DNA, Double helix, Supercoiling, Recombination, Transposition, DNA Repair

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Metabolism of Amino Acids and Nucleotides (BCH C-10)
Semester - IV

1. Course Objective

The main objective of the course is to offer detailed and comprehensive knowledge about the synthesis and degradation pathways of amino acids and nucleotides and their importance in the proper functioning of the cells. This course also interrelates the metabolism of these molecules with respect to health diseases in addition to providing overview of inhibitors of metabolism for treating the diseases of metabolic disorders.

2.1 Course Learning Outcomes

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

- Extend their school level concepts of nitrogen cycle to understand the mechanism by which nitrogen is fixed by microbes and how it's incorporation in diet is critical to human nutrition as well as comprehend the mechanism by which ammonia is incorporated in biomolecules
- Systematically learn the breakdown and synthesis of amino acids and nucleotides in humans and recognize its relevance with respect to nutrition and human diseases
- Gain knowledge of how amino acids are converted into a variety of precursors
- Acknowledge the role of inhibitors of nucleotide metabolism which are potentially being used as chemotherapeutic drugs
- Comprehend how the amino acid and nucleotide metabolism are integrated with carbohydrate and lipid metabolism

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Overview of Nitrogen and Amino Acid Metabolism **No. of hours: 8**

Nitrogen cycle, incorporation of ammonia into biomolecules. Digestion and absorption of dietary proteins. Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus, Nitrogen balance. Metabolic fates of amino groups. Transamination, role of pyridoxal phosphate, glucose-alanine cycle, Kreb's bicycle, urea cycle, its regulation and inherited defects of urea cycle. Gamaglutamyl cycle.

UNIT II: Catabolism and Biosynthesis of Amino Acids **No. of hours: 18**

Catabolic pathways of individual amino acids. Glucogenic and ketogenic amino acids. Metabolism of one carbon units. Disorders of amino acids metabolism, phenylketonuria, alkaptonuria, maple syrup urine disease, methyl malonic acidemia (MMA), homocystinuria

and Hartnup's disease. Overview of amino acid synthesis. Biosynthesis of non-essential amino acids and its regulation.

UNIT III: Precursor Functions of Amino Acids **No. of hours: 8**

Biosynthesis of creatine and creatinine, polyamines (putresine, spermine, spermidine), catecholamines (dopamine, epinephrine, norepinephrine) and neurotransmitters (serotonin, GABA). Porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.

UNIT IV: Biosynthesis, Degradation of Purine and Pyrimidine Nucleotides

No. of hours: 14

De novo synthesis of purine and pyrimidine nucleotides, regulation and salvage pathways. Digestion of nucleic acids, degradation of purine and pyrimidine nucleotides. Inhibitors of nucleotide metabolism. Disorders of purine and pyrimidine metabolism – Lesch-Nyhan syndrome, Gout, SCID, adenosine deaminase deficiency.

UNIT V: Deoxyribonucleotides and Synthesis of Nucleotide Triphosphate and Co-enzymes

No. of hours: 6

Biosynthesis of deoxyribonucleotides and its regulation, conversion to triphosphates, biosynthesis of coenzyme nucleotides.

UNIT VI: Integration of Metabolism **No. of hours: 6**

Integration of metabolic pathways (carbohydrate, lipid and amino acid metabolic pathways), tissue specific metabolism (brain, muscle, and liver).
Practical

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. Assay of serum transaminases – SGOT and SGPT.
2. Estimation of serum urea.
3. Estimation of serum uric acid.
4. Estimation of serum creatinine.
5. Estimation of bilirubin
6. Assay of glutamate dehydrogenase

2.3 References

1. Berg, J.M., Tymoczko, J.L. and Stryer L., (2012) *W.H. Biochemistry* (7th ed.), Freeman and Company (New York), ISBN:10: 1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
2. Devlin, T.M. (2011) *Textbook of Biochemistry with Clinical Correlations* (7th ed.), John Wiley & Sons, Inc. (New York), ISBN:978-0-470-28173-4 / BRV ISBN:978-0-470-60152-5.
3. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the concepts of nitrogen cycle, nitrogen fixation and assimilation, importance of nitrogen in human nutrition and its deficiency-associated disorders. Besides, students will be introduced to metabolic fates of amino groups, various metabolic cycles, their regulation and inherited defects of urea cycle.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and powerpoint presentation mode.	Internal assessment tests (midterm and end-term) will be conducted.
II.	Students will gain insight into the breakdown and synthesis of amino acids. Further, the students will gain knowledge about various disorders related to amino acids.	Chalk and board teaching method will be largely employed. Oral presentations by the students will help them learn the subject better.	Students will be given assignment on different topics specially disorders and will be asked to deliver a power-point presentation on the assigned topics.
III.	Students will learn how amino acids are converted into a variety of precursors, such as creatine and creatinine, polyamines catecholamines, neurotransmitters and porphyrin biosynthesis, catabolism and disorders of porphyrin metabolism.	Class discussions will be conducted in various group of students. Lecture by teachers.	MCQ based Internal assessment test will be conducted. Mid term examination evaluation.
IV	Students will gain insight into *de novo* synthesis and degradation of purine and pyrimidine nucleotides, regulation and salvage pathways. Further, the students will learn about the inhibitors of nucleotide metabolism and disorders related to purine and pyrimidine metabolism.	Oral questions will be asked by the teachers that will be orally answered by the students. Chalk and board teaching along with powerpoint presentations.	Internal assessment test (end term) will be conducted. Several short quiz will be held to motivate students
V.	Students will gain knowledge about biosynthesis of deoxyribonucleotides, its	Students will be asked to orally revise the	Students will be given

	regulation and conversion to triphosphates, Further they will also learn about the biosynthesis of coenzyme nucleotides.	previous class before every new class. Student presentations and class discussions.	assignment on various topics and will be asked to deliver a power-point presentation on the assigned topics. End term examination evaluation will be conducted.
VI.	Students will learn about the integration of various metabolic pathways and their cross-talk in specific tissues like brain, muscle, and liver.	Chalk and board teaching method will be largely employed. Oral presentations by the students will help them learn the subject better.	Students will be given assignment on different topics specially disorders and will be asked to deliver a power-point presentation on the assigned topics.

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

4. Keywords

Nitrogen Balance, Protein calorie malnutrition, Transamination, Amino acid metabolism, Purine and Pyrimidine Metabolism, Porphyrin metabolism, Urea cycle, Metabolic disorders, Integration of metabolism

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Concepts in Genetics (BCH C-11)
Semester – V

1. Course Objectives

The aim of the course is to provide students with an understanding of both classical and modern concepts in genetics with special emphasis on the areas of transmission genetics, molecular and developmental genetics, mapping techniques, chromosomal aberrations and population genetics. Students will gain a hands-on training experience of culturing and conducting experiments on the genetic model system *Drosophila melanogaster*. The course also works as preparation for further studies in a Master's programme in molecular biology or related topics.

2.1 Course Learning Outcomes

On successful completion of the course, the students will be:

- Understanding the principles of Mendelian genetics, extensions and applications
- Learning and appreciating the various factors that confer genotypic and phenotypic variability.
- Using the concepts of bacterial and viral genetics to understand resistance patterns and to create linkage and genetic maps.
- Able to use statistical tools to analyze biological data.
- Able to apply the principles of transmission and inheritance in real life situations.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Principles of heredity and transmission genetics: No of hours: 16

Mendelian genetics and chromosomal basis of heredity: Mendelian laws and ratios; Concept of segregation and independent assortment, and its chromosomal basis. Laws of probability & binomial expansion, formulating and testing genetic hypothesis, chromosomal basis of Mendelism - Sutton and Boveri hypothesis with other supporting experimental evidences; *Extensions to Mendelian genetics:* Complementation test using examples from Drosophila eye colour mutants to differentiate allelic variants from gene interaction. Allelic variation and gene function - dominance relationships, multiple alleles, lethal alleles and null alleles. Pleiotropic gene interaction - epistatic and non- epistatic, interaction between gene(s) and environment. 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.

UNIT II: Genetics of bacteria and viruses **No. of hours: 7**

Concept of cistron. Bacterial and viral genomes, Mechanism of genetic exchange - conjugation, transformation and transduction. Gene mapping in bacteria.

UNIT III: Linkage, crossing over and mapping techniques: **No. of hours: 10**

Linkage and crossing over, genetic mapping in eukaryotes, centromere mapping with ordered tetrads, cytogenetic mapping with deletions and duplications in *Drosophila*, detection of linked loci by pedigree analysis in humans, LOD score, somatic cell hybridization for positioning genes on chromosomes and physical maps using molecular markers.

UNIT IV: Molecular genetics **No. of hours: 12**

Sex determination and genetic control of development: Genetic basis of sex determination in Humans, *Drosophila melanogaster* and *C. elegans. Drosophila* development-maternal effect genes, morphogens and zygotic genes; Genetic basis of flower development in *Arabidopsis*-ABC model; *Non-nuclear inheritance and Epigenetics:* Extra nuclear inheritance, tests for organelle heredity and maternal effect; Mechanism of dosage compensation; X chromosomal inactivation in humans and *Drosophila melanogaster*. Epigenetic mechanisms of transcriptional regulation. Monoallelic expressions and Genomic imprinting.

UNIT V: Chromosomal aberrations **No. of hours: 7**

Variations in chromosome number: aneuploidy and polyploidy. Variations in chromosome structure- inversions, deletions, duplications and translocations.

UNIT VI: Quantitative, Population and Evolutionary Genetics **No. of hours: 8**

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

PRACTICALS

CREDITS : 2 **TOTAL HOURS : 60**

1. Squash preparation of salivary glands of Dipteran larva to observe polytene chromosomes.
2. Induction of polyploidy in onion roots.
3. Smear technique to demonstrate sex chromatin in buccal epithelial cells.
4. Monohybrid crosses in *Drosophila* for studying autosomal and sex linked inheritance.
5. PTC testing in a population and calculation of allelic and genotype frequencies.
6. Study of abnormal human karyotype and pedigrees (dry lab)

2.3 References

1. Griffiths, A.J.F, Wessler, S. R, Carroll, S. B. and Doebley, J. (2017) *An Introduction to Genetic Analysis*, (11th ed.), W.H. Freeman & Company (New York), ISBN: 1464109486
2. Pierce, B.A. (2012) *Genetics - A Conceptual Approach*, (6h ed.), W.H. Freeman & Co. (New York), ISBN:13:978-1-4292-7606-1 / ISBN:10:1-4292-7606-1.
3. Snustad, D.P. and Simmons, M.J. (2012) *Genetics* (6th ed.), John Wiley & Sons. (Singapore), ISBN: 978-1-118-09242-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding Mendel's laws and ratios; Understand relationship between genetic inheritance, generation of variation and cell division; Relating genes to chromosomes- chromosomal basis of heredity; Use of statistical tools in testing genetic hypothesis; Complementation test relating extensions to Mendelian ratios due to allelic variations; Understand gene interactions- both epistatic and non-epistatic; Concept of Penetrance, expressivity, phenocopy and pleiotropy; Understanding how to draw a human pedigree chart and analyze it for determining inheritance patterns	Students will be practically shown examples from crosses of different *Drosophila* eye colour mutant strains for explaining complementation test. Formulation and testing of genetic hypothesis will be explained using experiments with *Drosophila* crosses as well as exemplary numerical problems. Students will be encouraged to apply pedigree analysis in real life situations by helping them make their own family pedigrees for certain overt heritable physical features and genetic condition or disease, if any.	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.
II.	Understand the concept of cistron, operon and gene; Basics of bacterial and viral genomes; Mechanisms of genetic exchange in prokaryotes like conjugation, transformation and transduction; Gene mapping in bacteria.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	Powerpoint presentation on the assigned topics. Students will be given questions that are application based and require analytical skills
III.	Understand the of concept of recombination and linked genes; Use recombination	Teaching will be conducted both through black board	Internal assessment tests will be conducted

	frequencies to determine gene order and distance; Genetic mapping in eukaryotes using test crosses; Gene to centromere mapping with ordered tetrads and cytogenetic mapping; Detection of linked loci by pedigree analysis in humans and the concept of LOD score; Somatic cell hybridization for locating gene on a chromosome; Physical mapping using molecular markers.	mode and power point presentation mode. Numerical problems for genetic mapping using three point cross would be given for practice in class.	Questions on drawing a genetic map with gene order, map distance. and centromere mapping
IV	Understand the difference in the genetic basis of sex determination in Humans, *Drosophila* and *C.elegans;* Understand the role of maternal effect genes on axis formation during development using *Drosophila* as a model of study Role of zygotic and homeotic genes in development using *Drosophila* as a model of study; Genetic control of flower development in *Arabidopsis;* Nonnuclear inheritance and its role in determination of phenotypes; Epigenetic phenomenon like dosage compensation and Genomic Imprinting.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding	A PowerPoint presentation on any topic of interest relating to the concept of Epigenetics, non-nuclear inheritance and sex determination.
V.	Students will learn about various structural and numeric chromosomal aberrations possible in both plants and animals; Understand the disadvantages as well as some advantages of such aberrations.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using case studies will be conducted to help students understand the karyotype analysis.	Internal assessment tests will be conducted Analysis of case studies in groups.
VI.	Understand the concept of polygenic inheritance, additive gene effect, OTL, heterosis and hybrid vigor; Understand concept of gene pool, allelic and genotypic frequencies; Understand Hardy Weinberg principle and its limitations; Understand concept genetic	Teaching will be conducted both through black board mode and power point presentation mode. Discussions using population genetics based case studies will be conducted. Practical collection of data from	Numerical analysis and case study analysis.

	drift, founder effect, genetic bottleneck; Factors that influence gene flow, fitness of a population and speciation.	population to test Hardy-Weinberg principle.	

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

4. Keywords

Mendelian genetics, Allelic and gene interaction, Gene mapping, Microbial genetics, Pedigree analysis, Epigenetics, Quantitative, Development, Population and Evolutionary Genetics

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Gene Expression and Regulation (BCH C-12)
Semester - V

1. Course Objective

The objective of the course is to introduce to the students the basic knowledge about how genes are transcribed and how translation takes place in prokaryotes and eukaryotes and how these processes are regulated, so that students can apply this knowledge in enhancing their analytical and problem solving skills.

2.1 Course Learning Outcomes

After completion of the course students will:

- acquire basic knowledge about the processes of transcription and translation in prokaryotes and eukaryotes
- learn about the features of the genetic code and various experimental approaches used to crack the code
- develop understanding of the molecular basis of RNA processing and RNA splicing
- learn about the various ways in which these biological processes are regulated and the significance of regulation in maintaining life forms

2.2 Course Contents

THEORY

CREDIT : 4 **TOTAL HOURS : 60**

UNIT I: Transcription in prokaryotes **No. of hours : 8**

Comparison between transcription and DNA replication, RNA polymerases, transcription cycle in bacteria, sigma factor, bacterial promoters, identification of DNA binding sites by DNA footprinting, various stages of RNA synthesis, initiation, elongation and termination, rho-dependent and rho-independent termination. Inhibitors of transcription and applications as antimicrobial drugs.

UNIT II: Transcription in eukaryotes **No. of hours : 8**

Comparison between initiation, elongation and termination of prokaryotic and eukaryotic transcription. Introduction on basal transcription machinery and three classes of eukaryotic RNA polymerases – I, II and III and their respective promoters. Details on transcription by RNA polymerase II, features of RNA polymerase II core promoters and general transcription factors. Identification of DNA binding sites by DNA foot printing. Inhibitors of eukaryotic transcription and their applications.

UNIT III: RNA Processing **No. of hours : 8**

Various types of RNA processing- polyadenylation and capping, processing of rRNA and tRNA. Chemistry of RNA splicing, the spliceosome machinery, splicing pathways, group I and group II introns, alternative splicing, exon shuffling and RNA editing.

UNIT IV: Translation of proteins **No. of hours : 16**

Salient features of the genetic code, triplet nature, degenerate, wobble in the anticodon. Experimental approaches used to decipher the genetic code. Suppressor tRNAs. Exceptions to the nearly universal genetic code. Messenger RNA, transfer RNA, charging of tRNA. The structure of ribosome. Three stages of translation-initiation, elongation and termination. Translation in eukaryotes. Regulation of translation. Comparison of prokaryotic and eukaryotic protein synthesis. Inhibitors of translation and their clinical importance.

UNIT V: Regulation of gene expression in prokaryotes **No. of hours : 10**

Strategies for gene regulation, negative and positive regulation, concept of operons, regulatory proteins, activators, repressors, DNA binding domains, regulation of lac operon and the concept of combinatorial control, trp operon. Regulatory RNAs in bacteria, small RNA and riboswitches.

UNIT VI: Regulation of gene expression in eukaryotes **No. of hours : 10**

Gene regulation by chromatin remodeling, regulation of galactose metabolism in yeast, action Gof enhancers and insulators, working of activators and repressors, concept of combinatorial control. Regulatory RNAs in eukaryotes: synthesis and mechanism of siRNA and miRNA. Comparison of regulatory mechanisms of gene expression in prokaryotes and eukaryotes.

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Estimation of RNA by Orcinol Method
2. Extraction of total nucleic acids from plant tissue
3. To study growth curve and diauxic growth curve effect in *E. coli*
4. Isolation of total RNA from bacteria/yeast
5. To study the effect of inhibitors on protein synthesis

2.3 References

1. Nelson, D.L. and Cox, M.M (2017) *Lehninger: Principles of Biochemistry* (7th ed.) W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.
2. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R. (2008) *Watson: Molecular Biology of the Gene* (7th ed.), Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), ISBN:0-321-50781 / ISBN-13: 9780321762436

Additional Resources:

1. Lewin, B., Krebs, J.E., Kilpatrick, S.T., Goldstein, E.S., (2018) *Lewin's Gene X* (10th edition). Bartlett Learning publishers, LLC, ISBN: 978-0-7637-6632-0.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The student will learn about the difference between DNA replication and transcription, RNA polymerases and details of bacterial transcription	Traditional chalk and board method of teaching and regular class room discussion. Videos to showcase the structure and assembly of the transcription initiation complex and the stages of transcription in real time.	Problem solving assignments, regular question answer sessions, MCQs and unit-test for internal assessment
II.	Will appreciate the basics of prokaryotic and eukaryotic transcription, key features of the three classes of eukaryotic RNA polymerases, different promoters and use of various inhibitors.	Audio visual presentation with appropriate examples and black board teaching, regular class room discussion Estimation of RNA and isolation of RNA will be shown through practicals.	Regular question-answer sessions in the class, learning exercises through quiz and puzzles, analytical question solving to improve student understanding. Monitoring of practical record keeping, oral questions related to practicals
III.	Introduced to the ways of RNA processing, chemistry of splicing, various types of splicing and RNA editing	Chalk and board method of teaching; Power point presentation showing the steps of splicing and RNA editing and various examples of splicing.	Oral questions will be asked in the class. Problems will be assigned to test student's analytical ability.
IV	Able to describe the salient features of genetic code, triplet nature, wobble in the anticodon. Stages of translation and inhibitors of translation	Classroom teaching of discoveries from research papers, chalk and board method of teaching and use of powerpoint presentation. Practical demonstration of translation inhibitor. Audio visual to demonstrate the experimental strategies used to decipher the genetic code	Students will be challenged with analytical problems, puzzles and assignments related to genetic code and other topics covered in the class.
V.	Gain knowledge about regulation of gene expression in prokaryotes, concept of operon, regulatory RNA and riboswitches.	Traditional chalk and board method of teaching, audio visual presentation and regular class room discussion. Supportive powerpoint slides to display the structure of riboswitches	Various analytical problems will be assigned to students related to prokaryotic gene expression, oral question answer sessions will be held in the class.

VI.	Learn about regulation of gene expression in eukaryotes, working of activators and repressors and small RNA mediated silencing mechanisms.	Classroom teaching using powerpoint presentations along with use of traditional chalk and board class room discussion. audio visual aids to present RNA silencing mechanisms	Regular classroom interaction and analytical problem solving related to gene expression and silencing. Class tests will be conducted for internal assessment

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

4. Keywords

RNA, Transcription, Translation, Genetic code, Gene expression, Operon

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Genetic Engineering and Biotechnology (BCH C-13)
Semester – VI

1. Course objectives:

The objective of the course is to teach the basics of theoretical and practical aspects of recombinant DNA technology and various techniques for DNA manipulation in prokaryotes and eukaryotes. Applications of these techniques in production of recombinant therapeutic proteins and vaccines will also be outlined in this course.

2.1 Course Learning Outcome

The students will be able to understand:

- The process for isolation and engineering of DNA using restriction and modification enzymes.
- Use of cloning and expression vectors.
- The methods for creation of genomic and cDNA libraries, their applications and use.
- Understanding the methods for protein production and their application in industrial production systems.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: The basic principle of gene cloning **No of hours: 10**

Restriction and modification systems, restriction endonucleases and other enzymes used in manipulating DNA molecules. Ligation of DNA molecules. DNA ligase, sticky ends, blunt ends, linkers and adapters, homopolymer tailing, Synthetic oligonucleotides.

UNIT II: Cloning vectors for prokaryotes and eukaryotes **No of hours: 12**

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors based on *E. coli* plasmids, pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage, and in vitro packaging. Vectors for yeast, Ti-plasmid, and retroviral vectors, high capacity vectors BAC and YAC.

UNIT III: Introduction of DNA in cells, selection for recombinants and clone identification

No of hours: 10

Uptake of DNA by cells. Selection and identification for transformed cells, insertional inactivation, blue-white selection. Transfection. Chemical and physical methods of DNA introduction into cells. The problem of selection, direct selection, marker rescue. Identification of recombinant phages, cDNA and Genomic libraries, identification of a clone from gene

library, colony and plaque hybridization probing, Southern and Northern hybridization, methods based on detection of the translation product of the cloned gene.

UNIT IV: Expression of cloned genes **No of hours: 06**

Vectors for expression of foreign genes in *E. coli,* cassettes and gene fusions. Hybrid promoters: trc, tac, λpL and T7 promoter based expression vectors. Challenges in producing recombinant protein in *E. coli.* Production of recombinant protein by eukaryotic cells. Fusion tags such as, poly-histidine, glutathione, maltose binding protein and their role in purification of recombinant proteins.

UNIT V: Polymerase chain reaction and DNA sequencing **No of hours: 10**

Fundamentals of polymerase chain reaction, Types of PCR; hot start, multiplex, reverse transcriptase PCR and Nested PCR, quantitative PCR, Primer, designing for PCR. Cloning PCR products. DNA sequencing by Sanger's method including Automated Sanger's DNA sequencing. Introduction to Next Generation Sequencing.

UNIT VI: Applications of genetic engineering in Biotechnology **No of hours: 12**

Site–directed mutagenesis, Protein engineering (T4-lysozyme), yeast two hybrid systems, Production of recombinant pharmaceuticals such as insulin, human growth hormone, factor VIII. Recombinant vaccines. Gene therapy (SCID), Applications in agriculture – *Bt* cotton, glyphosate herbicide resistant crops, ethical concerns.

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Transformation of *E. coli* cells with plasmid DNA.
2. Isolation of plasmid DNA from *E. coli* cells.
3. Digestion of plasmid DNA with restriction enzymes.
4. Amplification of a DNA fragment by PCR.
5. Complementation of β−galactosidase for Blue and White selection.

2.3 References

1. Brown, T.A. (2010) *Gene Cloning and DNA Analysis* (6th ed.), Wiley-Blackwell publishing (Oxford, UK), ISBN: 978-1-4051-8173-0.
2. Glick B.R., Pasternak, J.J. and Patten, C.L., (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.), ASM Press (Washington DC), ISBN: 978-1-55581-498-4 (HC).
3. Michael R Green and J. Sambrook (2014) *Molecular Cloning: A laboratory manual*, (4th ed.), Cold spring Harbor laboratory press (3vol.), ISBN: 978-1-936113-42-2
4. Primrose, S.B., and Twyman, (2006) *Principles of Gene Manipulation and Genomics* (7th ed.), R. M., Blackwell publishing (Oxford, UK) ISBN:13: 978-1-4051-3544-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will learn about the significance of Restriction and Modification System, properties and uses of different restriction and modification enzymes and DNA as well as Methods to ligate DNA molecules	Describe different systems, and their applications with case studies using Chalk and board along with power point presentations.	The students will be given home assignment at the end of first unit.
II.	Students will learn about the biology of different types of vectors systems including plasmids and bacteriophages used in prokaryotes and eukaryotes along with their applications.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any.	The students will undergo internal test with syllabus covered in the two units and their answers will be discussed in the following class.
III.	Students will know about DNA transfer to cells, distinguishing between recombinants and non-recombinants and to identify a specific clone among many clones in a library	Chalk and board along with power point presentations, regular question answer activities. Consultation of text books.	The students will be given home assignment at the end of third unit.
IV	Students will earn about the signals that promote expression of heterologous proteins from expression vectors and their purification from the medium	Concepts will be taught using chalk and board and notes; Power point presentations for images for clarity of concepts;	The students will undergo internal test with syllabus covered in the third and the fourth units and their answers will be discussed in the following class.

V.	Students shall become aware of the basic process of PCR, different types of PCR and DNA sequencing techniques	Teaching using chalk and board; Oral discussion sessions in the class.	The students will be given home assignment at the end of fifth unit.
VI.	The students shall be able to understand how theoretical knowledge of RDT translates into production of commercially useful proteins that are used in medicine and about creating GMOs, while maintaining strong ethics	Teaching and learning activity will mainly include extensive discussions; chalk and board teaching; Discussion about principle and logic behind each methods and experiment.	The students will undergo internal test with syllabus covered in the fifth and the sixth units and their answers will be discussed in the following class.

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

4. Key Words:

Genetic Engineering, Recombinant Proteins expression and purification, Biotechnology, cloning

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
CORE PAPER
Immunology (BCH C-14)
Semester VI

1. Course Objective

This course describes the molecular and cellular basis of the development and function of the immune system. The course will provide the basic framework in immunology that will cover the major topics including innate and adaptive immunity, antibodies and antigens, the molecular events leading to the generation of antibody, humoral and cell mediated adaptive immune response, hypersensitivity, self-tolerance, autoimmunity and vaccines.

2.1 Course Learning Outcomes

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

- Trace the history and developments in immunology.
- Have an overview of the immune system including cells, organs and receptors.
- Describe the basic mechanism, differences and functional interplay of innate and adaptive immunity
- Understand Antigens & its Recognition, antigen processing and presentation
- Understand the structure & functions of different classes of Immunoglobulins, and understand the genetic basis of antibody diversity
- Define the cellular and molecular pathways of humoral and cell-mediated immune responses
- Describe the mechanisms involved in different types of hypersensitivity
- Explain the principles of tolerance and autoimmunity
- Understand Immunotherapies and basic concept of Vaccines
- Summarize role of immunity in protection against pathogens

2.2 Course contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Immune System and Innate Immunity **No. of hours: 10**

Historical Perspective, Innate and Adaptive Immunity, Hematopoiesis, cells of the immune system, primary and secondary lymphoid organs and tissues. Anatomical barriers, cell types of innate immunity, soluble molecules and membrane associated receptors (PRR), connections between innate and adaptive immunity, localized and systemic response. Complement activation by classical, alternate and MB lectin pathway, biological consequences of complement activation, regulation and complement deficiencies

UNIT II: Antigens and Antibody **No. of hours: 12**

Antigens, carriers, adjuvants and haptens, factors responsible for immunogenicity, B and T cell epitopes. Structure, classes and subclasses of immunoglobulins (Ig, Ig fold), effector functions of antibody, antigenic determinants on Ig, Ig super family. Monoclonal antibodies production and applications

UNIT III: Biology of the B Lymphocyte & Humoral Immunity **No. of hours: 10**

Dreyer-Bennett hypothesis, multigene organization of Ig locus, mechanism of V region DNA rearrangement, mechanisms of antibody diversity. Antigen independent phase of B cell maturation and selection, humoral response – T-dependent and T-independent response, anatomical distribution of B cell populations

UNIT IV: Biology of the T Lymphocyte & Cell Mediated Immunity **No. of hours: 12**

General organization and inheritance of MHC, structure, distribution and role of MHC class I and class II proteins, pathways of antigen processing and presentation. Structure and role of T cell receptor (TCR) and co-receptor, T cell development, generation of receptor diversity, selection and differentiation. General properties of effector T cells, cytotoxic T cells (Tc), natural killer cells; NK - T cells and antibody dependent cellular cytotoxicity (ADCC).

UNIT V: Autoimmunity and Hypersensitivity **No. of hours: 10**

Self-tolerance and possible mechanisms of induction of autoimmunity, Organ specific and systemic autoimmune diseases, Gell and Coombs classification, IgE mediated (Type I) hypersensitivity, antibody mediated cytotoxic (Type II) hypersensitivity, immune complex mediated (type III) hypersensitivity and delayed type (Type IV) hypersensitivity

UNIT VI: Transplantation Immunology and Vaccines **No. of hours: 6**

Immunological basis of graft rejection, clinical manifestations, immunosuppressive therapy and privileged sites. Vaccines - active and passive immunization, types of vaccines

PRACTICALS

CREDITS : 2 **TOTAL HOURS: 60**

1. Isolation of lymphocytes from blood / spleen.
2. Purification of immunoglobulins from serum
3. Assays based on precipitation reactions - Ouchterlony double immunodiffusion (DID) and Mancini radial immunodiffusion (SRID).
4. Assays based on agglutination reactions - Blood typing (active) & passive agglutination.
5. Enzyme linked immunosorbent assay (ELISA) & DOT ELISA

2.3 References

1. Coico, R and Sunshine, G. (2009) *Immunology: A Short Course* (6th ed.), John Wiley& sons, Inc (New Jersey), ISBN: 978-0-470-08158-7.
2. Kindt, T.L., Goldsby, R.A. and Osborne, B.A. (2007) *Kuby Immunology* (6th ed.), W.H Freeman and Company (New York), ISBN:13: 978-0-7167-8590-3 / ISBN: 10:0-7617-8590- 0.
3. Murphy, K., Mowat, A., and Weaver, C.T. (2012) *Janeway's Immunobiology* (8th ed.), Garland Science (London & New York), ISBN: 978-0-8153-4243-4

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

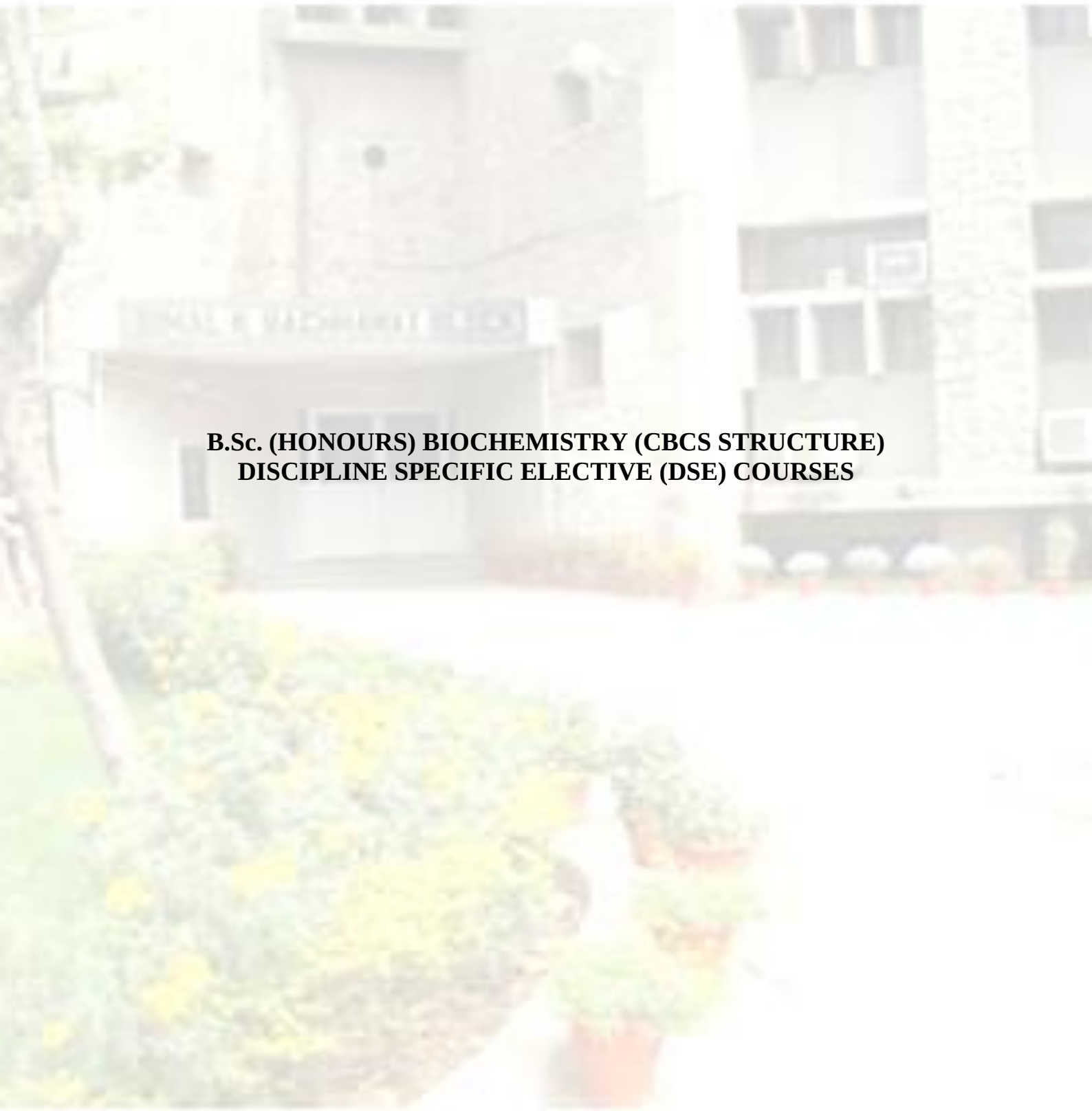
Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be taught about the historical perspective of immunology, They will learn about the cells and organs of the immune system and innate immune mechanisms..	Chalk and board method will be used and powerpoint presentation for depicting the structure of cells and hematopoiesis	Students will be asked to correlate the importance of immunity and health by asking them to site examples from their experience
II.	Students will be explained the concept of foreign molecules acting as antigens. What are antibodies and their basic structure will be dealt with. Will focus on how antigen and antibody can interact with each other	Chalk and board method will be used and powerpoint presentation for depicting the structure of antibodies	MCQ based assignments will be given to students to check their understanding of the subject. Students will be asked to come up with examples where antigen – antibody interactions can be utilized for diagnostic purposes. This will help them to understand the importance of these components of the immune system.
III.	Students will understand how antibodies are generated in the body. They will understand the importance of humoral response in infections	Chalk and board method will be used and powerpoint presentation for understanding antibody diversity and production	Discussion related to transcription and translation of proteins will be held and comparisons with antibody production will be highlighted. Class tests will be taken.

IV	Students will be exposed to the cellular arm of immunity. The various cells which participate in cellular response will be dealt with. Cytotoxic action of T cells will be discussed	Chalk and board method will be used and powerpoint presentation for understanding The interaction between various cells	Students will be asked to focus on the functioning of T cell as opposed to B cells. Certain articles related to these basic concepts will be discussed in groups
V.	Students will understand the importance of regulated immune response. What will happen if the immune response is exaggerated will be explained with examples. The concept of autoimmunity will also be explained	Chalk and board method will be used and supplemented with powerpoint presentation.	Interaction with students will be held in form of some case studies .Quiz will be held.
VI.	Importance of immunity will be highlighted by explaining the importance of vaccines and transplantation of organs.	Chalk and board method will be used and supplemented with powerpoint presentation.	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)

4. Keywords

Immunity, Innate Immunity, Adaptive Immunity, Antigens, Antibodies, Antibody Diversity, Antigen Processing & Presentation, MHC, Humoral Response, Cell mediated Immunity, Hypersenstivity, Tolerance, Autoimmunity, Vaccines



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

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Nutritional Biochemistry (BCH DSE-1)
Semester - V

1. Course Objective

This course provides students with knowledge and understanding of the characteristics, function, assimilation, distribution and deficiency of macro and micronutrients in the human body. It involves integrated learning between the areas of Biochemistry and Nutrition.

2.1 Course Learning Outcomes

At the end of the course, the students are expected to:

- Critically analyze and evaluate concepts in nutritional biochemistry that are important for an understanding of human nutrition.
- Appreciate the biochemical underpinning of human nutrition in maintaining health.
- Demonstrate understanding of the biochemical basis of essentiality of macro and micronutrients and their nutritional deficiencies.
- Be aware of techniques used in the assessment of nutritional status and nutritional disorders.
- Understand drug nutrient interactions.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to Nutrition and Energy Metabolism **No. of hours: 6**

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 : 20**

Food sources of carbohydrates, Review functions of carbohydrates. Factors affecting Digestion, absorption and utilization. Glycemic index and glycemic load. Dietary fiber and role of fibre in health. 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 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, 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:Marasmus and Kwashiorkor.

UNIT III: Micronutrients: Vitamins **No. of hours : 12**

Vitamin A, D, E, K and 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 role 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 : 10**

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 : 6**

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 interactions and Nutraceuticals **No. of hours : 6**

Nutrient interactions affecting ADME of drugs. Drug induced nutrient deficiency: Alcohol, Antibiotics, Anti-malarial drugs. Food as medicine: turmeric, garlic, ginger, cumin, asafoetida

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Anthropometric identifications for nutrition related diseases
2. Blood Lipid profile
3. Determination of oxidative stress: TBARS in serum, antioxidant enzymes in hemolysate/plant sources.
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
8. Case studies on nutritional disorders.

2.3 References

1. Coombs Jr. G. F., (2008). *The vitamins, Fundamental aspects in Nutrition and Health.* Elsevier's Publications. ISBN-13- 978-0-12- 183493-7.
2. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
3. Mahan, L.K., Strings, S. E., Raymond, J. (2012) *Krause's Food and Nutrition Care process.* 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.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Basic concepts of nutritional biochemistry that are important for an understanding of human nutrition will be learnt.	Chalk and board teaching for basic concepts	Assessment through regular discussion, Quiz and solving numerical problems on energy expenditure
II.	Understand the biochemical basis and nutritional importance of macronutrients. They will learn the importance of gut biome in maintenance of health and the role of dietary fiber in maintaining a good gut microbiome and will understand the concepts of diet composition in governing nutrient assimilation	Power point presentations will be used to teach about essential macronutrients. Discussions will be held to clarify the concepts.	Regular oral question answer sessions in class, case study evaluations and Internal assessment test
III.	Development of understanding of the ADME and essentiality of fat and water soluble vitamins. They will also learn the biochemical mechanisms for the symptoms of vitamin deficiencies and excesses	Chalk and board teaching, power point presentation on essential vitamins and their deficiency disorders, historical perspective on nutritional deficiencies Practical diagnosis of any one vitamin deficiency.	Oral question-answer sessions in class, assessment through test/quiz and case study analysis.
IV	Appreciate the importance of mineral macronutrients with special emphasis on calcium and iron	Black board teaching of the basic concepts and powerpoint 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	Get acquainted with the techniques used in the assessment of nutritional status and nutritional disorders.	Chalk and board teaching and discussion on case studies bases on anthropometry and biochemical estimations Anthropometric assessment- Practical class. Practical assessment of oxidative stress.	Assessment test and case study evaluation
VI.	Gain knowledge about drug nutrient interactions.	Power point presentation and chalk and board teaching.	Test/quiz on various groups of drugs and their effect on nutrient availability Power point presentations Onnutraceuticals.

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

4. Keywords

Nutrition, macro nutrients, micro nutrients, nutrient assessment, nutrient deficiency

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Advanced Cell Biology (BCH DSE-2)
Semester - V

1. Course Objective

The course aims to provide advanced knowledge of the function of cellular organelles, the structure and function of cytoskeleton and its role in motility. The course will also provide details of cellular interaction with cells and tissues around and the molecular regulation of cell growth and cell death. The course will outline the molecular details of the origin of cancer and the diagnosis and treatment.

2.1 Course Learning Outcomes

The learning outcomes will be as follows:

- Students will develop understanding of the principle and application of some of the classical and advanced cell biology techniques
- Students will be able to describe the role of organelles in the secretion of mature proteins and key role of the cytoskeleton in the living cell.
- Students will be able to understand the factors regulating mitosis, meiosis, apoptosis and necrosis. They will also be able to comprehend the role and therapeutic value of stem cells.
- Students will be able to understand the genetic basis of development of cancer, the molecular diagnosis and molecular drugs which are used for chemotherapy.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Advanced Methods in Cell Biology **No. of hours: 6**

Principle and application of ultracentrifugation

UNIT II: Protein Sorting and Secretory Pathway **No. of hours: 16**

Transport of proteins across nuclear envelope; Regulation of nuclear protein import and export. Overview of the endomembrane system; Targeting, modification and sorting of proteins from and into Endoplasmic Reticulum; Synthesis and targeting Mitochondrial protein; Chloroplast Proteins and Peroxisomal proteins; Mechanism of Vesicular Transport; Coat Proteins and Vesicle Budding; Vesicle Fusion; Targeting of Proteins

UNIT III: Cytoskeleton and Cell Motility **No. of hours: 10**

Function and origin of the cytoskeleton; Organization and assembly of Actin Filaments and Myosin; Assembly and organization of Microtubules and Intermediate Filaments; Motor proteins of microtubules and their functions. Cell movement.

UNIT IV: Cell Division and its Regulation **No. of hours: 10**

Overview of the cell cycle; Eukaryotic cell cycle; Events of Mitotic Phase; Cytokinesis; Events of Meiosis And Fertilization; Regulation of Cell Division and Cell Growth;

UNIT V: Cell Death and its Regulation **No. of hours: 8**

Apoptosis and Necrosis, Application of stem cells in health and disease. Hematopoiesis, Embryonic Stem Cells and Therapeutic Cloning.

UNIT VI: Molecular Basis of Cancer Biology **No. of hours: 10**

Development and causes of cancer; Genetic basis of cancer; Oncogenes, Tumor Viruses; Molecular approach to cancer treatment.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Techniques of Plant /Animal Tissue Culture
2. Study of pinocytosis by paramecium under microscopy
3. Calculating viability of bacterial cells after exposure of the bacterial culture to UV rays
4. Preparing temporary mount of nerve cell from mammalian spinal cord
5. Differential centrifugation of cell and validation of separated organelles by enzyme markers
6. Study of cell- cell agglutination by lectin and calculation of haem-agglutination titre.
7. Demonstration of phagocytosis/apoptosis

2.3 References

1. Cooper, G.M. and Hausman, R.E., (2009). *The Cell: A Molecular Approach*.(7th ed.). ASM Press & Sunderland (Washington DC), Sinauer Associates, MA. ISBN:978-0-87893-30.
2. Karp, G., (2010). *Cell and Molecular Biology: Concepts and Experiments* (8th ed.). John Wiley & Sons. Inc. ISBN : 978-1-118-65322-7.
3. Kleinsmith, L. J., Hardin, H., Wayne G., Becker, M. (2009). *The World of the cell* (7th ed.). ISBN-13: 978-0805393934 / ISBN-10: 0805393935.

Additional Resources:

1. Alberts, B., Johnson, A., Lewis, J., and Enlarge, M. (2008). *Molecular Biology of the* Cell. (5th ed.). Garland Science (Princeton), ISBN:0-8153-1619-4 / ISBN:0-8153-1620-8.

2. Lodish, H., Berk, A., Zipursky, S.L., Matsudaira, P., Baltimore, D. and Darnell. J., (2012). *Molecular Cell Biology* (7th ed.). W.H. Freeman & Company (New York). ISBN:13:978-14641-0981-2 / ISBN:10: 1-4641-0981-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

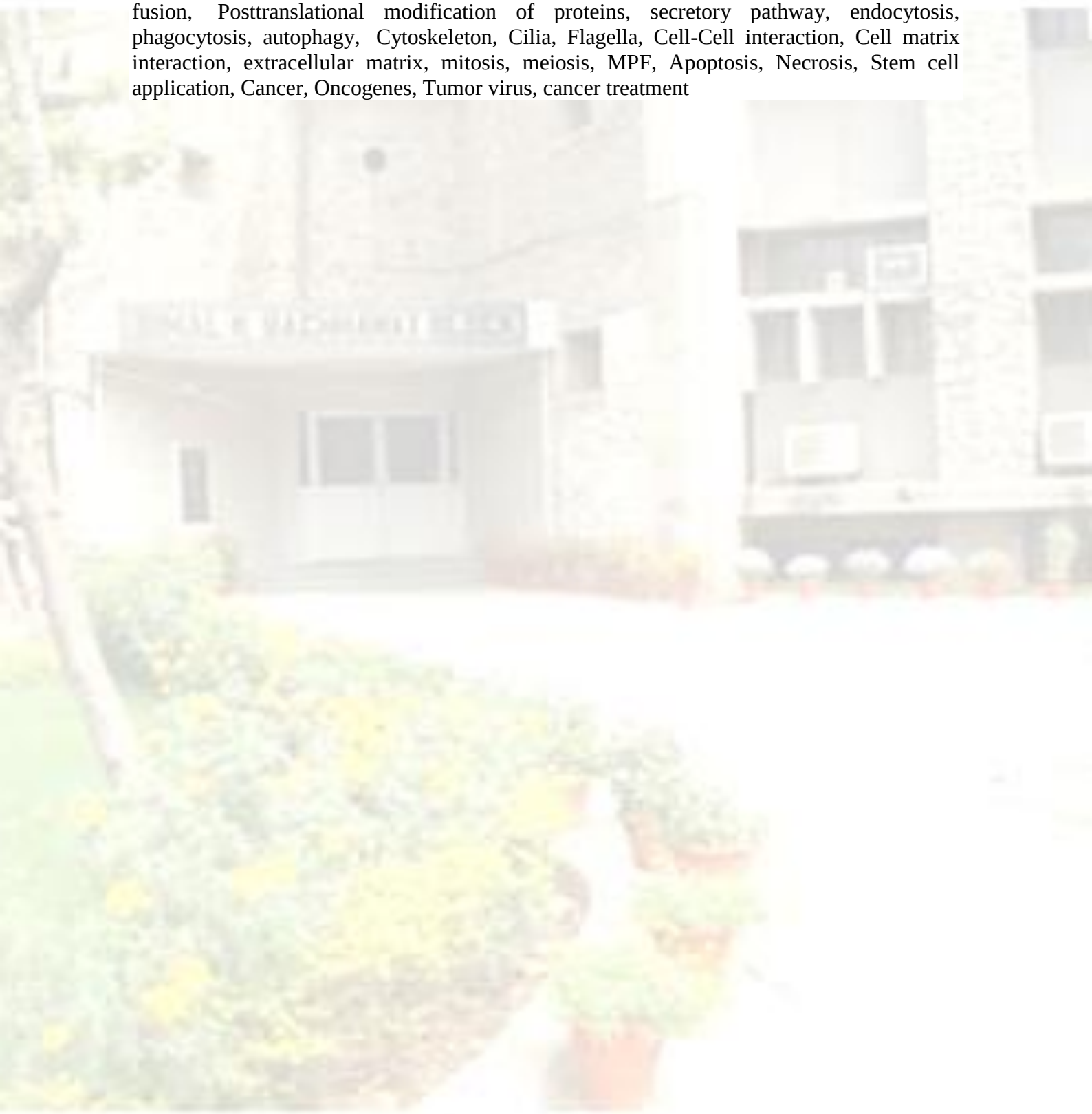
Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The students will be given an in-depth understanding of the principles, working, application and limitations of various advanced techniques used in cell biology	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals. The students will be taken to prestigious institutes during educational trips to further help them grasp the concepts taught to them in class.	Internal assessment tests and quiz will be conducted. Students will be assigned various topics and will be asked to deliver a power point presentation on the assigned topics.
II.	The students will gain knowledge regarding the roles various organelles in protein sorting in the cell. They will also learn about the mechanisms involved in vesicular transport and cell-cell/cell-virus fusion.	The students will learn to correlate the advanced techniques learnt by them in the previous unit with the organelles learnt in this unit with the help of electron micrograph diagrams of the various organelles of the cell. They will be given an insight into the original experiments conducted by scientists to discover the protein sorting and secretory pathways of the cell. The students will be taught using power point presentations and chalk board teaching.	The students will be assessed by assignments and internal tests. They will be required to identify the various pathways adopted by the proteins for proper folding and reaching correct destination. They will also be tested on their understanding of difference between the various types of vesicular transport as well as steps involved in fusion of cells/cell-virus.
III.	The students will learn about the organization and assembly of the components of the cytoskeleton like the actin and myosin filaments; the microtubules and intermediate as well as the cilia and flagella. They will also learn about the	The students will be taught the basic concepts regarding the various components of the cytoskeleton and their role in cell motility by using power point presentations and chalk board teaching.	The students will be assessed by assignments and internal tests. Tests in the form of quiz will be held and students will mention the characteristics of each of the components of the cytoskeleton. They will also be quizzed about their knowledge on the types of cellular junctions, method of polarization of cell etc.

	various mechanism of action of the factors contributing to cell motility.		
IV	The students will learn the salient features and phases of cell cycle. They will understand the various events that lead to the progression of cell division – both mitosis and meiosis. They will also understand basic differences between the two types of cell division, and the cell types associated with these divisions.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals. The students will observe the various stages of cell division under the microscope, using various samples.	The students will be tested by asking them to prepare slides identify specific stages of cell division observed by them, and its significance in cell division. The students will also be assessed with assignments and internal tests.
V.	Students will learn the basic concept of cell death and the importance of programmed cell death. They will also understand the various types and importance of stem cells along with their application in therapeutic cloning.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals.	Group discussions will be conducted to elucidate the importance of stem cells in therapeutics. The students will also be assessed with assignments and internal tests.
VI.	The students will learn the basic concepts of cancer biology and understand how and why cancer develops in a system. They will also learn about the currently used approaches towards cancer treatment.	Basic concepts will be explained with the help of power point presentations /chalk board teaching along with informative audio-visuals.	Internal assessment tests and quiz will be conducted. Students will be given assignments outlining the various sources of carcinogens in our surroundings. The assignment will also require them to enlist the various food items that are popularly said help prevent cancer and mention scientific evidence if any, to support these claims.

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

4. Keywords

Ultracentrifugation, FACS, FRET, Confocal Microscopy, Electron microscopy, Plant tissue culture, Animal tissue culture, Immunihistochemistry, Cell-Cell fusion, Posttranslational modification of proteins, secretory pathway, endocytosis, phagocytosis, autophagy, Cytoskeleton, Cilia, Flagella, Cell-Cell interaction, Cell matrix interaction, extracellular matrix, mitosis, meiosis, MPF, Apoptosis, Necrosis, Stem cell application, Cancer, Oncogenes, Tumor virus, cancer treatment



B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Microbiology (BCH DSE-3)
Semester - V

1. Course Objectives

The objective of the course is to trace the history of development of the discipline of Microbiology and to emphasize the existence of the immense diversity in the microbial world and maintenance of microbes under laboratory conditions. The course also aims to make the students aware of both pathogenic as well as beneficial microbes to prepare students for higher education in microbiology-related disciplines.

2.1 Course Learning Outcomes

On successful completion of this paper, students should be able to:

- Identify different microbes
- Perform routine microbiological practices including sterilization, media preparation, maintenance of microbial culture, staining etc.
- Carry out research using microbes.
- Test microbial culture for antibiotic resistance.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: History of Microbiology **No. of hours: 8**

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: 14

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: 14**

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

Introduction to pathogenic microbes; Bacteria, Viruses, Algae, protozoa and fungi. General Characteristics of antimicrobial drugs, determining the level of microbial activity: dilution susceptibility test and disc diffusion test. Range of activity and mechanism of action of penicillin, vancomycin and tetracycline.

UNIT V: Food and Industrial Microbiology **No. of hours: 16**

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.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

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)
6. To prepare temporary mount of fungi (Penicillium)
7. Study of different shapes of bacteria, fungi, algae, protozoa using permanent slides/pictographs

2.3 References

1. Chan, M. J., Krieg E. C. S., Pelczar, N. R. (2004) *Microbiology* (5th ed.). McGraw Hill International. ISBN 13: 9780094623206.
2. Willey, J., Sherwood, L., Woolverton, C. (2017). *Prescott's Microbiology* (10th ed.). McGraw Hill international. ISBN 13: 9781259657573.

Additional Resources:

1. Cappuccino J. G., and Sherman N., *Microbiology: A Laboratory manual* (10th ed.). Benajamin/ Cummings. ISBN 13: 9780321840226.

2. Madigan, M. T., Martinko J. M., & Stahl D. A., (2010) *Brock Biology of Microorganisms* (13th ed.). Pearson Education International. ISBN 13: 9780321649638.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be able to understand the historical development and contributions of various scientists in the field of microbiology	Power point presentations and blackboard teaching. General discussion with students about the topic taught to understand their knowledge.	Class test will be taken. Questions related to the topic will be given in the form of assignment
II.	Students will be able to understand the existence and diversity of the microbial world. They will get familiarize with the Gram staining techniques	Power point presentations and blackboard teaching. Hands on experience on gram staining technique during practical classes	Class test will be taken at the end of module. Questions related to the topic will be given in the form of assignment. Students will also be assessed based on their ability to prepare gram-stained slides.
III.	Students will learn about the nutritional requirements of microorganisms. They will also learn about the various physical and chemical methods used for the control of microbial growth.	Blackboard teaching. principle and working of some of the instruments will be explained using online resources. Experience on handling various instruments during practical classes	Students will be assessed by asking oral questions and also assessed during practical classes for the preparation of media and handling of instruments
IV	Students will gain knowledge about pathogenic microbes and characteristic features of antimicrobial drugs.	Blackboard teaching. General discussion with students about the existence of disease causing microbes in our day-today life.	Class test will be taken at the end of module. Assignment will be given to understand the concept of mechanism of action of different antimicrobial drugs.
V.	Students will be able to understand the	Blackboard teaching. Powerpoint presentation and	Students will be evaluated on the basis of

	industrial applications of microbes	oral discussions in the class	presentations and assignments

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

4. Keywords

Microorganisms, diversity, culture, Pathogenicity, industrial applications

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
Molecular Basis of Infectious Disease (BCH DSE-4)
Semester - VI

1. Course Objective

The course aims to provide knowledge about various microbial infectious agents that cause diseases in humans, the concepts of treatment and the biochemical basis of mechanism of action and drug resistance for various antimicrobial agents. The course will also provide outline of the various strategies that are employed for preventing infectious diseases and the role of vaccination in eradication of diseases. It will cover the concept of emergence and re-emergence of diseases and idea of bio-terrorism and its impact worldwide. The course will also summarize the significance of hygiene, sanitation, drugs and vaccination in prevention and eradication of infectious diseases.

2.1 Course Learning Outcomes

Upon completion of this course, a student will:

- Understand various classes of pathogens and their mode of action and transmission.
- Be exposed to the molecular basis of treatment, diagnosis and vaccine design strategies for all the diseases listed.
- Gain insight into host immune responses that ensue subsequent to infection.
- Learn the details of diseases such as tuberculosis, AIDS and malaria which are highly prevalent in Indian subcontinent.

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Infectious diseases: an introduction **No. of hours : 7**

Classification of infectious diseases, Nosocomial infections; Patterns of Disease; Measuring infectious disease frequency; Past and present emerging and re-emerging infectious diseases and pathogens. Source, reservoir and transmission of pathogens. Safety measure when working with pathogen biosafety levels, infection and evasion

UNIT II: Strategies for management of infectious diseases **No. of hours : 4**

Role of drugs, vaccines, hygiene and sanitation in prevention, transmission control and treatment of infectious diseases

UNIT III: Diseases caused by bacteria **No. of hours : 20**

Classification of bacterial pathogens based on structure and nutritional requirements; Overview of bacterial virulence factors and host pathogen interactions; detailed study of tuberculosis: History, causative agent, molecular basis of host specificity, infection and pathogenicity, diagnostics, therapeutics and vaccines, drug resistance and implications on public health. Other

bacterial diseases - virulence factors, host pathogen interaction, symptoms, diagnosis, vaccines and drugs against - Typhoid, Diphtheria, Pertussis, Tetanus, Botulism Cholera, Anthrax and Pneumonia

UNIT IV: Diseases caused by viruses **No. of hours : 15**

Structure of viruses, Baltimore system for virus classification; Overview of viral virulence factors and host pathogen interactions; detailed study of AIDS: history, causative agent, pathogenesis, diagnostics, drugs; other viral diseases including hepatitis, Influenza (Antigenic shift and antigenic drift), Rabies, Dengue and Polio; Chicken Pox, Herpes Virus

UNIT V: Diseases caused by parasites **No. of hours: 8**

Detailed study of Malaria: history, causative agents, vectors, life cycle, Host parasite interactions, diagnostics, drugs, vaccine development. Other diseases including Leishmaniasis and Amoebiasis, Giardiasis and Trypanosoma infections

UNIT VI: Diseases caused by fungi **No. of hours: 6**

Fungal diseases such as Candidiasis, Sporotrichosis, Aspergillosis and Ring worm: general disease characteristics, medical importance, pathogenesis, diagnosis and treatment

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample
2. WIDAL test as a diagnostic test for typhoid
3. To perform Gram staining of bacterial samples
4. Acid fast staining of non-pathogenic *Mycobacterium*
5. Permanent slides of pathogens: *Mycobacterium tuberculosis*, *Leishmania*, *Plasmodium falciparum*
6. MIC determination using Kirby Bauer / Alamar Blue assay
7. To prepare temporary mount of fungi and identify through staining
8. Research and presentation on current trends in infectious diseases

2.3 References

1. Jawetz, Melnick & Adelbergs (27th ed.), *Medical Microbiology*. McGraw Hill Education. ISBN-10: 0071790314; ISBN-13: 978-007179031.
2. Kenneth J. Ryan, C., George Ray (2010), *Sherris Medical Microbiology: An introduction to infectious diseases*. McGraw-Hill. ISBN-13: 978-0071604024 ISBN-10: 0071604022
3. Prescott, Harley, Wiley, J.M., Sherwood, L.M., Woolverton, C.J. Klien's (2008). Microbiology (7th ed.). Mc Graw Hill International Edition (New York) ISBN: 978-007-126727

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will develop an understanding of important terminologies used in infectious diseases. They will develop an understanding of transmission of pathogens and will gain insight into host immune responses that ensue following infection. They will understand the importance of biosafety equipment for people who work on infectious disease causing pathogens	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Group discussion and quiz will be conducted, and students will be given assignments
II.	Students will learn the strategies used for management of infectious diseases i.e. prevention, transmission control and treatment of infectious diseases	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
III.	Students will learn classification of bacteria and study various bacterial virulence factors. Students will understand the pathophysiology of the Mycobacterium and study ways to prevent and treat Tuberculosis. They will also learn about various bacterial diseases (Typhoid, Diphtheria, Pertussis, Tetanus Botulism, Cholera, Anthrax, Pneumonia) their molecular mechanisms and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Group discussion, Quiz will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
IV	Students will learn about Baltimore classification system of viruses and viral	Revision of concepts covered in the previous class will be done. This	Group discussion, Class tests will be conducted, and students will be given

	virulence factors. They will understand the pathophysiology of the HIV, Influenza and Hepatitis virus and study ways to prevent and treat AIDS, Influenza and Hepatitis. Students will learn about other various viral diseases (Chicken Pox, Herpes, Rabies, Dengue and Polio) their molecular mechanisms, diagnosis and intervention strategies.	will be followed by traditional chalk and board teaching aided with Power Point presentations	assignments and will be asked to give PowerPoint presentations on the assigned topics
V.	Students will learn about various parasitic diseases, host parasite interaction, their molecular mechanisms of infection, diagnosis and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Quiz, Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics
VI.	Students will learn about various fungal diseases, their molecular mechanisms, diagnosis and intervention strategies	Revision of concepts covered in the previous class will be done. This will be followed by traditional chalk and board teaching aided with Power Point presentations	Class tests will be conducted, and students will be asked to deliver Power Point presentations on the assigned topics

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

4. Keywords

Infection, Pathogen, Immune response, Diagnosis, Vaccines, Diseases

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE PAPER
Plant Biochemistry (BCH DSE-5)
Semester - VI

1. Course Objectives

The course aims at providing deep understanding of metabolic processes in plants and the role of different biosynthetic pathways in plant growth and development. The course will also impart basic concepts and applications of plant tissue culture.

2.1 Course Learning Outcomes

Successful completion of this course will provide students with the following learning outcomes:

- Understanding of plant cell structure and organization.
- Concept of the biochemical processes and metabolic pathways specific to plants, including photosynthesis, photorespiration, cell wall biosynthesis, nitrogen fixation and assimilation and plant secondary metabolism.
- Insight on how plants have evolved to cope up with the different stress conditions.
- Knowledge of the basic concepts of plant tissue culture and its application in generating transgenic crops.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to plant cell structure and carbon fixation **No. of hours: 16**

Introduction to Plant cells, Plasma membrane, Vacuole and Tonoplast membrane, Cell wall, Plastids and Peroxisomes. Photosynthesis and Carbon assimilation. Structure of PSI and PSII complexes, Light reaction, Cyclic and non-cyclic photophosphorylation, Calvin cycle and regulation; C4 cycle and Crassulacean acid metabolism (CAM), Photorespiration, Photo inhibition of photosynthesis, Photosynthetic carbon reduction (PCR) cycle, Synthesis of polysaccharides in plants.

UNIT II: Respiration **No. of hours: 12**

Overview of glycolysis, Alternative reactions of glycolysis, Regulation of plant glycolysis, Translocation of metabolites across mitochondrial membrane, TCA cycle, electron transport chain, Alternative NAD(P)H oxidative pathways; Cyanide resistant respiration.

UNIT III: Nitrogen metabolism **No. of hours: 10**

Biological nitrogen fixation by free living and in symbiotic association; Structure and function of the enzyme nitrogenase. Nitrate assimilation: Nitrate and Nitrite reductase. Primary and secondary ammonia assimilation in plants; ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway. Seed storage proteins in legumes and cereals.

UNIT IV: Regulation of plant growth and stress physiology **No. of hours: 8**

Introduction to plant hormones and their effect on plant growth and development, Regulation of plant morphogenetic processes by light.Plant stress, Plant responses to abiotic and biotic stresses, Water deficit and drought resistance, Flooding, Temperature stress, Salt stress, Ion toxicity, Pollution stress and potential biotic stress (insects and diseases).

UNIT V: Secondary metabolites and toxins **No. of hours: 8**

Representative alkaloid group and their amino acid precursors, function of alkaloids. Examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin, biological role of plant phenolics, Classification of terpenoids and representative examples from each class, biological functions of terpenoids.

UNIT VI: Plant tissue culture and biotechnology **No. of hours**: **6**

Cell and tissue culture techniques, types of cultures: organ and explants culture, callus culture, cell suspension culture and protoplast culture. Plant regeneration pathways: organogenesis and somatic embryogenesis. Applications of cell and tissue culture and somoclonal variation. Germplasm storage and cryo- preservation. Brief introduction to transgenic plants.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Induction of hydrolytic enzymes proteinases /amylases/lipase during germination
2. Extraction and assay of urease from Jack bean
3. Estimation of carotene/ascorbic acid/phenols/tannins in fruits and vegetables.
4. Separation of photosynthetic pigments by TLC.
5. Culture of plants (explants).

2.3 References

1. Buchann (2015). *Biochemistry and Molecular Biology of plant*. (2nd ed.). I K International. ISBN-10: 8188237116, ISBN- 978047 07 14218
2. Caroline Bowsher, Martin steer, Alyson Tobin (2008). *Plant Biochemistry*. Garland Science. ISBN 978-0-8153-4121-5.
3. Dey, P. M. and J.B. Harborne, J.B., (Editors) (1997). *Plant Biochemistry*. Academic Press. ISBN-10:0122146743, ISBN-13:978-0122146749.

Additional Reading

1. Taiz, L. and Zeiger, E. (2010). *Plant Physiology* (5th ed.). Sinauer Associates Inc. ISBN-13: 978-0878938667, ISBN-10: 0878938664.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to basic structure of plant cell and roles of different organelles. Students will gain detailed knowledge on the process of photosynthesis. Students will also learn about carbon fixation by Calvin cycle (C3 cycle), C4 cycle and Crassulacean acid metabolism (CAM).	Teaching will be conducted through both black board mode and power point presentation mode. Special lecture will be organized on current aspects of photosynthesis and carbon fixation.	. Preparation of summary of differences of plant cells from cells of various other organisms; Retrieval of original research papers on photosynthesis, carbon assimilation, light reactions and associated topics. They will separate photosynthetic pigments by TLC.
II.	Students will gain insight into the process of respiration in plants with major focus on how it is different from animal respiration. Further, the students will understand the importance of translocation of metabolites across mitochondrial membrane.	Students will be asked to orally revise the previous class before every new class helping them in better understanding.. Teaching will be conducted through both black board mode and power point presentation mode.	. Students will be given assignment on different topics and will be asked to deliver a power-point presentation on the assigned topics.
III.	Students will learn in detail about how biological nitrogen fixation is carried out by free living and symbiotic bacterial associations. Students will gain insight into nitrate and nitrite reductase and their role in nitrate assimilation. This unit will also emphasize on ammonia assimilation by glutamine synthetase-glutamine oxoglutarate amino transferase (GS-GOGAT) pathway in plants.	Classical black board and power point presentation mode will be used for teaching. Videos on the topic will be used for concept building	A written test will be conducted. Students will be assigned the task of retrieving research papers where nitrogen metabolism in plants were engineered. Debate as to whether nitrogen metabolism may be affected by changing environmental conditions.
IV	Students will gain insight of plant hormones and their	Class room lectures, power point presentations,	

	effect on plant growth and development. Students will also understand how plants respond to various abiotic and biotic stresses like water deficit and drought resistance, flooding, temperature stress, salt stress, ion toxicity, pollution stress and potential biotic stress (insects and diseases).	MOOCs/ UGC e-pathshala/ Open education resources to be used. Stress biology is a significant research area in the University and faculties will be invited for lectures.	The applications of stress biology in the generation of transgenic plants resistant to environmental stresses to be reviewed. Interaction with University researchers in the area.
V.	Students will learn about the significance of secondary metabolites and toxins in plants with the help of examples of major phenolic groups; simple phenylpropanoids, coumarins, benzoic acid derivatives, flavonoids, tannins and lignin. It will also help the students understand the biological role of plant phenolics and terpenoids.	Powerpoint presentations, classroom lectures, videos to be utilized.	. Students will be given assignment on topics related to plant secondary metabolites and their biological role and applications. s They will review methods on the identification of such metabolites and estimate some of them in laboratory .
VI.	Students will gain knowledge about basic cell and plant tissue culture techniques and their application in generation of transgenic plants. This will help them learn the concept of organ and explant culture, callus culture, cell suspension culture and protoplast culture. Concepts related to plant regeneration pathways: organogenesis and somatic embryogenesis will be imparted to the students.	Chalk and board teaching, power point presentations, videos on plant tissue culture and biotechnology. Research papers will be discussed.	Internal assessment test will be conducted. Students will learn how to culture explants in laboratories. They will identify transgenic plants in use and their status in India.

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

4. Keywords

Plant cell, photosynthesis, respiration, nitrogen fixation and assimilation, secondary metabolism, stress biology, plant tissue culture.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
DISCIPLINE SPECIFIC ELECTIVE PAPER
Advanced Methodologies (BCH DSE-6)
Semester - VI

1. Course Objectives

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

2.1 Course Learning Outcomes

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

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Methods for analysis of nucleic acids **No. of hours :20**

Hybridization methods: Southern blotting, Northern blotting, *In situ* hybridization, Colony hybridization. Binding of nucleic acids with protein: DNA pull down assays, Electrophoretic Mobility Shift Assay (EMSA), DNA footprinting, Primer Extension, Chromatin immunoprecipitation (ChIP), ChIP on ChIP. Gene expression analysis: Reporter assays - example luciferase assay, DNA Microarrays, RNA seq.

UNIT II: Methods for analysis of proteins **No. of hours :20**

Protein-Protein Interaction: Immunoprecipitation, Co-Immunoprecipitation (Co-IP), Pull down assays, Yeast two hybrid, Protein fragment complementation assay, Western blotting, Far western blotting, Protein microarrays, ELISA. Protein Separation: Isoelectric focusing, 2D protein gel electrophoresis, 2D-DIGE, Pulse field Electrophoresis; Structural Analysis: Mass Spectrometry, MS/MS, LC/MS.

UNIT III: Microscopy based methods **No. of hours : 6**

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

UNIT IV: Cell Biology techniques **No. of hours : 8**

Cell culture and transfection, Immunohistochemistry, Immunofluorescence, Flow cytometry, FACS, TUNEL assay, Non-invasive scanning of soft tissue

UNIT V: Labeling methods **No. of hours : 6**

Radioactive and Non-radioactive labeling: DNA, Proteins, Whole cells, Fluorescent labeling. DNA, Proteins, bacteria, living cells; Metabolic labeling, Pulse chase analysis

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Western Blotting
2. Southern hybridization
3. Labeling DNA with biotinylated primers using PCR
4. EMSA (virtual lab)
5. Protein Pull down assay
6. Virtual lab on Microarray profiling or 2D-DIGE

2.3 References

1. Ausubel, F.M. et al. (2012). *Current protocols in molecular biology*. New York: John Wiley & Sons.
2. Bisen, P. S., & Sharma, A. (2013). *Introduction to instrumentation in life sciences*. Boca Raton: CRC Press.
3. Bonifacino, J. S., Dasso, M., Lippincott-Schwartz, J., Hartford, J. B., & Yamada, K. M. (Eds.). (1999). *Current protocols in cell biology*. New York: John Wiley.
4. Coligan, J. E., Dunn, B. M., Ploegh, H. L., Speicher, D. W., & Wingfield, P. T. (1995). *Current protocols in protein science*. New York: John Wiley & Sons.
5. Coligan, J. E. et al. (1991). *Current protocols in immunology*. New York: John Wiley & Sons.
6. Fu, H. (Ed.). (2004). *Protein-protein interactions: Methods and protocols* (Vol. 261). Totowa, NJ: Humana.
7. Levine, S., & Johnstone, L. (2008). *The ultimate guide to your microscope*. New York: Sterling Pub.
8. Schimmel. (2013). *Biophysical Chemistry*. MacMillan Higher Education.
9. Wilson, K., & Walker, J. (Eds.). (2010). *Principles and techniques of biochemistry and molecular biology* (7th ed.). Cambridge: Cambridge Univ. Press.

Additional Resources

1. Golemis, E., & Adams, P. D. (2005). *Protein-protein interactions: A molecular cloning manual* (2nd ed.). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
2. Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual* (4th ed., Vol. 1-3). Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
3. Sheehan, D. (2010). *Physical biochemistry: Principles and applications* (2nd ed.). Chichester: Wiley-Blackwell.

3. Teaching Learning Process and Assessment Methods

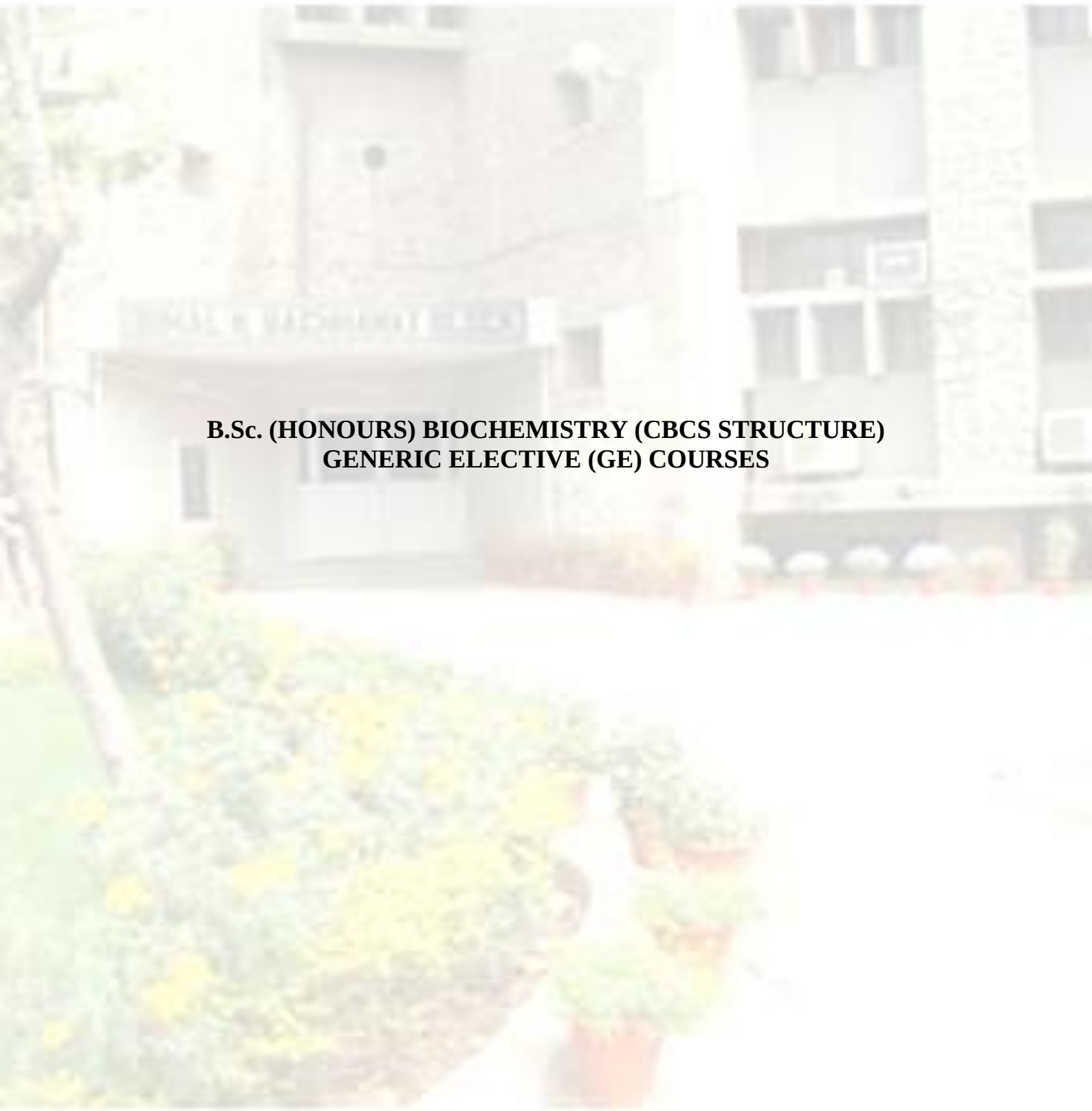
Facilitating the Achievement of Course Learning Outcomes**

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

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

4. Keywords

Southern Blotting, Colony hybridization, DNA footprinting, EMSA, Western Blotting, Immunoprecipation, Pull down assay



B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biomolecules (BCH GE-1)
Semester - I

1. Course Objectives

The objective of the course is to provide students with an understanding of biomolecules, the basic building blocks that are vital for various life forms, focusing on their key properties, biological roles and functions. The course also aims to outline organic and physical aspects of biomolecules.

2.1 Course Learning Outcomes

- Students will acquire knowledge about structure and function of proteins, RNA, DNA, carbohydrates and co-enzymes
- The course will provide an understanding of how structure of biomolecules determine their chemical properties
- Students will develop understanding of biochemistry at atomic level and appreciate the biological importance of each biomolecule

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Biomolecules in their cellular environment **No. of hours : 7**

The cellular basis of life, structure and function of a cell and its subcellular components (eukaryotes, prokaryotes); Physical properties and structure of water molecule, pH, Buffers, biological buffer systems (body fluids and their principal buffers)

UNIT II: Amino Acid and Peptides **No. of hours : 11**

Introduction, general nature of amino acids, classification of amino acids, importance of amino acids, modified and standard amino acids, physical and optical properties of aminoacids, ionization of amino acids, buffering of amino acids, peptide bond, biologically important peptides. Introduction to chromatography, separation of amino acid by paper chromatography

UNIT III: Carbohydrate Chemistry **No. of hours : 11**

Introduction; Definition, classification and functions of carbohydrates, monosaccharides, disaccharides, polysaccharides, homo polysaccharides, hetero polysaccharides; Structure of glucose, isomerism; keto aldo, D-and L- isomerism, optical isomerism, epimerism, anomerism, Mutarotation, chemical properties of monosaccharides, action of strong acids, alkalis,

oxidation, reduction, osazone formation glycoside formation; Derivatives of monosaccharides, phosphoric acid ester, amino sugar, deoxy sugar, sugar acids, sugar alcohols, disaccharides maltose, lactose, sucrose. Homo polysaccharides - starch, glycogen, cellulose, dextrin; Hetero polysaccharides - types of glycosoaminoglycans and functions of glycoproteins

UNIT IV: Chemistry of Lipids **No. of hours: 11**

Introduction; Definition, classification and functions of lipids; Fatty acids; Essential fatty; acids; Reactions of lipids; Triacylglycerol or neutral fat; phospholipids glycolipids; cholesterol; Eicosaanoids; prosatglandins; lipoprotein

UNIT V: Chemistry of Nucleic Acid **No. of hours : 11**

Introduction, nucleic acid, nucleotide, biologically important nucleotides, synthetic analogues of nucleotides or antimetabolites; DNA structure and function; Types of DNA; Organization of DNA; RNA structure and function

UNIT VI: Vitamins and Coenzymes **No. of hours : 8**

Definition and classification of vitamins, water soluble vitamins, fat soluble vitamins, occurrence and nutritional role. Coenzymes and their role in metabolism. Metal ion containing biomoleculeus (heme, porphyrins and cyanocobalamine) and their biological role

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1 Safety measures in laboratories.
2. Preparation of normal and molar solutions.
3. Preparation of buffers.
4. Determination of pKa of acetic acid and glycine.
5. Qualitative tests for carbohydrates, and nucleic acids.
6. Separation of amino acids/ sugars/ bases by thin layer chromatography

2.3 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. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7^{th} ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No	Course Learning Outcomes	Teaching & Learning Activity	Assessment Tasks
I	Student will learn the fundamental concepts of cellular basis of life, cellular structure of prokaryotes and eukaryotes. They will also learn the role of water in design of these molecules.	Chalk and board method will be used and power point presentation for depicting the structure of cells and role of water in design of these molecules.	Students will be asked to correlate the importance of these molecules from their cells by take home assignments.
II	Students will gain insight into basic structures, chemistry and property of amino acids along with derivatives of amino acids. They will be introduced to chromatography	Chalk and board method will be used. Power point presentation for understanding these structure and their role.	MCQ based assignments will be given to students to check their understanding.
III	Understanding of the basic chemistry, structure and classification of all types carbohydrates, along with their biological role.	Chalk and board method and power point presentation will be used for describing these structures distribution &their biological role.	MCQ based assignment will be given to students. Structures will be shown for them to identify the type and class of carbohydrate
IV	Students will learn about the basic building blocks of lipids and the different categories of lipids in the body with main emphasis being on understanding their structure. They will also be exposed to some aspects of function of the different lipids in the body including their role as cofactors, pigments and signaling molecules.	Learning of individual students will be conducted by a traditional chalk and board method and supported by power point slides wherever appropriate.	Multiple choice questions, take home assignments and regular Q&A sessions during class.
V	Students will learn the basic aspects of the structure of DNA and RNA along with unusual structures of DNA. Students will also be made aware of the other roles that nucleotides can play in the body.	Regular question answer sessions in the class to encourage student participation. Regular chalk and board teaching will be used.	Students' knowledge will be assessed via regular quizzes and take home assignments

VI	Students will learn about the nutritional roles of all water soluble and lipid soluble vitamins in the body along with their occurrence. They will also be made aware of how vitamins are crucial in metabolism of the body.	Students will be communicated to mainly using chalk and board method with occasional support taken from structures projected on transparencies or power point slides	Assessment of the student learning will be done by home exams, multiple choice quizzes and take home assignments. They will review research papers as well.

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

4. Keywords

Buffer, Amino Acids, Glucose, Disaccahrides, Polysaccharides, Lipids, Nucleic Acids, Vitamins, Chromatography

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Techniques in Biochemistry (BCH GE-2)
Semester – I / II

1. Course Objectives

The objective of the course is to introduce various techniques to students that are used in biological research as well as to provide them with an understanding of the underlying principles of these techniques. The emphasis is also on experimental skills in the form of practical exercises so that students can apply this knowledge to improve their understanding of the subject for better execution of these techniques.

2.1 Course Learning Outcomes

- Students will acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques used in a biochemistry lab.
- Students will learn about the principle and application of electrophoresis, centrifugation techniques, cell culture and microscopic techniques.
- It will also give them an opportunity to get hands on experience to develop their experimental skills expected from any biochemist working in a research lab.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS:60**

UNIT I: Spectroscopic Techniques **No. of hours: 15**

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. Fluorescence spectrophotometry: Phenomena of fluorescence, intrinsic and extrinsic fluorescence, applications of fluorescence in biochemistry.

UNIT II: Chromatography **No. of hours: 15**

Preparation of sample, different methods of cell lysis, salting out, dialysis. Introduction to chromatography. Different modes of chromatography: paper, thin layer and column. Preparative and analytical applications. Principles and applications of: Paper Chromatography, Thin Layer Chromatography, Ion Exchange Chromatography, Molecular Sieve Chromatography, Affinity Chromatography.

UNIT III: Electrophoresis **No. of hours: 12**

Basic Principle of electrophoresis, Paper electrophoresis, Gel electrophoresis, discontinuous gel electrophoresis, PAGE, SDS-PAGE, Native gels, denaturing gels, agarose gel

electrophoresis, buffer systems in electrophoresis, electrophoresis of proteins and nucleic acids, protein and nucleic acid blotting, detection and identification (staining procedures), molecular weight determination, isoelectric focusing of proteins.

UNIT IV: Centrifugation **No. of hours: 8**

Principle of centrifugation, basic rules of sedimentation, sedimentation coefficient. Various types of centrifuges, low speed centrifuge, high speed centrifuge and ultracentrifuge, types of rotors. Application of centrifugation, differential centrifugation, density gradient centrifugation- zonal and isopycnic.

UNIT V: Microbiological/Cell culture techniques **No. of hours: 5**

Types of media, selective and enrichment media, sterilization methods, bacterial culturing, CFU determination, growth curves, Generation/doubling times, cell counting, viable and non-viable. Growth and maintenance of cultures, biosafety cabinets, CO_2incubator. Staining procedures, plating and microtony.

UNIT VI: Microscopy **No. of hours: 5**

Principle of light microscopy, phase contrast microscopy, fluorescence microscopy. Permanent and temporary slide preparation, histology and staining.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Verification of Beer's Law
2. Estimation of proteins by Biuret/Lowry method
3. Separation of amino acid acids by TLC/paper chromatography
4. To perform agarose gel electrophoresis
5. To isolate mitochondria by differential centrifugation
6. Visualization of cells by methylene blue

2.3 References

1. Boyer, R.F. (2012). *Biochemistry Laboratory: Modern Theory and Techniques* (6th ed.). Boston, Mass: Prentice Hall. ISBN-13: 9780136043027.
2. Plummer, D. T. (1998). *An Introduction to Practical Biochemistry*. (3rd ed.). Tata McGraw Hill Education Pvt. Ltd. (New Delhi). ISBN: 13: 9780070994874 / ISBN:10: 0070994870.
3. Wiley, J.M., Sherwood, L.M., Woolverton, C.J. (2017). *Prescott's Microbiology*. (10th ed.). McGraw Hill Higher Education. ISBN13: 9781259657573.
4. Wilson, K., Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*, (7th ed.). Cambridge University Press. ISBN 9780521516358.

Additional Resources:

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: 0716713152 / ISBN:0716714442.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about the principle and applications of spectrophotometry and flourimetry.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Problems will be assigned related to 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.	Previous classes will be revised. Group 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 in analyzing proteins and nucleic acids	Oral discussion sessions in the class. Chalk and board teaching.	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.	Revision of the previous classes for a better understanding of the students. Demonstration of various centrifuges. Chalk and board teaching.	Demonstration with the help of centrifuges and rotors to improve their understanding.
V	Students will learn and understand the different cell culture and microbiological techniques used in biochemistry.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Various analytical problems will be assigned to students related to cell counting.
VI	Students will learn about various microscopes and slide preparation, histology and staining techniques.	Group discussion sessions will be held in the class along with powerpoint presentations	Various analytical problems will be assigned to students related to working of microscope.

4. Keywords

Spectrophotometry, Chromatography, Proteins, Nucleic Acids, Centrifugation and Electrophoresis

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Proteins and Enzymes (BCH GE-3)
Semester – II / III

1. Course Objectives

The objective of this course is to provide overview of protein biochemistry and enzymology to undergraduate students with diverse science backgrounds, since proteins and enzymes are the most versatile functional entities in life with applications in various life sciences research as well as in industry and biomedicine. The biochemical, structural, functional and aspects of interaction of proteins and enzymes will be introduced in this course.

2.1 Course Learning Outcomes

On successful completion of the course students will be:

- Familiar with unique features and characteristics of proteins and enzymes and their applications in research, medicine and industry.
- Aware of the relationship between three-dimensional structure of proteins and enzymes and their functions.
- Able to comprehend the basic mechanism of action of enzymes and their remarkable regulation
- Aware of the principles of protein isolation, purification and characterization
- Able to gain hands-on-experience in handling proteins and enzymes from various sources, thus improving their ability of learning and imbibing the basic concepts.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to proteins and their structural organization No. of hours :10

Amino acids and their properties. Peptides and their biological significance - hormones, antibiotics and growth factors. Diversity of proteins and their functions. Protein sequence - Edman degradation. Solid phase peptide synthesis. Organization of protein structure - primary, secondary, tertiary and quaternary structures. Conjugated proteins, multimeric proteins and metalloproteins. Bonds in protein structures - covalent and non-covalent. Dihedral angles. Ramachandran map, Secondary structure - helices, sheets and turns.

UNIT II: Three-dimensional structures and protein folding No. of hours: 12

Characteristics of tertiary and quaternary structures. Motifs and domains. Structure-function relationship in proteins. 3D structures of myoglobin and hemoglobin. Oxygen binding curves, influence of pH and effector molecules. Concerted and sequential models for allosteric

proteins. Hemoglobin disorders. Protein folding - denaturation and renaturation. Role of chaperones. Protein misfolding and aggregation diseases.

UNIT III: Isolation, purification and analysis of proteins No. of hours: 8

Ammonium sulphate fractionation, centrifugation 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 enzymes, their characteristics and kinetics No. of hours: 12

Nature of enzymes - protein and non-protein (ribozyme, abzymes). Cofactor and prosthetic group, apo- and holo-enzymes. Features of enzyme catalysis. Classification of enzymes and nomenclature. Fischer's lock & key and Koshland's induced fit hypothesis. Enzyme specificity. Enzyme kinetics- Michaelis-Menten equation, Lineweaver-Burk plot. Determination of K_m, V_{max}, K_{cat}. Factors affecting enzyme activity. Enzyme inhibition- Reversible (competitive, uncompetitive, non-competitive) and irreversible inhibition. Mechanism based inhibitors.

UNIT V: Mechanism of enzyme action and enzyme regulation No. of hours: 10

General mechanisms of action. 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: Applications of enzymes No. of hours: 8

Isoenzymes. Applications of enzymes in research. Application of enzymes in diagnostics (SGPT, SGOT, creatine kinase), Enzyme immunoassay (HRP), Enzyme therapy (Streptokinase). Enzyme immobilization and its applications. Industrial applications.

PRACTICALS

CREDITS: 2 TOTAL HOURS:60

1. Estimation of proteins by Biuret and Lowry methods
2. Ammonium sulphate fractionation of crude homogenate from germinated mung beans
3. Enzyme activity assay (acid phosphatase)
4. Progress curve of enzyme
5. Effect of pH / temperature on enzyme activity
6. Determination of K_m and V_{max} using Lineweaver-Burk plot.

2.3 References

1. Cooper, T. G. (2011). *The Tools of Biochemistry* (2nd ed.). Wiley-Interscience Publication (New Delhi). ISBN: 13:9788126530168.
2. Nelson, D.L. and Cox, M.M. (2017). *Lehninger: Principles of Biochemistry* (7th ed.). W.H. Freeman & Company (New York), ISBN:13: 9781464126116 / ISBN:10-1464126119.

3. Nicholas, C.P., Lewis, S. (1999). *Fundamentals of Enzymology* (3rd ed.). Oxford University Press Inc. (New York), ISBN: 0 19 850229 X.
4. Sheehan, D. (2009). *Physical Biochemistry* (2nd ed.). Wiley-Blackwell (West Sussex), ISBN: 9780470856024 / ISBN: 9780470856031.
5. Voet, D., Voet, J., Pratt, C. (2013). *Biochemistry* (4th ed.) Wiley & Sons, Inc. (New Jersey). ISBN: 978-1-11809244-6.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will gain knowledge about the building blocks of proteins i.e. amino acids and understand about the structural organization of proteins.	Students will be taught using power point presentations, chalk and board. In class oral discussion sessions will be conducted.	Oral questions will be asked in the class. Assignment and tests will be given.
II	Students will understand about the characteristics of tertiary and quaternary structures, 3D structure of Hemoglobin and Myoglobin. They will also understand the concept of protein folding (denaturation and renaturation).	They will be taught using power point presentations, chalk and board. The use of E-learning through online Web and Video courses will be included.	Internal assessment will be done on the basis of quiz and class tests.
III	Students will acquire knowledge about the basic concepts of various techniques used for isolation, purification and analysis of proteins.	Students will be taught using chalk and board. A visit to a Research Lab. for the demonstration/ hands-on-experience of protein purification techniques will be planned to enhance their ability of learning and imbibing the basic concepts.	Students will be assigned different techniques and will be asked to deliver a power point presentation. Various analytical problems will be assigned to students related to purification of proteins.
IV	Students will learn about enzyme catalysis, role of coenzymes, cofactors and different aspects of enzyme kinetics. They will understand about different types of enzyme inhibitors, role of drugs as	They will be shown power point presentations and will be taught using chalk and board. The use of E-learning through online Web and Video courses will be included for the	Regular question- answer sessions in class will be conducted. Internal assessment will include problems/ numericals based on enzyme kinetics.

	enzyme inhibitors and the respective mechanism.	better understanding of the enzyme kinetics.	
V	Students will understand the basic mechanism of enzyme action and enzyme regulation.	Students will be shown power point presentations and will be taught using chalk and board. Oral discussion sessions in the class will be conducted.	They will be assessed on the basis of assignments and class tests.
VI	Students will learn about diverse applications of enzymes in research, diagnostics, therapy and Industry.	Teaching using chalk and board will be done. Oral discussion sessions in the class will be conducted.	Students will undergo internal test for the syllabus covered in Unit 1-V and their answers will be discussed in the following class. Quiz will be conducted. Various analytical problems will be assigned to students based on enzyme applications.

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

4. Keywords

Proteins, Enzymes, Protein structure, Protein folding, Enzyme kinetics, Enzyme regulation

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biochemical Correlations of Diseases (BCH GE-4)
Semester – II / IV

1. Course Objective

This course provides students with knowledge and understanding of various human diseases. It will introduce the concepts of a well-balanced diet, healthy lifestyle, biochemical basis of diseases, treatment strategies, mechanism of action of drugs and drug resistance against various antimicrobials. The course also aims to outline the various strategies that are employed for preventing infectious and non-infectious diseases.

2.1 Course Learning Outcomes

- Students will develop understanding about the importance of balanced diet, regular exercises and healthy lifestyle.
- Students will gain insight into various disorders associated with imbalanced diet and poor lifestyle.
- Students will learn various strategies employed for preventing various human diseases.
- Students will understand the molecular basis of microbial pathogenicity, drug resistance and implications in public health management.
- Students should be able to handle and solve analytical problems related to theory classes.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Inherited metabolic diseases **No. of hours: 8**

Alkaptonuria, Phenylketonuria, Glycogen storage diseases: Von Gierke, Cori and McArdle, Lipid storage diseases: Gauchers diseases, Niemann-Pick disease, SCID: Adenosine Deaminase deficiency.

UNIT II : Nutritional deficiency and lifestyle based diseases **No. of hours: 16**

Kwashiorkar, Marasmus, Beri-beri, Scurvy, Pellagra, Anaemia, Night blindness, Rickets, Osteomalacia, Osteoporosis, Obesity, Cardiovascular diseases, Atherosclerosis, Diabetes Mellitus-II, Inflammatory Bowel Disease (IBD).

UNIT III: Hormonal imbalances **No. of hours : 8**

Hormonal imbalances leading to disease: Diabetes Insipidus, Acromegaly, Gigantism, Dwarfism, Goitre, Cretinism, Cushing and Conn's syndrome, Addison's disease.

UNIT IV: Autoimmune diseases **No. of hours: 8**

Concepts in immune recognition-self and non-self-discrimination, organ specific autoimmune diseases-Hashimoto's thyroiditis, Graves' disease, Myasthenia Gravis, Diabetes Melitus-I, Systemic diseases: Systemic lupus erythematosus (SLE), Rheumatoid arthritis.

UNIT V: Diseases caused due to misfolded proteins **No. of hours: 6**

Alzheimer's, Huntington's diseases, Kuru, Creutzfeldt-Jakob disease, Sickle Cell anaemia, Thalassemia.

UNIT VI: Infectious diseases **No. of hours: 16**

Viral infection: Polio, Measles, Mumps, influenza, HIV. Bacterial infections: Tetanus, Diphtheria, Tuberculosis, Typhoid, Cholera. Protozoan: Malaria and Trypanosomiasis. Parasitic infections: Leishmania.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Determination of blood Lipid Profile: Triglyceride, Cholesterol
2. Anthrompometric measurements: BMI, Waist/Hip Ratio, Mid Arm Muscle Area (MAMA), Mid Arm Area (MAA).
3. Haemoglobin estimation
4. Blood pressure measurement
5. Calcium estimation in serum
6. Estimation of blood glucose

2.3 References

1. Berg, J.M., Tymoczko, J. L., Stryer, L. (2012). *Biochemistry* (7th ed.). W.H Freeman and Company (New York).
2. Coico, R., Sunshine, G. (2009). *Immunology: A Short Course* (6th ed.). John Wiley & Sons, Inc (New Jersey). ISBN; 978-0-470-08158-7.
3. Devlin, T. M., (2011). *Textbook of Biochemistry with Clinical Correlations.* John Wiley & Sons, Inc. (New York). ISBN: 978-0-4710-28173-4.
4. Prescott, Harley, Wiley, J.M., Sherwood, L.M., Woolverton, C.J. (2008). *Klein's Microbiology*. (7th ed.). Mc Graw Hill International Edition (New York) ISBN: 978-007-126727.
5. Snustad, D.P., Simmons, M.J. (2012). *Genetics* (6th ed.). John Wiley & Sons. (Singapore) ISBN: 978-1-118-09242-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	The students will understand the concepts of metabolism of macromolecules and the diseases related to metabolic errors. Biochemical basis of diseases related to inherited metabolic disorders will also be learned.	Traditional chalk and board method and illustrations through powerpoint presentations. Discussion of case studies. Estimation of Glucose, Calcium and Blood pressure measurement will be taught in the practicals.	Students will be assigned the task of identifying examples of abnormal enzymes that directly relate to each feature of metabolic disorders. A host of characteristics and features will be provided to students and they will need to match them with the type of metabolic disorder. They will encouraged to participate in group discussions related to topics thought in class.
II.	Develop understanding of the importance of balanced diet, regular exercises and healthy lifestyle and disorders associated with imbalanced diet and poor lifestyle. Appreciate the importance of micronutrients and disorders associated with deficiency of minerals and vitamins The students will also learn about life style disorders.	Explaining each topic through power point presentations / chalk and board teaching. Discussion of case studies.	Group discussions and class tests will be held. Assignments on classification of diseases in various macromolecule and micromolecule deficient disorders. Signs and symptoms of diseases will be provided and students will be asked to match them with the type of nutrient disorders. Students will also be given assignments on matching the symptoms with the diseases.
III.	Learn about role of hormones in our daily life and gain insight into various diseases associated with hormonal imbalance.	Class teaching using chalk and board and power point presentations.	Students will be given assignments to match symptoms with the correct disease/ disorders. Group discussions and Tests will be held.
IV	The students will learn about induction of an appropriate immune response and the	Traditional chalk and board method with powerpoint presentations. Few case studies will also	Pre-lecture quiz to evaluate student's understanding of previous lecture. Signs and

	associated disorders, also understand the concept of immune recognition - self and nonself.	be discussed.	symptoms of diseases will be provided and students will be asked to classify them in various types of autoimmune diseases.
V.	Understand the significance of appropriate folding of proteins and the diseases caused due to misfolding of proteins.	Illustrations through power point presentations and through regular chalk and board method. Discussion of case studies.	Group discussions. Quiz, Assignments. Signs and symptoms of diseases will be provided and students will be asked to classify them in diseases caused by misfolding of proteins. Internal assessment test.
VI.	Gain knowledge about various microbial infectious agents that cause diseases in humans. Students will gain insight into host immune responses that ensue following infection.	Traditional chalk and board method with powerpoint presentations.	Pre-lecture quiz to evaluate student's understanding of previous lecture. Assessment tests (end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a powerpoint presentation on the assigned topics.

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

4. Keywords

Lifestyle and metabolic disorders, nutritional deficiency, hormonal disorder, autoimmunity and infectious diseases.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Intermediary Metabolism (BCH GE-5)
Semester - III

1. Course Objectives

The objective of this course is to provide the students an understanding of the major metabolic pathways associated with biomolecules within a cell and their regulation. It will also provide knowledge about the possible correlation between various metabolic pathways.

2.1 Course Learning Outcomes

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

- Understand the basics of metabolic pathways
- Outline the pathways involved in catabolism and biosynthesis of glucose.
- Describe the mechanism of ATP synthesis.
- Understand the biosynthesis and degradation of glycogen
- Comprehend the metabolism of fatty acids, amino acids, and nucleotides
- Develop an understanding of metabolic integration

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Glycolysis and gluconeogenesis **No. of hours: 12**

Nature of metabolism. Role of oxidation and reduction and coupling of these. ATP as energy currency. Glycolysis a universal pathway, fructose and galactose oxidation, anaerobic glycolysis, fermentation, gluconeogenesis, reciprocal regulation of glycolysis and gluconeogenesis. Pentose phosphate pathway, importance of various pathways and their regulation

UNIT II: Citric acid cycle and oxidative phosphorylation **No. of hours: 12**

Pyruvate dehydrogenase complex, oxidation of acetyl CoA, amphibolic role, regulation and glyoxylate pathway. The respiratory chain in mitochondria, proton gradient powering ATP synthesis, glycerol-3-phosphate and malate-aspartate shuttle, regulation of oxidative phosphorylation.

UNIT III: Glycogen metabolism **No. of hours: 8**

Glycogenolysis, phosphorylase regulation, role of epinephrine and glucagon for glycogenolysis, glycogenesis; reciprocal regulation of glycogenesis and glycogenolysis. Diseases associated with the abnormal carbohydrate metabolism.

UNIT IV: Fatty acid and amino acid degradation **No. of hours: 12**

TAG as energy source, β oxidation of fatty acids in mitochondria and peroxisomes, ketone bodies. Fatty acids activation, regulation of fatty acid oxidation, Protein degradation to amino acids, Role of essential and non-essential amino acids in growth and development. Protein calorie malnutrition - Kwashiorkar and Marasmus, urea cycle, feeder pathways into TCA cycle. Nitrogen fixation. Diseases associated with the abnormal metabolism.

UNIT V: Nucleotide metabolism **No. of hours: 10**

Biosynthesis - de novo and salvage pathways, regulation of nucleotide synthesis by feedback inhibition, degradation and excretion. Diseases associated with the abnormal metabolism

UNIT VI: Integration of metabolism **No. of hours: 6**

Brief role of hormones - insulin, glucagon; metabolic shifts to provide fuel to brain during fasting and starvation, Increase in gluconeogenesis and muscle protein breakdown.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Estimation of blood glucose
2. Demonstration of alcohol fermentation by yeast.
3. Estimation of serum urea.
4. Estimation of serum uric acid.
5. Estimation of serum creatinine

2.3 References

1. Berg, J.M., Tymoczko, J.L., Stryer L., (2012) *Biochemistry*7th ed., W.H. Freeman and Company (New York); ISBN:10:1-4292-2936-5, ISBN:13:978-1-4292-2936-4.
2. Campbell, M.K., Farrel, S.O. (2012) *Biochemistry*7th ed, S.O. Brooks/Cole, Cengage Learning (Boston); ISBN: 13:978-1-111-42564-7 ISBN:10:1-4292-2936-5.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understanding the concept of metabolism. Understand Glycolysis, gluconeogenesis and Pentose phosphate pathway and their regulation.	Traditional chalk & board method with power-point presentations.	Post lecture students will be given home assignments to enhance their learning and for assimilation of concepts.

II.	Understand the citric acid cycle and ATP synthesis by oxidative phosphorylation.	Revision of the previous classes will be conducted. Teaching will be through traditional chalk & board method and power-point presentations	Pre-lecture quiz to evaluate students understanding of previous lecture. Internal assessment tests will be conducted.
III.	Have knowledge about glycogenolysis and glycogenesis and their reciprocal regulation	Group discussions will be held on various topics of this unit. Blackboard teaching as well as powerpoint presentations will be conducted.	Home assignments and MCQ based questions will be given to students.
IV	Understand the β-oxidation of fatty acids and its regulation.	Traditional chalk & board method with power-point presentations. Oral question-answers will be held.	Pre-lecture quiz to evaluate students understanding of previous lecture. Students will be asked to deliver presentations and will be assessed on that.
V.	Understand de novo and salvage pathways of nucleotide Biosynthesis and Degradation.	Oral revision of the previous classes will be conducted. Teaching will be through traditional chalk & board method with power-point presentations.	Internal assessment test and crossword puzzles will be given to students for their evaluation.
VI.	Understand the concept of metabolic integration.	Overview of all the metabolic pathways will be discussed along with group discussions. Traditional chalk & board method with power-point presentations.	A continuous evaluation based on their class response will be made. End term examination evaluation. MCQ based questions.

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

4. Keywords

Glycolysis, *De novo* salvage pathway, TCA, catabolism, anabolism, integrative pathways, nucleotide metabolism, beta oxidation, glycogen metabolism, gluconeogenesis.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Biochemical Applications in Forensics (BCH GE-6)
Semester – III / IV

1. Course Objectives

The course aims to provide an understanding of the applications of biochemistry in forensic sciences through analysis of evidences, which will help students develop analytical and problem solving skills for real life situation. The course will keep abreast with all recent developments and emerging trends in forensic science thus helping interested students take up forensic science as future course of study.

2.1 Course Learning Outcomes

- Students will learn the fundamental concepts and principles of forensic science and their significance.
- Students will understand how a forensic investigation is initiated through preservation of evidences, as well as chemical, physical and biological methods of their analysis including analysis of DNA and other bodily fluids.
- Students will learn how to establish identity of an individual by document evaluation, fingerprints, footprints and DNA analysis.
- Students will obtain hands-on-experience in some of the basic biochemical processes involved in forensic investigation.

2.2 Course Contents

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to forensic sciences **No. of hours: 10**

Basic Principles and Significance; History and Development of Forensic Science; Defining the scene of investigation; Collection, Packaging, Labelling and Forwarding of biological exhibits to forensic laboratories; Preservation of biological evidence; Importance of Health and Safety Protocols in sample collection and analysis.

UNIT II: Biological science and its application in investigation **No. of hours: 20**

Biochemical analysis of various biological evidences like blood, semen & other biological fluids, viscera, bite marks, hair (animal and human), fibers & fabrics, pollen and soil; Establishment of identity of individuals - fingerprints, footprints, blood and DNA analysis, anthropology – skeletal remains, Odontology; Time of death - rigor mortis, liver mortis, algor mortis, forensic entomology. Biochemical basis for determination of cause of death, case studies

UNIT III: Chemical science and its application in investigation No. of hours: 15

Detection of drugs of abuse and narcotics in biological samples; Toxicological examination of viscera, detection of petroleum products, food adulteration; Analysis of inks and their use in questioned document identification, blood splatter analysis, stain analysis, case studies.

UNIT IV: Recent advances in forensics No. of hours: 15

Narco analysis: theory, forensic significance, future prospect; *Brain mapping:* introduction, EEG, P-3000 wave, forensic applications, limitation of technique; *Polygraph*: Principle and technique, polygraph as forensic investigative tool, use of psychoactive drugs in forensic analysis. NHRC guidelines for polygraph test; *Facial reconstruction*: Method and technique, facial reconstruction in forensic identification; DNA Finger Printing; DNA-Introduction, source of DNA in Forensic case work, Extraction of DNA, Techniques of DNA fingerprinting-RFLP, STR, PCR. DNA fingerprinting in paternity disputes, mass disaster and other forensic case work, case studies.

PRACTICALS

CREDITS: 2 TOTAL HOURS: 60

1. TLC method for differentiation of ink/drugs
2. Fingerprint development from various surfaces
3. Handwriting identification based on class characteristic and individual characteristics
4. Microscopic examination of hair/fiber/pollen/diatom
5. Examination of blood samples: Blood grouping, DNA finger printing, Blood splatter analysis.
6. Examination of urine samples: Identification of drugs.
7. Field trip to a forensic laboratory.

2.3 References

1. James, S. H., Nordby, J. J. & Bell, S. (2014). *Forensic Science: An Introduction to Scientific and Investigative Techniques, Fourth Edition*: Taylor & Francis. ISBN 9781439853832
2. Jones, P., & Williams, R. E. (2009). *Crime Scene Processing and Laboratory Workbook First Edition*: CRC Press. ISBN 9780429249976
3. Lee, H., Palmbach, T. & Miller, M. (2001). *Henry Lee's crime scene handbook, First Edition*: Academic Press ISBN 9780080507989
4. Parikh, C. K. (2016). *Parikh's textbook of medical jurisprudence, forensic medicine and toxicology : for classrooms and courtrooms, Seventh Edition*: CBS Publishers and Distributors. ISBN 9788123926469
5. Saferstein, R. (2018). *Criminalistics: An Introduction to Forensic Science, Twelveth edition*: Pearson Education. ISBN 10:0134477596, ISBN 13: 9780134477596
6. Tewari, R. K., Sastry P. K., Ravikumar, K. V. (2002). *Computer Crime and Computer Forensic, First Edition*: Selective & Scientific Books
7. Veeraraghavan, V. (2009). *Handbook of Forensic Psychology, First Edition*: Selective & Scientific Books

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Comprehend the developments in the field of forensic sciences, learn to observe a crime scene for identification of relevant evidences and samples for forensic analysis. Understand the importance of collection, packaging and preservation of samples to ensure reliability of data generated.	Teaching will be conducted both through black board mode and power point presentation mode. Discussions and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding. Use models of crime scenes for practical training on sample identification and collection.	Internal assessment tests. Students will be given questions that are application based and require analytical skills
II.	Understand the importance of precision, reproducibility and accuracy in identification of a biological sample. Learn the methods to identify the accurate age, sex and identity of an individual and identify time and cause of death in a forensic investigation.	Class teaching with black board and power point presentation modes. Discussions on case studies and quizzes will be conducted to keep the students up-to-date with the information they have received and to gauge their conceptual understanding. Practical training on microscopic identification of various biological samples, finger print development from surfaces and identification of fingerprints.	Conduct of Internal assessment tests. PowerPoint presentation on the assigned topics.
III.	Gain knowledge about the methods used to analyse samples for drug testing, ink and stain testing and document and handwriting verification.	Power point presentation will be used to teach various methods. Use of blackboard and general discussions in the class. Practical analysis of urine samples for drug tests. Practical analysis of inks and stains.	Internal assessment tests will be conducted. Analyzing case studies. Open book tests to promote self-learning.
IV	Understand the physiology and biochemistry behind tests like Narcoanalysis, polygraphy, lie detection and facial reconstruction. Also, learn the	Teaching using chalk and board and video tutorials. Expert lecture on course related topics and filed trip	Internal assessment tests will be conducted. A PowerPoint presentation on

	importance of DNA fingerprinting in forensic investigations	to labs. Practical exercises on DNA fingerprinting.	any interesting case study and the use of forensic technology in investigation. Practical record book assessment, oral discussion and question- answer sessions on practical topics.

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

4. Keywords

Forensic biology; blood splatter analysis; toxicology; narco-analysis; DNA fingerprinting; polygraph; odontology; forensic entomology.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
GENERIC ELECTIVE (GE) COURSES
Recombinant DNA Technology (BCH GE-7)
Semester - IV

1. Course Objectives:

The objective of the course is to teach basics of theory and practical aspects of recombinant DNA technology and the various techniques for DNA manipulation in prokaryotes and eukaryotes. The course will also outline the applications of this knowledge for the development of diagnostics, therapeutics and vaccines.

2.1 Course Learning Outcomes:

The students after completing this course will be able to understand:

- Principles and importance of gene cloning
- Various methods for screening of recombinants and identification of cloned gene
- Polymerase chain reaction and DNA sequencing
- Recombinant gene expression system
- Application of recombinant technology in the production of Biopharmaceutical processes and products such as insulin, vaccines and DNA finger printing.

THEORY

CREDITS: 4 **TOTAL HOURS: 60**

UNIT I: Introduction to recombinant DNA technology **No. of hours: 8**

Overview of gene cloning. Restriction, modification systems and DNA modifying enzymes, DNA analysis by electrophoresis.

UNIT II: Cloning vectors for prokaryotes and eukaryotes **No. of hours: 12**

Plasmids and bacteriophages as vectors for gene cloning. Cloning vectors for *E. coli* like pBR322, pUC8, pGEM3Z. Cloning vectors based on M13 and λ bacteriophage. Ti plasmid, BAC and YAC.

UNIT III: Introduction of DNA into cells and selection of recombinants No. of hours: 12

Ligation of DNA molecules. Introduction of DNA into cells, Transformation, selection for transformed cells. Identification of recombinants, blue-white selection. Identification of recombinant phages. cDNA and Genomic libraries.

UNIT IV: Polymerase chain reaction and DNA sequencing **No. of hours: 08**

Fundamentals of polymerase chain reaction, designing primers for PCR. DNA sequencing by Sanger's method and automated DNA sequencing.

UNIT V: Expression of cloned genes **No. of hours: 12**

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

UNIT VI: Applications of genetic engineering in biotechnology **No. of hours: 12**

Production of recombinant proteins such as insulin and factor VIII. Gene therapy. Genetically modified herbicide glyphosate resistant crops. Ethics concerns.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. DNA estimation by UV spectrophotometry.
2. Isolation of plasmid DNA from *E. coli.*
3. Restriction digestion and agarose gel electrophoresis.
4. Amplification of a DNA fragment by PCR.

2.3 References

1. Brown, T. A. (2016) *Gene Cloning and DNA Analysis: An Introduction,* (7th ed.). Wiley-Blackwell Publishing (Oxford, UK); ISBN: 978-1-119-07256-0
2. Glick, B.R., Pasternak, J.J., Patten, C. L. (2010) *Molecular Biotechnology: Principles and Applications of Recombinant DNA* (4th ed.). ASM Press (Washington DC); ISBN: 978-1-55581-498-4.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be introduced to purpose and importance of gene cloning, Restriction, modification systems and DNA modifying enzymes, DNA analysis by electrophoresis.	Teaching will be conducted through both black board mode and power point presentation mode. They are also encouraged to attend the practicals for the better understanding of the techniques.	MCQ tests, assignments, Analytical questions
II.	Students will gain insight of different vectors used for gene cloning like pBR322, pUC8, pGEM3Z,	Students will be asked to orally revise the previous class before every new class helping them in	Students will be given assignment on different topics and will be asked to deliver a power-point

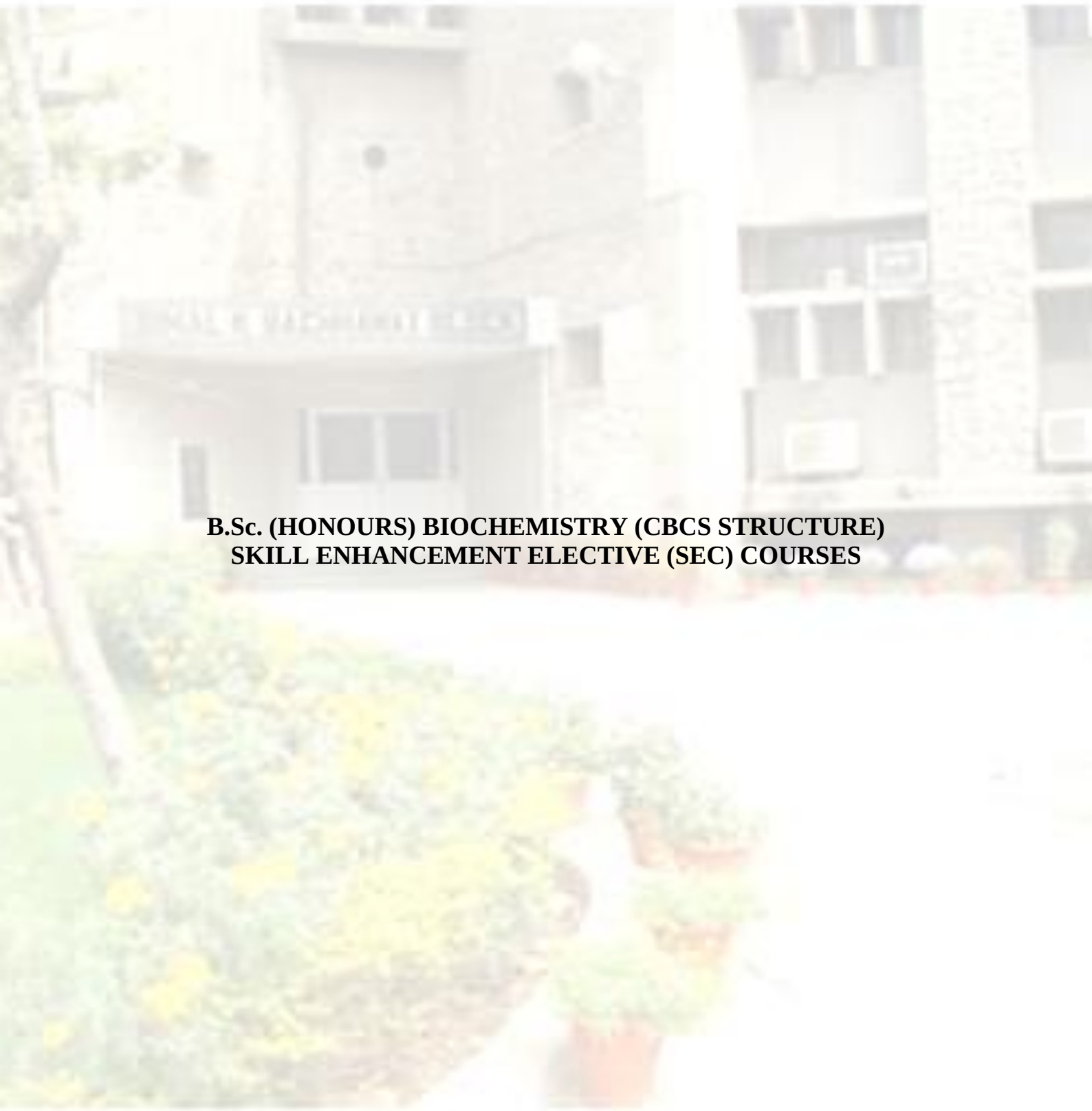
	Cloning vectors based on M13 and λ bacteriophage. Plant vectors like Ti plasmid, high capacity vectors like BAC and YAC.	better understanding and their doubts cleared, if any. Regular classroom teaching, visual aids, discussions	presentation on the applications of vectors, MCQ tests and quizzes to assess regular understanding of the topic
III.	Students will learn in detail about Ligation of DNA molecules into vectors, Introduction of recombinant DNA into host cells, Transformation, selection for transformed cells. Identification of recombinants through blue-white selection. Identification of recombinant phages. Gene libraries.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and power point presentation mode.	Mid-term tests will be conducted.
IV	Students will gain insight of principle of polymerase chain reaction, designing primers for PCR.DNA sequencing by Sanger's method and automated DNA sequencing.	Students will be asked to orally revise the previous class before every new class helping them in better understanding and their doubts cleared, if any. Teaching will be conducted through both black board mode and power point presentation mode.	Assignments and presentations , analytical problems and class tests
V.	Students will learn about the Vectors used for expression of foreign genes in *E. coli*, cassettes and gene fusions. Production of recombinant protein by eukaryotic cells. Fusion tags and their role in purification of recombinant proteins	Presentations, Classroom Teaching, connect with practicals, discussions	Presentations and assignments
VI.	Students will gain knowledge about the various application of recombinant DNA technology through various examples like Production of recombinant proteins such as insulin and factor VIII. Gene therapy. Genetically	Visual aids, Presentations, Classroom Teaching and discussions.	Internal assessment test (end term) will be conducted.

	modified herbicide glyphosate resistant crops. Ethics concerns.		

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

4. Key Words

Genetic Engineering, Recombinant Proteins, Biotechnology



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

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Biochemical Techniques (BCH SEC-1)
Semester - III

1. Course Objectives

The objective of the course is to introduce to the students, various techniques that are used in a biochemistry lab and to provide them with an understanding of the principle underlying these techniques and laboratory skills in the form of practical exercises so that students can apply this knowledge to pursue research.

2.1 Course Learning Outcomes

The course is designed for undergraduate students to learn the basic concepts of various techniques used in Biochemistry. The course will enable students to:

- Acquire knowledge about the principles and applications of spectrophotometric and chromatography techniques used in a biochemistry lab.
- Learn about the principle and applications of electrophoresis and centrifugation techniques.
- Obtain hands-on-experience and laboratory skills expected of any biochemist working in a research lab.

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Spectroscopic Techniques **No. of hours: 6**

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. Fluorescence spectrophotometry and its applications in biochemistry.

UNIT II: Chromatography **No. of hours: 10**

Introduction to chromatography. Principle and applications of Paper Chromatography, Thin Layer Chromatography, Ion-Exchange Chromatography, Gel filtration and Affinity Chromatography.

UNIT III: Electrophoresis **No. of hours: 8**

Principle of electrophoresis, Polyacrylamide gel electrophoresis (native and denaturing) for proteins and nucleic acids. Agarose gel electrophoresis, Isoelectric focusing of proteins, two-dimensional. Detection and identification of proteins and nucleic acids and determination of molecular weight.

UNIT IV: Centrifugation **No. of hours: 6**

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).

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Determination of absorption maxima (λ_{max}) of small molecules and macromolecules.
2. Verification of Beer's Law.
3. Determination of molar extinction coefficient.
4. Separation of amino acid acids/sugars by thin layer chromatography (TLC)
5. Separation of proteins by gel filtration chromatography
6. Separation of proteins by ion-exchange chromatography
7. Separation of nucleic acids using agarose gel electrophoresis
8. Separation of protein by SDS-PAGE.

2.3 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. & 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:0-7167-1444-2.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I	Students will learn about the principle and applications of spectrophotometry and flourimetry.	Teaching using chalk and board; Oral discussion sessions in the class. Powerpoint presentations.	Problems will be assigned related to 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.	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 in analyzing proteins and nucleic acids	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.	Power point presentations; Teaching using chalk and board; Oral discussion sessions in the class	Demonstration with the help of centrifuges and rotors to improve their understanding.

4. Keywords

Spectrophotometry, Chromatography, Proteins, Nucleic Acids, Centrifugation and Electrophoresis

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Biostatistics (BCH SEC-2)
Semester - III

1. Course Objectives

The primary objective of this course is to provide understanding about the principles of biological data collection, statistical analysis and presentation. The course will also provide hands-on-experience through practicals that are well correlated with the theory topics and are designed to support skill oriented learning outcomes in the management of biological data.

2.1 Course Learning Outcomes

Learners will be able to:

- Understand the principles of biological data collection, statistical analysis and presentation.
- Appreciate various factors that influence the type of sample collected and sample size.
- Analyze and interpret biological data using appropriate statistical tools
- Apply the principles of biological data management in real life situations
- Improvise their computational, mathematical and computer skills, which would increase their eligibility to pursue research based higher education.

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Data Collection and Presentation **No. of hours: 4**

Importance of statistical analysis in biological data management. Sampling schemes – Simple Random sampling, Systemic sampling, Stratified sampling, Cluster sampling, Non probability sampling; Types of numerical data – nominal data, ordinal data, ranked data, discrete data, continuous data; Modes of presenting data: Frequency distributions, Relative frequency.

UNIT II: Measures of central tendency and analysis of variance **No. of hours: 12**

Mean, median, mode; Co-efficient of variation and standard deviation; Range and interquartile range; Grouped mean and grouped variance; Frequency distributions; One way ANOVA; Two-way ANOVA; AMOVA; student's t test

UNIT III: Probability **No. of hours: 4**

Operations on events, Venn diagrams, Conditional Probability; Probability distributions.

UNIT IV: Hypothesis Testing **No. of hours: 4**

General concepts – Null hypothesis, alternative hypothesis, Rejection of hypothesis; Type I and Type II errors; P value and sample size estimation.

UNIT V: Regression and Correlation **No. of hours: 6**

Chi Square Test – Observed and expected frequencies, Calculating p values, assumptions of a chi square goodness of fit; Correlation –Two-way scatter plot, Pearson's correlation coefficient; Regression – regression concepts, simple linear regression; Calculation of R^2 and ρ.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Collection of data - Random sampling method; Stratified sampling method; Cluster sampling method
2. Data representation - Frequency and relative frequency distribution table, Plotting different biological data in a best representative graphical format.
3. Data analysis - Calculating Mean, median, mode, variance, standard deviation and standard error for a given data set. Standard t-test for grouped samples. Analysis of 2 way variance
4. Chi square goodness of fit test. Regression analysis and calculating regression coefficient
5. Learning to analyze data using SPSS or R software
6. Project assignment.

2.3 References

1. Michael, C.W. (2015) *The Analysis of Biological Data* (2nd ed.), Macmillan Publishers, ISBN-10: 1-936221-48-9; ISBN-13: 978-1-936221-48-6
2. Pagano, M . and Gauvreau , K .(2018) *Principles of Biostatistics* (2nd ed.), Chapman and Hall/CRC; ISBN 9781138593145

Additional Resources:

1. Zar, J.H. (2010) *Biostatistical analysis*, (5th ed.), Pearsons Int. Edition; ISBN- 978-0-13-206502-3.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Understand the principles of biological data collection and presentation. Learn and appreciate various factors that	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on	Internal assessment tests. Students will be given questions that are application based and

	influence type of sample collected and sample size.	Collection and presentation of data. Field exercises on collection of data	require analytical skills
II.	Analyze and interpret biological data using simple statistical tools like mean, median, mode, variance and standard deviation. Apply the principles of biological data management in real life situations Improve their computational, mathematical and computer skills by learning to use ANOVA,AMOVA and student t-test on free access statistical software	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on statistical analysis of biological data. Learning to analyze data using SPSS or R software	Conduct of Internal assessment tests Students will be given questions that are application based and require analytical and computational skills
III.	Understand the concept of probability and the importance and use of probability in analyzing biological data.	Teaching will be conducted both through black board mode and power point presentation mode.	Students will be given MCQ based tests and quiz
IV	Learn and appreciate various factors that influence stating and formulating a hypothesis, relevance to type of sample collected and sample size.	Teaching will be conducted both through black board mode and power point presentation mode. Analyzing case studies to understand hypothesis formulation	Formulate a hypothesis on any are/topic of interest, determine appropriate sample size and collect data.
V	Understanding how to manage data for a goodness of fit chi-square test versus an interdependence chi-square test. Learn and appreciate various factors that influence the use of correlation and regression analysis for biological data.	Teaching will be conducted both through black board mode and power point presentation mode. Exercises on statistical analysis of biological data. Learning to analyze data using SPSS or R software	Internal assessment tests will be conducted. Analyze data collected using appropriate statistical tools and present the data.

4. Keywords

Statistical analysis, biological data collection, sampling, data presentation, measures of central tendency, ANOVA, chi-square, regression

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Research Methodology (BCH SEC-3)
Semester – III / IV

1. Course Objectives

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

2. 1 Course Learning Outcomes:

By studying this paper students will be able to:

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

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Objectives of research **No. of hours: 4**

Definition, objectives, types of research, classification, various phases of research.

UNIT II: Research proposals and literature survey **No. of hours: 6**

Research proposal and aspects, Review of literature using appropriate sources – reviews, patents, research papers, books.

UNIT III: Basic principles of research design **No. of hours: 6**

Types of research designs – exploratory, descriptive, experimental, survey and case study.

UNIT IV: Experimental, sampling design and data collection **No. of hours: 6**

Sample - types, criteria, characteristics and steps; Tools and techniques to execute experiments; Observation, questionnaire, interview

UNIT V: Interpretation, report writing and the art of oral presentation

No. of hours: 4

Report writing, format of publications in research journals, how to present papers and research findings

UNIT VI: Bioethics and Plagiarism in Research **No. of hours: 4**

Biosafety and Ethics - compliance and concerns; Plagiarism; Introduction to Intellectual Property Rights; Citation and acknowledgement

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Writing of a mini-review paper
2. Design of a research survey on a specific problem
3. Idea presentations in small groups
4. Interaction with an expert during special lecture

2.3 References

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

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be able to define research and understand its objectives. They will recognize the various types and classes of research.	Teaching will be conducted through both black board mode and power point presentation mode.	Internal assessment tests will be conducted. Group discussions will be assigned.

II.	Students will gain insight about the importance of Research proposals and literature survey. They will be made capable in identifying broad area of research and write research proposal. They will be able to review literature using a wide variety of sources like web and libraries	Group discussions; Idea presentations; Proposing a research topic; Perform a literature survey on the given/proposed topic	Assign group discussion on specific topics; Will be asked to retrieve literature based on a given topic. Students will be encouraged to meet departmental faculties and discuss on their successful research proposals.
III.	Students will learn the basic principles of research design and its various types.	Group discussions; Design of a proposed research topic; Online courses on the topic	Internal assessment tests will be conducted. Report/paper writing will be assigned
IV	Students will gain insight about the experimental, sampling design and data collection. They will learn a variety of ways to collect the samples. They will be able to devise optional plans, tools and techniques for experimental design and its execution	Plan the sampling and data collection method of their proposed topic of research. Learn the proper way of data reporting and its record keeping	Internal assessment tests will be conducted. Group discussions; Paper presentation; Seminars
V.	Students will gain knowledge about data interpretation, report writing and the art of oral presentation. They will not only be able to understand the format of report writing but also scientific publications	Learn the skill of report and publication writing in their proposed topic of research based on input from teachers	Will be assigned writing of small reports and defending them orally. They will be encouraged to present scientific papers as well.
VI.	Students will learn about the role of bioethics and plagiarism in Research. They will be educated to follow ethics compliance and concerns. They will be educated about the concept of Citation and acknowledgement	Articles on these issues will be provided to students. Classical mode of chalk and board teaching as well as power point presentations will be used. Experts in these areas will be invited to deliver special lectures.	Students will be assigned the task of retrieving bioethics, plagiarism, ethical issues related policies of the government or of institutions. They will be assigned the task of identifying citations of publications of faculties.

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

4. Keywords

Research methodology; Patents; Plagiarism; Ethics; Biosafety; Report writing

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Bioinformatics (BCH SEC-4)
Semester - IV

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.

2.1 Course Learning Outcomes

After completion of the course, a student will:

- Understand the basics of bioinformatics and computational biology and develop awareness of the interdisciplinary nature of this field.
- Gain the ability to use several softwares/tools in biology
- Gain confidence to discuss, access and use biological databases in public domain
- Understand protein structure using visualization softwares
- Be able to gain understanding of sequence alignments
- Be able to analyze phylogeny using alignment tools
- Comprehend the fundamental aspects of *in-silico* protein structure prediction
- Understand how theoretical approaches can be used to analyze biological systems
- Obtain knowledge on applications of bioinformatics from genomes to personalized medicine.

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Introduction to bioinformatics **No. of hours: 4**

Introduction to Bioinformatics, Computer fundamentals – Operating Systems, Hardware, Software, Programming languages in bioinformatics - PERL/R programming, role of supercomputers in biology, Historical background. Scope of bioinformatics - Genomics, Proteomics, Computer aided drug discovery and 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, amino acid substitution matrices (PAM and BLOSUM), BLAST and CLUSTALW, Definition of phylogeny and its importance, Methods of Phylogenetic tree generation, Phylip

UNIT IV: Genomics **No. of hours: 4**

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

UNIT V: Protein sequence, structure prediction and analysis **No. of hours: 6**

Protein Structure - Primary, Secondary and Tertiary structure, Protein structure prediction methods: Homology modeling, Fold recognition and *ab-initio* methods, Ramachandran plot.

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

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 guide trees
5. Gene prediction using GENSCAN/GLIMMER
6. Primary sequence analyses (Protparam) and Secondary structure prediction (GOR, nnPredict).
7. Tertiary structure prediction (SWISSMODEL) and Protein structure evaluation - Ramachandran map (PROCHECK

2.3 References

1. Chandra, S.M., Choudhary, K.R. and Mir Asif Iquebal A.M. (2017) *Basic Applied Bioinformatics* John Wiley & Sons; ISBN9781119244370
2. Ghosh, Z. and Mallick, B., (2008) *Bioinformatics – Principles and Applications*, (1st ed.) Oxford University Press (India), ISBN: 9780195692303.
3. Gromiha, M.M. (2010). *Protein Bioinformatics: From Sequence to Function*; Academic Press eBook; ISBN: 9780123884244 Paperback ISBN: 9788131222973

4. David M. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press; ISBN 978-087969712-9
5. Andreas D., Baxevanis D.A. and Ouellette Francis B.F. (2005), Bioinformatics: A *Practical Guide to the Analysis of Genes and Proteins* (3rd ed.), John Wiley & Sons, Inc. (New Jersey), ISBN: 0-47147878-4.

Additional Reading

1. Krane, D.E. and Raymer, M. L. (2006). *Fundamental concepts of bioinformatics*, Pearson Education Inc.; ISBN 10: 0805346333 ISBN 13: 9780805346336
2. Pevsner, J. (2003). *Bioinformatics and Functional Genomics* (1st ed.), John Wiley & Sons, Inc. (New Jersey); ISBN: 0-47121004-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will be familiarized with the concept of Bioinformatics & Computational tools with applications in biology	Outlining history of development about Bioinformatics through power point presentations and chalk & board method;	Discussion of research and review articles and class presentations
II.	Students will learn about Biological Databases and the types of databases. They will also understand various file formats used for sequence and structure analysis	Traditional chalk & board method with powerpoint presentations on biological databases	Computer assisted quizzes, assignments. Students will be assigned a topic and asked to search for databases associated to the topic
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 help students understand phylogeny
IV	Students will understand different	Power point presentations; Chalk and board; Student	Assignments & Quiz

	applications of genomics in gene prediction. Functional Genomics & Comparative Genomics will be discussed	interaction in class	
V.	Students will learn the various approaches for protein tertiary structure prediction, tools used and validation methods employed.	Chalk & board method and Powerpoint presentations. Group discussions will be held.	Assignments and Class presentations with hands on computer training. Students will be assigned the task of identifying tools used in structure based drug discovery from research papers.

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

4. Keywords

Biological Databases, NCBI, PDB, Visualization Softwares, Sequence Alignment, BLAST, Gene Prediction, Secondary Structure Prediction, Protein Structure Prediction.

B.Sc. (HONOURS) BIOCHEMISTRY (CBCS STRUCTURE)
SKILL ENHANCEMENT ELECTIVE (SEC) COURSES
Microbial Techniques (BCH SEC-5)
Semester - IV

1. Course Objectives

This course aims to impart basic understanding of microbial techniques by hands-on-experience on working with microorganisms. It will also provide knowledge about various control methods for the growth of microbes and the characteristic features of different microbes

2.1 Course Learning Outcomes

After completion of this course, a student will be able:

- To visualize and identify various microorganisms
- To culture microorganisms in aseptic conditions
- To prepare and sterilize different types of media
- To maintain different types of cultures
- To carry out research using microorganisms.
- To learn the principles behind and importance of sterilization while working in varied areas of biology in various laboratories.

2.2 Course Contents

THEORY

CREDITS: 2 **TOTAL HOURS: 30**

UNIT I: Introduction **No. of hours: 4**

Development of microbiology as a discipline, Spontaneous generation vs. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister and Alexander Fleming. Development of various microbiological techniques and golden era of microbiology.

UNIT II: Microbial nutrition and growth **No. of hours: 8**

The common nutrient requirements. Nutritional types of microorganisms. Culture media and its components, Synthetic or defined media, Complex media, Enriched media, Selective media, Differential media. Isolation of Pure culture: Streaking, Serial dilution and Plating methods, cultivation, maintenance of pure cultures. Microbial Growth: phases of growth, measurement of microbial growth

UNIT III: Control of microorganisms by physical and chemical methods

No. of hours: 6

Mechanism of Dry Heat, Moist Heat, Hot air oven, Filtration and Radiations, Use of Phenolics, alcoholics, halogens, heavy metals, aldehydes and gases for sterilization.

UNIT IV: Bacterial, Fungal and Algal cell organization and staining

No. of hours: 8

Overview of characteristic features of bacterial, fungal and algal cell. Composition and detailed structure of gram- positive and gram- negative cell wall. Simple staining and negative staining of bacteria. Mechanism of gram staining.

UNIT V: Introduction to Viruses **No. of hours: 4**

General characteristic features of viruses. Nacked and envelop viruses. Examples of RNA and DNA viruses. Subviral particles: viroids, prions, virusoids and their importance. Isolation and cultivation of viruses. Virus purification and assays

PRACTICALS

CREDITS: 2 **TOTAL HOURS: 60**

1. Microbiology Laboratory: Basic rules and requirements.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory.
3. Preparation of glassware for microbiological work, cotton plugs, medium and their sterilization.
4. Sterilization of heat sensitive material by filtration.
5. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
6. Study of different shapes of bacteria, fungi and algae using permanent slides/pictographs
7. To stain bacteria using crystal violet/methylene blue.
8. To perform Gram's staining.
9. To prepare temporary mount of algae.
10. To prepare temporary mount of fungi.
11. Isolation of pure cultures of bacteria by streaking method.
12. Enumeration of colony forming units (CFU) count by spread plate method/pour plate
13. Study the morphological structures of viruses (DNA and RNA) and their important characters using electron micrographs.
14. Isolation and enumeration of bacteriophages (PFU) from water sample.

2.3 References

1. Willey, J.M, Sherwood, L.M. and Woolverton, C.J. (2017). *Prescott's Microbiology*, (10th ed.), McGraw Hill Higher Education; ISBN13: 9781259657573.
2. Pelczar, Jr M.J., Chan, E.C.S and Krieg, N.R. (2004). *Microbiology,* (5th ed.), Tata McGraw Hill; ISBN13: 9780074623206.

3. Cappucino, J. and Sherman, N. (2013). *Microbiology: A Laboratory Manual*. (10th ed.) Pearson Education Limited; ISBN13: 9780321840226

Additional Resources:

1. Madigan, M.T., Martinko, J.M., Dunlap, P.V. and Clark, D.P. (2010). *Brock Biology of Micro-organisms*. (13th ed.) Pearson Education, Inc. ISBN 13: 9780321649638.
2. Dubey, R.C. and Maheshwari, D.K. (2010). *Practical Microbiology*. (1st ed.). S. Chand. ISBN: 81-219-2153-8.

3. Teaching Learning Process and Assessment Methods

Facilitating the Achievement of Course Learning Outcomes**

Unit No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
I.	Students will gain overall knowledge and understand the significance of microbiology as a discipline	Chalk and board teaching method, regular question-answer activities. Consultation of text books and reviews	Internal assessment tests (mid- term and end-term) will be conducted. Students will be assigned various topics and will be asked to deliver a power-point presentation on the assigned topics.
II.	Students will gain insight into nutrient requirements of microbes, microbial growth and different types of cultures and media used for the growth of microbes.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through class test at the end of the module. Questions will be given as a part of the assignment. Students will also be assessed on the basis of their performance and involvement during practical classes.
III.	Students will learn about the control of microorganisms by various physical and chemical methods.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through interactive discussion in the class and periodic question-answer sessions during teaching.
IV	Students will learn about the bacterial, fungal and algal cell organization and staining.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Assessment through class test at the end of the module. Questions will be given as a part of the assignment.

V.	Students will learn about general characteristics of viruses and subviral particles like viriods, prions and virusoids.	Students will be asked to orally revise the previous class before every new class helping them in better understanding of the particular topic. Teaching will be conducted both through black board mode and powerpoint presentation mode.	Students will be evaluated through class discussion and their performance and involvement during practical classes

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

4. Keywords

Microorganisms, microbial growth, staining, culture, media

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