Learning Outcomes-based Curriculum Framework (LOCF) under the Choice Based Credit System (CBCS) For Bachelor's Degree (B.Sc. Honours) Programme in Biochemistry

OFFICE OF THE PRINCIPAL
MANIPUR COLLEGE IMPHAL

MANIPUR UNIVERSITY

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Manipur College
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Under-Graduate Board of Studies
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Introduction
Learning Outcomes-based Curriculum Framework (LOCF) under the Choice Based Credit System (CBCS) for **Bachelor's Degree with Honours Programme in Biochemistry** is prepared according to UGC guidelines and Ordinance for Undergraduate Programmes in Science, Arts And Commerce, 2021 of Manipur University which was approved by the NEP 2020(UG) Committee, Manipur University on 26.10.2021

Name of the programme:
Bachelor's Degree Programmme in Biochemistry

The Bachelor's Degree Programme in Biochemistry shall be of four years duration with multiple exit options within this period with appropriate certifications namely,

(a) **Bachelor's Certificate** in Biochemistry upon the successful completion of the First Year (Two Semesters);

(b) **Bachelor's Diploma** in Biochemistry upon the successful completion of the Second Year (Four Semesters);

(c) **Bachelor's Degree** in Biochemistry at the successful completion of the Third Year (Six Semesters);

(d) **Bachelor's Degree with Honours** in Biochemistry at the successful completion of the Four Year (Eight Semesters).

Eligibility to apply for admission:
Grade 12 or equivalent stage of education.

Programme Learning Outcomes (B.Sc. Hons. in Biochemistry):
The students who complete four years of full time undergraduate (Honours) programme in Biochemistry would earn a Bachelor's Degree with Honours in Biochemistry. The learning outcomes that a student should be able to demonstrate on completion of a degree level programme may involve academic, personal and behavioral as well as entrepreneurial and social competencies. It is expected that a student completing a particular course must have a level of understanding of the Biochemistry subject and its sub-areas in consonance with the learning outcomes mentioned at the end of that course.The programme learning outcomes relating to B.Sc.(Honours) degree programme in Biochemistry can be summarized as under :

1. Academic Competence

1.1 Disciplinary knowledge and understanding of biochemistry, structure and function of biological molecules.
1.2 Explain biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions.
1.3 Explain the biochemical processes that underlie the relationship between genotype and phenotype.
1.4 Demonstrate an experiential learning and critical thinking of the structure and function of both prokaryotic and eukaryotic cells (including the molecular basis and role of sub-cellular compartmentalization).
1.5 Demonstrate an understanding of the principles, and have practical experience of, a wide range of biochemical techniques (e.g. Basic molecular biology, cell biology and microbiology methods, spectrophotometry, the use of standards for quantification,

enzyme kinetics; macromolecular purification, chromatography electrophoresis, etc).
1.6 Analyse biochemical data (e.g. in enzyme kinetics, molecular structure analysis and biological databases).

2. Personal and Behavioural Competence

2.1 Carry out laboratory-orientated numerical calculations (e.g. inter-conversion of masses, moles, and molarity, preparation of solutions and accurate dilutions), be capable in data visualization and analysis, including the application of data transformations (e.g. logarithmic, exponential).
2.2 Basic professional skills pertaining to biochemical analysis,carrying out clinical diagnostic tests.
2.3 Ability to use skills in specific areas related to biochemistry such as industrial production, technology development, clinical, health, agriculture, community development, etc.
2.4 Curiosity and ability to formulate biochemistry related problems and using appropriate concepts and methods to solve them.
2.5 Ability to use various e-resources in order to solve challenges related to biochemistry.
2.6 Articulation of ideas, scientific writing and authentic reporting, effective presentation skills.
2.7 Having conversational competence including communication and effective interaction with others, listening, speaking, and observational skills.

3. Entrepreneurial and social competence

3.1 Collaboration, cooperation and realizing the power of groups and community, ability to work in a group, community.
3.2 The ability to plan and manage projects in order to achieve the objectives.
3.3 Ability to grasp ideas and to turn ideas into action related to biochemical mechanisms and processes related to industries, industrial production, health, agriculture, etc.
3.4 Creativity, innovation and risk-taking ability.
3.5 Social skills to build great teams.
3.6 Multilevel commitment to health and well being.

3. Course Structure for the LOCF of the CBCS - Eight Semester B.Sc. (Honours) Biochemistry Program:

The LOCF for 4-Year BSc Biochemistry is prepared on the contours and curricular structure provided by the UGC without sacrificing the spirit of CBCS and LOCF. The programme includes a variety of courses with different credits comprising of four course components.

1. Core Course: This is a course which is to be compulsorily studied by a student as a core requirement to complete the requirement of 4-Year BSc Biochemistry program. The Core courses also termed as Foundational Courses are designed to promote common educational edifice for the discipline of Biochemistry. These courses will provide foundational knowledge of Biochemistry and its various sub disciplines to the students. Each Core Course in Biochemistry will be of six credits comprising of four credits theory and two credits practical.

2. Elective Course: Generally, an elective course is a course which can be chosen from a pool of courses which may be very specific or specialized or advanced or supportive to the

discipline/ subject of study or which provides an extended scope, or which enables an exposure to some other discipline/subject/domain or nurtures the candidate's proficiency/skill. An elective course is of three types:

2.1 **Discipline Specific Elective Course (DSE)**: The Discipline-Specific Elective courses are specialized or advanced courses and are intended to cater to various specializations within Biochemistry. The students are offered choices and can be opted from a pool of courses. These courses provide extensive exposure in the area chosen. Students pursuing 4-Year B.Sc. (Honours/Research) Biochemistry programme will opt four DSE course, one each in Semesters V and VI. Each Discipline Specific Elective Course in Biochemistry will be of six credits comprising of four credits theory and two credits practical.

2.2 **Generic Elective Course (GEC):** Generic Elective courses (GEC) designed in the present Biochemistry curriculum will be offered to non-Biochemistry students, i.e. the students of other departments, such as from Botany, Zoology, Microbiology or any other department of the institution. Students will have to opt (elect) one GEC in each of Semesters I, II, III, and IV. The GE courses will be of six credits each (four credits theory and two credits practical). Students pursuing 4-Year B.Sc. (Honours/Research) Biochemistry programme will opt six GECs, one each in Semesters III, IV, V, VI, VII and VIII run by other departments of the institution. As the discipline of Biochemistry is interdisciplinary in nature, students pursuing 4-year B.Sc. Biochemistry can opt GECs from the disciplines allied to Biochemistry, such as from Chemistry, Botany, Zoology, Biotechnology, Microbiology, Environmental Biology, etc.

2.3 Dissertation/Project/Internship: An elective course designed to acquire special/advanced knowledge is termed as dissertation/project. This is considered as a special course involving application of knowledge in solving/ analysing/ exploring a real-life situation/ difficult problem. A student pursuing a 4-Year Bachelor's degree with Honours in Biochemistry will be required to take up a research project of 6 credit hours in the eight semester. These activities will include writing of project/research proposal, review of related literature or studies, collection of the required data and performing required experimental works. The report of the research report is expected to be submitted to the concerned authority at least one week before commencement of the end-semester examination.

3. Ability Enhancement Course: The Ability Enhancement Course may be of two kinds: Ability Enhancement Compulsory Courses (AECC) and Skill Enhancement Courses (SEC).

3.1 AECC courses are the courses based upon the content that leads to Knowledge enhancement: (i) Environmental Science and (ii) English/MIL Communication. These are mandatory for all disciplines. Students will undertake one AECC course in Semester I and the other in Semester II. Each AECC course will be of 4 credits theory only. These courses are aimed to develop language proficiency and environmental consciousness in the students.

3.2 SEC courses are value-based and/or skill-based and are aimed at providing hands-on-training, competencies, skills, etc. These may be chosen from a pool of courses designed to provide value-based and/or skill-based knowledge. Students will have to undertake a total of two Skill Enhancement Courses (SEC), one in Semester I and the

other in Semester II. Each SEC course will be of 2 credits theory and 2 credit practical course.

4. Value Addition Courses (VAC): These are courses that will help develop all capacities of human beings – intellectual, aesthetic, social, physical, emotional, and moral in an integrated manner. It includes subjects like Yoga, Sports, Health Care, NCC, NSS, Ethics, Culture etc. VAC courses may be chosen from a pool of courses. Each VAC course shall carry 2 Credits. A student must opt a total of eight VACs, two each in 1st and 2nd semesters and one VAC each in 3rd, 4th 5th and 6th semesters.

To complete the 4-Year B.Sc. (Honours/Research) Biochemistry programme, a student must study:

- ✓ Eighteen(18) Core Courses (108 credits),
- ✓ Three(3) Discipline-Specific Elective Courses (18 credits),
- ✓ Six(6) Generic Elective Courses (36 credits),
- ✓ Two(2) Skill Enhancement Courses (8 credits),
- ✓ Two(2) Ability Enhancement Compulsory Courses (8 credits),
- ✓ Eight(8) Value Addition Courses (16 credits) and
- ✓ One(1) Project Work Course (6 credits).

A student must earn a minimum of 182 credits to obtain B.Sc. (Honours) in Biochemistry degree. The curriculum proposes to have a strong interface between regular and online learning modes, thereby, actively utilizing national knowledge network resources. The faculty would utilize virtual and actual classrooms through video lectures, small group discussions, tutorials, and individual presentations. Community engagement may be incorporated through socially driven small scale research projects, workshops, field/laboratory training/experiential exercises and simulations utilizing currently available knowledge systems and technological facilities. The number of credits per course as suggested in the CBCS document, that is, four credits per theory paper course and two credits for each Practical paper course has been followed.

Course Structure of Bachelor's Degree Programme in Biochemistry

Course Code	Course Name	Credits*
First Semester		
BC101-C	**Introduction to Biochemistry (Theory)**	**4**
BC101-CP	**Introduction to Biochemistry (Practical)**	**2**
BC102-C	**Bio-organic Chemistry (Theory)**	**4**
BC102-CP	**Bio-organic Chemistry (Practical)**	**2**
BC101-S	**Biostatistics (Theory)**	**2**
BC101-SP	**Biostatistics (Practical)**	**2**
AECC-1	**English**	**4**
VAC-1	**NSS/NCC/YRC/UHV**	**2**
VAC-2	**NSS/NCC/YRC/UHV**	**2**
Second Semester		
BC103-C	**Cell Biology (Theory)**	**4**
BC103-CP	**Cell Biology (Practical)**	**2**
BC104-C	**Biochemical Techniques-I (Theory)**	**4**
BC104-CP	**Biochemical Techniques-I (Practical)**	**2**
BC102-S	**Bioinformatics (Theory)**	**2**

BC102-SP	**Bioinformatics (Practical)**	**2**
AECC-2	**Environmental Science**	**4**
VAC-3	**NSS/NCC/YRC/UHV**	**2**
VAC-4	**NSS/NCC/YRC/UHV**	**2**

Exit option with Bachelor's certificate in Biochemistry on completion of course equal to a minimum of 46 credits

Third Semester

BC201-C	**Chemistry of Biomacromolecules (Theory)**	**4**
BC201-CP	**Chemistry of Biomacromolecules (Practical)**	**2**
BC202-C	**Nutritional Biochemistry (Theory)**	**4**
BC202-CP	**Nutritional Biochemistry (Practical)**	**2**
BC203-C	**Intermediary Metabolism-I (Theory)**	**4**
BC203-CP	**Intermediary Metabolism-I (Practical)**	**2**
BC201-G	**Biomolecules (Theory)**	**4**
BC201-GP	**Biomolecules (Practical)**	**2**
VAC-5	**NSS/NCC/YRC//UHV**	**2**

Fourth Semester

BC204-C	**Membrane Biology & Bioenergetics (Theory)**	**4**
BC204-CP	**Membrane Biology & Bioenergetics (Practical)**	**2**
BC205-C	**Protein Biochemistry & Enzymology-I (Theory)**	**4**
BC205-CP	**Protein Biochemistry & Enzymology-I (Practical)**	**2**
BC206-C	**Molecular Biology-I (Theory)**	**4**
BC206-CP	**Molecular Biology-I (Practical)**	**2**
BC202-G	**Biochemical Techniques (Theory)**	**4**
BC202-GP	**Biochemical Techniques (Practical)**	**2**
VAC-6	**NSS/NCC/YRC/UHV**	**2**

Exit option with Bachelor's Diploma in Biochemistry on completion of course equal to a minimum of 96 credits

Fifth Semester

BC301-C	**Microbiology (Theory)**	**4**
BC301-CP	**Microbiology (Practical)**	**2**
BC302-C	**Immunology (Theory)**	**4**
BC302-CP	**Immunology (Practical)**	**2**
BC301-D	**Plant Biochemistry (Theory)**	**4**
BC301-DP	**Plant Biochemistry(Practical)**	**2**
BC302-D	**Advanced Cell Biology (Theory)**	**4**
BC302-DP	**Advanced Cell Biology (Practical)**	**2**
BC301-G	**Nutritional Biochemistry (Theory)**	**4**
BC301-GP	**Nutritional Biochemistry (Practical)**	**2**
VAC-7	**NSS/NCC/YRC/UHV**	**2**

Sixth Semester

BC303-C	**Molecular Physiology (Theory)**	**4**
BC303-CP	**Molecular Physiology (Practical)**	**2**
BC304-C	**Clinical Biochemistry (Theory)**	**4**
BC304-CP	**Clinical Biochemistry (Practical)**	**2**
BC303-D	**Biology of Infectious Diseases (Theory)**	**4**
BC303-DP	**Biology of Infectious Diseases (Practical)**	**2**

BC304-D	**Biochemistry of Hormones (Theory)**	**4**
BC304-DP	**Biochemistry of Hormones (Practical)**	**2**
BC302-G	**Biochemical Basis of Diseases (Theory)**	**4**
BC302-GP	**Biochemical Basis of Diseases (Practical)**	**2**
VAC-8	**NSS/NCC/YRC/UHV**	**2**

Exit option with Bachelor's Degree in Biochemistry on completion of course equal to a minimum of 140 credits

Seventh Semester

BC401-C	**Intermediary Metabolism-II (Theory)**	**4**
BC401-CP	**Intermediary Metabolism -II (Practical)**	**2**
BC402-C	**Molecular Biology-II (Theory)**	**4**
BC402-CP	**Molecular Biology-II (Practical)**	**2**
BC401-D	**Inborn Errors in Metabolism (Theory)**	**4**
BC401-DP	**Inborn Errors in Metabolism (Practical)**	**2**
BC402-D	**Biochemical Applications In Forensics (Theory)**	**4**
BC402-DP	**Biochemical Applications In Forensics (Practical)**	**2**
BC401-G	**Intermediary Metabolism (Theory)**	**4**
BC401-GP	**Intermediary Metabolism (Practical)**	**2**

Eighth Semester

BC403-C	**Biochemical Techniques-II (Theory)**	**4**
BC403-CP	**Biochemical Techniques-II (Practical)**	**2**
BC404-C	**Protein Biochemistry & Enzymology -II (Theory)**	**4**
BC404-CP	**Protein Biochemistry & Enzymology -II (Practical)**	**2**
BC402-G	**Protein Biochemistry & Enzymology (Theory)**	**4**
BC402-GP	**Protein Biochemistry & Enzymology(Practical)**	**2**
BC401-PW	**Project Work**	**6**

Bachelor's Degree with Honours in Biochemistry on completion of course equal to a minimum of 182 credits

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Total Credits = 200

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1. Each credit* equal to 15 one-hour lectures for theory courses and 15 two-hour laboratory activities for practical courses.
2. A student has to take 72 Core course (C) credits, 36 Core Practical course (CP) credits, 12 Displine specific elective course (D) credits, 6 Displine specific elective Practical course (DP) credits, 24 Generic elective course (G) credits, 12 Generic elective Practical course (G) credits, 8 Ability Enhancement Compulsory Course (AECC) credits, 8 Skill Enhancement Course (SEC) credits, 16 Value Added Course (VAC) credits and 6 project Work course (PW) credits.
3. Two Displine Specific Elective courses are offered in each semester from fifth to seventh semester. A student has to choose only one in each semester.
4. Generic Elective courses (GEC) designed in the present Biochemistry curriculum will be offered to non-Biochemistry students. The students of B.Sc. Biochemistry must opt the Generic Elective Courses from other disciplines outside the Biochemistry Department.
5. Suggested Value Added Courses (VAC): National Service Scheme (NSS), National cadet Corps, Youth Red Cross(YRC) and Universal Human Values (UHV)

TABLE 1: SEMESTER-WISE DISTRIBUTION OF COURSES AND CREDITS* FOR 4-YEAR B.SC. (HONOURS) BIOCHEMISTRY PROGRAMME

SEMESTER	CORE (CREDIT)	DSE(CREDIT)	GEC (CREDIT)	AECC (CREDIT)	SEC (CREDIT)	VAC (CREDIT)	SEMESTER (CREDIT)
I	CORE-1 (4+2) INTRODUCTION TO BIOCHEMISTRY CORE-2 (4 +2) BIOORGANIC CHEMISTRY			AECC-1 (4) ENGLISH	SEC-1 (2+2) BIOSTATISTICS	VAC -1 (2) NSS/NCC/YRC/UHV VAC -2 (2) NSS/NCC/YRC/UHV	24
II	CORE-3 (4 +2) CELL BIOLOGY CORE-4 (4 +2) BIOCHEMICAL TECHNIQUES-I			AECC-2 (4) ENVIRONMENTAL SCIENCE	SEC-2 (2+2) BIOINFORMATICS	VAC -3 (2) NSS/NCC/YRC/UHV VAC -4 (2) NSS/NCC/YRC/UHV	24
EXIT OPTION WITH BACHELOR'S CERTIFICATE IN A DISCIPLINE ON COMPLETION OF COURSE EQUAL TO A MINIMUM OF 46 CREDITS							
III	CORE-5 (4 +2)) CHEMISTRY OF BIOMACROMOLECULES CORE-6 (4 +2) NUTRITIONAL BIOCHEMISTRY CORE-7 (4 +2) INTERMEDIARY METABOLISM-I		GEC- 1(4 +2) BIOMOLECULES			VAC -5 (2) NSS/NCC/YRC/UHV	26
IV	CORE-8 ((4 +2) MEMBRANE BIOLOGY & BIOENERGETICS CORE-9 (4 +2) PROTEIN BIOCHEMISTRY & ENZYMOLOGY-I CORE-10 (4 +2) MOLECULAR BIOLOGY-I		GEC- 2(4 +2) BIOCHEMICAL TECHNIQUES			VAC -6 (2) NSS/NCC/YRC/UHV	26
EXIT OPTION WITH BACHELOR'S DIPLOMA IN A DISCIPLINE ON COMPLETION OF COURSE EQUAL TO A MINIMUM OF 96 CREDITS							
V	CORE-11 (4 +2) MICROBIOLOGY CORE-12 ((4 +2) IMMUNOLOGY	DSE-1(4 +2) PLANT BIOCHEMISTRY / ADVANCED CELL BIOLOGY	GEC- 3(4 +2) NUTRITIONAL BIOCHEMISTRY			VAC -7 (2) NSS/NCC/YRC/UHV	26
VI	CORE-13 (4 +2) MOLECULAR PHYSIOLOGY CORE-14 (4 +2) CLINICAL BIOCHEMISTRY	DSE-2(4 +2) BIOLOGY OF INFECTIOUS DISEASES / BIOCHEMISTRY OF HORMONES	GEC- 4(4 +2) BIOCHEMICAL BASIS OF DISEASES			VAC -8 (2) NSS/NCC/YRC/UHV	26
EXIT OPTION WITH BACHELOR'S DEGREE IN A DISCIPLINE ON COMPLETION OF COURSE EQUAL TO A MINIMUM OF 140 CREDITS							
VII	CORE-15 (4 +2) INTERMEDIARY METABOLISM-II CORE-16 (4 +2) MOLECULAR BIOLOGY-II	DSE-3(4 +2) INBORN ERRORS IN METABOLISM / BIOCHEMICAL APPLICATIONS IN FORENSICS	GEC- 5(4 +2) INTERMEDIARY METABOLISM				24
VIII	CORE-17 (4+2) BIOCHEMICAL TECHNIQUES-II CORE-18 (4+2) PROTEIN BIOCHEMISTRY & ENZYMOLOGY-II	RESEARCH PROJECT WORK (6)	GEC- 6(4 +2) PROTEIN BIOCHEMISTRY & ENZYMOLOGY				24
GRAND TOTAL(CREDITS)							200
BACHELOR'S DEGREE WITH HONOURS IN A DISCIPLINE ON COMPLETION OF COURSE EQUAL WITH A MINIMUM OF 182 CREDITS							

SEMESTER-WISE COURSE-LEVEL LEARNING OUTCOMES OF COURSES

SEMESTER - I
Core Course-1 Theory (BC101-C)
Introduction to Biochemistry

Theory Credits: 4 Total Hours: 60

Course level learning outcomes:

- Understanding of Biochemistry as a discipline and milestone discoveries in life sciences that led to establishment of Biochemistry as separate discipline.
- Fundamental properties of elements, their role in formation of biomolecules and biochemical reactions within living organisms.
- Understanding of the concepts of mole, mole fraction, molarity, etc. and to apply them in preparations of solutions of desired strengths.
- Unique property of water as a universal solvent and its importance in biological system.
- Understanding of fundamentals of physical phenomena associated with Adsorption, Viscosity, Distribution law, Osmotic pressure, etc. and their importance in living organisms.
- Understanding of concepts of acids, bases, indicators, pKa values, etc. Acquiring skill to determine pKa value of amino acids.
- Fundamental laws relating to photochemistry and applications of UV-visible, Fluorescence and IR spectrophotometry in analytical determination and characterization of biomolecules.
- Appreciation of the roles of metals, non-metals, transition metals and coordination compounds in biological systems.
- Apply the principles of radiochemistry to analytical determination of biomolecules and life processes.

Course content:

- Overview of Biochemistry: Definition, scope and significance of Biochemistry. Important discoveries in Biochemistry. An overview of elements, chemical reactions, and biomolecules in living organisms.
- Concentration units: Avagadro's number, mole, mole fraction, molarity, equivalent weight, normality, molality, percentage (Problems to be worked out).
- Properties of water:Molecular structure of water, physical properties of water. Its effect on biomolecules. Effect of non-polar compounds on water.
- Colligative properties: Osmotic pressure and its measurements by Berkely and Hartley's method. Laws of osmotic pressure. Hypo, hyper and isotonic solutions. Effects of osmotic pressure on living cells. Donnan membrane equilibrium.
- Physical properties of molecules: (1) Adsorption -Definition, Freundlich and Langmuir's adsorption isotherm. Applications of adsorption. (2) Viscosity-Definition, Determination of viscosity of liquids and solutions by Ostwalds's viscometer (solutions of gum and protein to be taken as example). (3) Distribution law -Distribution law, partition coefficient. Applications of distribution law.
- Ionic equilibria: Lewis concept of acids and bases. Ionic product of water. pH scale, buffers, Henderson Hasselbalch equation, buffer capacity, preparation of acidic and basic buffer solutions. Theory of acid base indicators. Choice of indicators. pH titration

curves and isoelectric pH of amino acids. Electrodes (Hydrogen Electrode &Calomel electrode), glass

- electrode. Conductometric titrations: Strong acid against strong base, weak acid (amino acid) against NaOH], Determination of pKa value of amino acid by using pH meter.
- Photochemistry: Laws of photochemistry, quantum efficiency, light absorption, Beer Lambert's law, spectrophotometer, colorimeter, fluorescence, phosphorescence, chemiluminescence, bioluminescence (Elementary treatment). Applications of UV-visible and fluorescence spectra. Principle of IR spectra and its applications.
- Co-ordination compounds: Transition metals, properties (Colour, oxidation states, magnetic properties). Co-ordinate bond, double and complex salts - differences with examples.
- Postulates of Werner's theory. Types of ligands - uni, bi and polydentate with examples. Coordination number. Porphyrin nucleus and classification. Important metalloporphyrins occurring in nature-structure and their biological importance (Hb, cytochrome, chlorophyll, Vit-B12). Bile pigments-Types, structure and chemical nature.
- Nitrogen: Fixation of atmospheric nitrogen - symbiotic and non-symbiotic. Nitrogen cycle. Environmental pollution by nitrogen compounds.
- Phosphorous importance of phosphorus compounds in biological system, phosphorous cycle.
- Oxygen: Importance of oxygen in biological system. Formation and role of ozone in maintenance of life on earth. Effects of environmental pollutants on ozone layer.
- Sulphur and selenium: Importance of compounds of sulphur and selenium in biological system. Effect of sulphur compounds on environmental pollution.
- Chemical bonding: Different types of bonds & bond characteristics. Ionic bonding, covalent bonding, co-ordinate bonding, Van der Waal's forces, ion- dipole, dipole - dipole interactions,
- London forces, hydrophobic interaction, hydrogen bonding. Effect of chemical forces on physical properties'
- Biochemical toxicology: Source, entry into biological system and toxicity of lead, mercury, cadmium, and arsenic.

Suggested Readings:

- Barrow, G. M. Physical Chemistry Tata McGraw-Hill, India.
- Castellan, G. W. Physical Chemistry, Narosa, India.
- Kotz, J. C., Treichel, P. M. & Townsend, J. R. General Chemistry Cengage Leaming India Pvt. Ltd.: New Delhi.
- Mahan, B. H. University Chemistry, Narosa, India.
- J. D. Lee, A new Concise Inorganic Chemistry, ELBS,4th Edition.
- F. A. Cotton & G. Wilkinson. Basic Inorganic Chemistry, John Wiley.
- Douglas, McDaniel and Alexander : Concepts and Models in Inorganic Chemistry, John Wiley
- James E. Huheey, Ellen Keiter and Richard Keiter : Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Public.
- Pattabhi. V. and GauthamN. Biophysics. Narosa Publishing House, India.
- Physical Chemistry - Puri, Pathania & Sharma.

Note: All the textbooks are of latest editions

SEMESTER - I

Core Course-1 Practical (BC101-CP):
Introduction to Biochemistry (Practical)

Practical Credits: 2 Total Hours: 60

Course level learning outcomes:

- Understanding Good laboratory practices in a chemistry/biochemistry laboratory.
- Learn safety and precautionary measures for working in a laboratory.
- Develop skill and proficiency in preparation of laboratory reagents.
- Use of handling of glass wares, minor equipment for conducting experiments.
- Develop skills to prepare standard chemical solutions and secondary standards.
- Demonstration of basic oxidation and reduction reactions.

Practical content:

- Use of analytical balance and weighting.
- Calculation, preparation of normal, molar and percentage solutions.
- Calibration of volumetric glassware (Burette, pipette and measuring cylinder).
- Preparation of standard sodium carbonate solution, standardization of HC1 (Methyl orange) and estimation of NaOH in the given solution. (Methyl orange or phenolphthalein).
- Preparation of standard oxalic acid. Standardization of NaOH and estimation of H_2SO_4 in the given solution (phenolphthalein).
- Preparation of standard oxalic acid. Standardization of $KMnO_4$ and estimation of H_2O_2 in the given solution.
- Preparation of standard $K_2Cr_2O_7$. Standardization of $Na_2S_2O_3$ and estimation of $CuSO_4$ in the given solution.
- Preparation of $ZnSO_4$. Standardization of EDTA and estimation of total hardness of water using eriochrome black-T indicator.
- Preparation of standard potassium biphthalate. Standardization of NaOH and estimation of HC1 in the given solution. (Phenolphthalein).
- Conductometric titration of strong acid against strong base.
- Conductometric titration of weak acid (amino acid) against strong base.
- Determination of rate constant of decomposition of H_2O_2 using $KMnO_4$ by volumetric analysis method.
- Demonstration: i) Determination of density and viscosity of the given liquid using specific gravity bottle and Ostwald's viscometer.
- Determination of miscibility temperature by water-phenol system.
- Safety hazards and disposal of wastes.
- Good laboratory practices.

SEMESTER - I

Core Course-2 Theory (BC102-C): Bio-organic Chemistry

Theory Credits: 4 Total Hours: 60

Course level learning outcomes:

- Understand the significance of organic reactions with reference to biological systems.
- Apply the principles of electrochemistry to conductance, voltaic, and electrolytic systems.
- Understanding chemical bonding, strong and weak interactions, hydrogen bonding and to apply these principles in various biomolecules and biological reactions.
- To develop understanding of aliphatic and aromatic compounds, IUPAC nomenclature, reactivity of functional groups and the importance of stereoisomers in biological systems.
- Understanding the formation of polymers and their importance; difference between biodegradable and non-biodegradable polymers and biohazards of polymers.
- Apply concept of stereochemistry in determining conformations of biomolecules

Course Content:

- Introduction to organic chemistry: Classification of organic compounds, unique characteristics, IUPAC nomenclature of organic compounds (including bi-functional) and biomolecules.
- Reaction mechanisms: Concept of inductive effect, resonance and hyperconjugation. Classification of organic reactions (substitution, addition, elimination, and rearrangement), with two examples for each. Concepts of the following - carbanions, carbocations, free radicals, carbenes, nucleophiles and electophiles (Formation and Stability).
- Aliphatic hydrocarbons: Mechanism of Markownikoff and anti-Markownikoff addition. Addition of HBr to propene. Dienes - types with examples, 1,3 butadiene -preparation, stability and mechanism of addition of HBr. Diels-Alder reaction. Conformational analysis of ethane.
- Cycloalkanes: Reactivity and relative stability. Bayer's strain theory. Sachse-Mohr theory. Boat and chair forms of cyclohexanes. Axial and equatorial bonds and their relation with biological activities of carbohydrates.
- Arenes: Structure of benzene - by Resonance and molecular orbital theories. Aromaticity. Mechanism of Nitration and Friedel-craft reaction. Electronic interpretation of the orientating influence of substituents in the electrophilic substitution of toluene, chlorobenzene, nitrobenzene, and phenol. Resonance structures of naphthalene and anthracene.
- Alkyl halides and organomatellic compounds: SnI and Sn2 reaction, their mechanism with one example for each. Concept of elimination reactions (El and E2 with an example). Applications of organometallic compounds - organo lead, organo lithium, cisplatin.
- Alcohols: Definition. classification, monohydric alcohols-distinguishing reactions for primary, secondary and tertiary alcohols. Dihydric alcohols: Glycol, preparation (any 2 methods) and uses.Trihydric alcohols: Glycerol, synthesis from propene, properties, (reaction with cone. H_2SO_4, HNO_3, Oxalic acid and HI). Phenols: Acidity of phenols, effect of substituent on acidity.

- Hydroxy acids and dicarboxylic acids: Structure & properties of hydroxy acids: Lactic acid, citric acid and isocitric acid. Dicarboxylic acid: Maleic and fumaric acid. Ketoacids: Pyruvic, a- ketoglutaric, oxalo acetic acids.
- Amines: Classification, properties, functional amino group - Basicity of amines, acylation. React with HNO_2 & Schiff's base formation. Distinguishing reactions of primary, secondary and tertiary amines.
- Heterocyclic compounds: Definition, classification with examples, structure and biological importance of furan, pyrrole, thiophene, pyridine, pyran, thiazole, pyrimidine, purine, indole, imidazole, quinoline and isoquinoline. Basicity of pyrrole and pyridine.
- Terpenes: Definition, isoprene rule, classification, isolation, structure and biological importance of menthol, camphor, famesol, phytol, lanosterol, lycopene and dolichols.
- Steroids: Basic ring structure in steroids. Structure and biological importance of cholesterol, phytosterols and ergosterol. Bile acids [Mono, Di & Tri cholic acids].
- Alkaloids: Definition, classification based on their structure and biological functions, isolation, structure and biological action of morphine, nicotine & atropine. Chemical synthesis of nicotine and atropine.
- Vitamins: Classification- Water soluble & fat soluble. Structural formulae and co-enzyme forms of B1, B2, B6 and niacin. Vitamin C as red-ox reagent, Chemical synthesis of vitamin C. Structural formula of vitamin A, D, E and K.
- Stereochemistry: Stereoisomerism types, Fischer-projection formulae, chiral carbon atom, asymmetry and dissymmetry, chirality, conditions for optical isomerism ex: glyceraldehyde, lactic acid, tartaric acid, Nomenclature of enantiomers, diastereomers. D and L notation, R and S system, racemisation, and resolution (Biochemical, chemical and physical methods). Geometrical isomerism.

Suggested Readings:

- Arun Bahl and B. S. Bahl. Organic Chemistry, S. Chand.
- R. T. Morrison & R. N. A.Organic Chemistry, Prentice Hall.
- L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.

Note: All the textbooks are of latest editions

SEMESTER - I

Core Course-2 Practical (BC102-CP)
Bio-organic Chemistry

Practical Credits: 2 Total Hours: 60

Course level learning outcomes:

- Analyse common organic reagents and compounds based on their properties.
- Analyse organic compounds from unknown mixture/origin.
- Apply the properties of functional groups of organic compounds to carry out selective organic reactions.
- Verify reactivity of organic functional groups.
- Develop skills to prepare useful organic compounds in the laboratory

Practical content:

- Systematic qualitative analysis of the organic compounds: Urea, benzamide, benzaldehyde, aniline, acetophenone, m-cresol, nitrobenzene, chlorobenzene, naphthalene, p-toluidine, benzoic acid, salicylic acid, resorcinol, benzyl alcohol and p-dichloro benzene.
- Organic preparations: Aspirin from salicylic acid, benzoic acid from benzaldehyde, p-bromo acetanilide from acetanilide and meta-dinitrobezene from nitrobenzene.

SEMESTER II

Core Course-3 Theory (BC103-C)
Cell Biology

Theory Credits: 4 Total Hours: 60

Course Level Learning Outcomes:

- Understanding of the structure of cell and various cellular events.
- Understanding of the function of various subcellular organelles.
- Students will learn about cell theory and techniques for fractionation of sub-cellular organelles.
- They will be acquainted to various microscopic techniques to visualize subcellular organelles.
- Students will have an understanding of the composition of cytoskeleton and extracellular matrix.
- Students will acquire knowledge of cell cycle, cell division and cell death mechanisms.

Course Content:

- Origin of life, Cell theory, Structure of prokaryotic and eukaryotic cell. Differences in Animal and Plant cell. Mycoplasma, viruses, viroids, prions.
- Structure and function of subcellular organelles - Composition Of biological membranes. Nucleus: Structure of nuclear envelope, nuclear pore complex nucleolus and chromatin.

- Endoplasmic Reticulum: RER - Brief overview of co-translational 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.
- Cell Fractionation techniques: 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; Staining techniques for microscopy studies. Principles of identification of sub cellular organelles.
- Lysosomes: Different forms of lysosomes, role in cellular digestion, lysosomal storage diseases. Peroxisomes: assembly, functions, glyoxysomes.
- Mitochondria: structure, endosymbiont theory, genome. Chloroplast: structure, endosymbiont theory genome.
- Cell Wall: Structure of prokaryotic and eukaryotic cell wall. ECM components-proteins, polysaccharides and adhesion proteins; concept of anchoring junctions, tight junctions and communication junctions (gap junctions and plasmodesmata).
- Cytoskeleton. Microtubules: Axonemal and cytoplasmic microtubules (cilia, flagella, centrioles, basal bodies). Microfilaments: Actin and Myosin Filaments. Role of cytoskeletal elements in the entry of infectious agents
- Cell Cycle, Cell Division (mitosis and meiosis); 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.

Suggested Readings:

- The Cell: A Molecular Approach, Cooper, G.M. and Hausman, R.E., ASM Press & Sunderland (Washington DC), Sinauer Associates, MA, ISBN:978-0- 87893-300
- Cell and Molecular Biology: Concepts and Experiments. Karp, G., John Wiley and Sons. Inc. ISBN: 978-1-118-65322-7
- Principles and Techniques of Biochemistry and Molecular Biology: - Ed. K. Wilson and J. Walker, Cambridge University Press.
- Physical Biochemistry- Application to Biochemistry and Molecular Biology Friefelder D. WH Freeman and Company.
- Lehninger: Principles of Biochemistry, Nelson, D.L. and Cox, M.M. W.H. Freeman & Company (New York), ISBN: 13: 9781464126116 / ISBN: 101464126119.
- Molecular Biology of the Gene,Watson, J.D., Baker,
- T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold Spring Harbor (New York)

Note: All the textbooks are of latest editions

SEMESTER II

Core Course- 3 Practical (BC103-CP)
Cell Biology

Practical Credits: 2 Total Hours: 60

Course level learning outcomes:

- Students will learn the handling of microscope.
- Obtain hands-on training in basic separation techniques in biochemistry.
- Gain expertise in the isolation of various cell organelles and staining of cellular biomolecules.

Course Content:

- To study different parts of microscope
- Cytochemical staining of proteins by Methylene blue
- Cytochemical staining of polysaccharides by PAS
- Cytochemical staining of RNA by Methyl Green
- Study of stages of Mitosis using onion root tip
- Study of stages of Meiosis in onion flower buds/ grasshopper testes
- To study cell organelles using electron micrographs
- To study the effect of isotonic, hypotonic and hypertonic solutions on cells

SEMESTER II

Core Course- 4 Theory (BC104-C)
Biochemical Techniques-I

Theory Credits: 4 Total Hours: 60

Course Level Learning Outcomes:

- Develop competence in handing various chromatographic techniques and apply them in isolating and characterizing different biological molecules.
- Understanding the applications of centrifugation and chromatography in biological investigations.
- Purify proteins by affinity chromatography using epitope tags such as histidine tag, GST tag, Flag tag etc.
- Understanding the principles of Electrophoresis, Spectrophotometry and ELISA and their applications in biological investigations/experiments.

Course Content:

- Chromatography: General Principles of chromatography – adsorption and partition. Techniques: Paper chromatography –Ascending, descending and circular, 2D - chromatography, Rf values, column chromatography, principle of gel filtration, ion-exchange chromatography, affinity chromatography. Thin layer chromatography (TLC)

- principle, procedure and applications.
- Electrophoresis, Paper and gel electrophoresis, SDS-PAGE, 2D -Electrophoresis
- Centrifugation: Principle of differential centrifugation. Types of Rotors, Ultracentrifuge - construction and applications in subcellular fractionation.
- Radiochemistry: Natural and artificial radioactivity, characteristics of radioactive elements, units of radioactivity, disintegration constant, half-life, a, P and y radiation. Detection of radioactivity by GM counter. Applications of radioisotopes - ^{3}H, ^{14}C, ^{60}Co and ^{32}P. Biological effects of radiations. Safety measure in handling radio isotopes.
- ELISA
- Spectrometry- Beer and Lamberts law, Principals of colorimeter, spectrophotometer. Nephelometry and turbidimetry and its applications.

Suggested Readings:

- Biophysical Chemistry, Principles & Techniques – Upadhyay, Upadhyay and Nath – Himalaya Publ. House.
- Principles & Techniques of Practical Biochemistry – Wilson, Walker- Cambridge Univ. Press.
- Chromatography – G. Abbott.Aupadhyay, K. Upadhyay and N. Nath Biophysical Chemistry, Himalaya Publishing House.
- Principles and Techniques of Biochemistry and Molecular Biology:- Ed.K. Wison and J Walker. Cambridge University Press.

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SEMESTER II

Core Course- 4 Practical (BC104-CP)
Biochemical Techniques-I

Practical Credits: 2 Total Hours: 60

Course level learning outcomes:

- The students will obtain hands-on training in basic separation techniques in biochemistry like electrophoresis, chromatography, etc.
- Gain expertise in the isolation of various biomolecules and organelles.

Practical content:

- Identification of amino acids by paper chromatography.
- Ascending paper chromatography of amino acids.
- Separation of plant pigments using paper chromatography.
- Separation of plant pigments by column chromatography using silica gel-G.
- Polyacrylamide gel electrophoresis of proteins.
- SDS-PAGE
- Demonstration of separation of lipids by TLC.
- Demonstration of two-dimensional chromatography of amino acids

Skill Enhancement Course -1 Theory (BC101-S)

Biostatistics

Theory Credits: 2 **Total Hours: 60**

Course level learning outcomes:

- The students will understand the principles of collection of data in biological experiments, proper statistical analysis of the data and its presentation.
- Students will understand the importance of sample size and various variables that affect data.
- Students will know the importance of mean, standard error, standard deviation, significance in presenting the data.
- Knowing statistical methods will help students in improving their analytical and interpretation skill.

Course content

- **Data Collection and Presentation:** Biological data management using statistical tools. Concepts of population and sample, advantages of sampling, Basic concepts in sampling and designing experiments, Estimation of sample size for biological experiments, sources of errors. Sampling schemes – Simple Random sampling, Systemic sampling, Stratified sampling, Cluster sampling, Non probability sampling; Estimation of mean proportion and standard error in cluster sampling, Multistage and multiphase sampling, Types of numerical data – nominal data, ordinal data, ranked data, discrete data, continuous data; Modes of presenting data: Frequency distributions, Relative frequency.
- **Analysis of variance**: 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.
- **Probability**: Operations on events, Venn diagrams, Conditional Probability; Probability distributions.
- **Hypothesis testing**: General concepts – Null hypothesis, alternative hypothesis, Rejection of hypothesis; Type I and Type II errors; P value and sample size estimation. **Regression and Correlation:** 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 R2 and ρ.

Semester – I
Skill Enhancement Course -1 Practical (BC101-SP)
Biostatistics

Practical Credits: 2 **Total Hours: 60**

Course level learning outcomes:

- Students will acquire hands-on practical training to plan biological experiments with requisite sample size.
- After completion of experiments based on different sample sizes students will be able to perform proper statistical analysis of the data using mean, median, mode, variance and standard deviations. Students will be able to apply the principles of biological data management in real life situations.
- Statistical training will improve computational, mathematical and computer skills of the students by learning the use of ANOVA, AMOVA and student t-test.
- Students will be able to formulate a hypothesis, relevance to type of sample collected and sample size.

Course content

- Estimation of population means and variance in simple random sampling.
- Collection of data - Random sampling method; Stratified sampling method; Cluster sampling method
- Cluster Sampling- Equal and unequal cluster sizes. Double sampling using regression and ratio estimates and double sampling for stratification.
- Data representation - Frequency and relative frequency distribution table, Plotting of biological data in a representative graphicalformat.
- 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
- Chi square goodness of fit test. Regression analysis and calculating regression coefficient
- Learning to analyze data using SPSS software.

Suggested readings :

- Principles of Biostatistics, M. Pagano and K. Gauvreau ; Duxbury Thomas learnings.
- Analysis of Biological Data, M. Whitlock and D. Schluter; Roberts and company publishers.

Note: All the textbooks are of latest editions.

Semester – II
Skill Enhancement Course -2 Theory (BC102-S)
Bioinformatics

Theory Credits: 2 **Total Hours: 30**

Course level learning outcomes:

- The students will have an understanding of the tools of bioinformatics and computational biology and will be in a position to access biological data bases and softwares which will be helpful in understanding sequencealignments and predicting the structures of biomolecules such as proteins.
- Students will be exposed to available bioinformatics tools and databases.
- They will be in a position to comprehend the fundamental aspects of *in-silico*protein structureprediction.
- They will understand application of theoretical approaches to biological systems.
- Students will get trained in the application of programs used for database searching, protein and DNA sequence analysis, and prediction of protein structures.

Course content

- Bioinformatics: Introduction, Basics of Computer and operating systems, Hardware, Software, Introduction to programming Languages and Paradigms, PERL/R programming, role of supercomputers in biology.
- Scope of bioinformatics - Genomics, Proteomics, comparative and functional genomics, Genome annotation, gene prediction approaches andtools.Transcriptome and Proteome, Tools of proteome analysis. DNA microarray: understanding of microarray data and correlation of gene expression data to biological processes and computational analysis tools. Computer aided drug design (CADD) and Systems Biology.
- Biological databases: Introduction to biological databases - primary, secondary and composite databases, useful programs, ClustalW, BLASTp. NCBI, EBI, ExPaSy, nucleic acid databases (GenBank, EMBL, DDBJ, NDB), protein databases (PIR, Swiss-Prot,TrEMBL, PDB), metabolic pathway database (KEGG, EcoCyc).
- Sequence alignment: Similarity, identity and homology. Concept of Alignment–Pair-wise sequence alignment, gaps, gap-penalties, scoring matrices, PAM250, BLOSUM62, local and global sequence alignment, multiple sequence alignment, Progressive Alignment Algorithm, Application of multiple sequence alignment. BLAST and CLUSTALW.
- Protein Structure: Methods for prediction of Protein structure, Homology modeling, Fold recognition and *ab-initio* methods.

Semester – II
Skill Enhancement Course-2 Practical (BC102-SP)
Bioinformatics

PracticalCredits: 2 **Total Hours: 60**

Course level learning outcomes:

- The students will acquire training in different areas of bioinformatics related to various biological databases such as protein databases, nucleic acid databases, metabolic pathway databases, etc.
- With training in multiple sequence alignments they will be in a position to perform *in-silico* experiments and will predict structures of proteins.

Practical Contents

- Downloading and analysis of the pdb file of the biomolecules.
- Tertiary structure prediction of proteins (SWISSMODEL) and Protein structure evaluation.
- Analysis of Secondary and tertiary structure of protein using visualizing software like Rasmol.
- Primary sequence analyses (Protparam) and Secondary structure prediction (GOR, nnPredict).
- Sequence retrieval (protein and gene) from NCBI and Molecular file formats-FASTA,GenBank/Genpept.
- BLAST suite of tools for pairwisealignment. Multiple sequence alignment (CLUSTALW/TCoffee) and construction of guidetrees Gene prediction using GENSCAN/GLIMMER.

Suggested readings:

- Bioinformatics: Principles and Applications , Ghosh, Z. and Mallick, B., Oxford University Press (India)
- M. Michael Gromiha. Protein Bioinformatics: From Sequence to Function, Academic Press.
- Bioinformatics: Sequence and Genome Analysis, Mount, D.W. Cold Spring HarborLaborator Press (New York).
- Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Baxevanis, A.D. and Ouellette, B.F., John Wiley & Sons, Inc. (New Jersey).

Note: All the textbooks are of latest editions.