Postgraduate CBCS Syllabus of M.Sc. Biochemistry program, West Bengal State University

Effective from session 2019-2020

Postgraduate CBCS structure of M.Sc. Biochemistry program, WBSU

Semester	Name of the courses with code	Credit	Marks	Total
I	Biomolecules and Cellular organization (BC 1.1)	4	50	Marks : 275
	Thermodynamic Principles in Biology and Bioenergetics (BC1.2)	4	50	Credits : 22
	Systems Biology (BC 1.3)	4	50	
	Enzymology (BC 1.4)	4	50	
	Lab course (BC 1.5)	4	50	
	AECC (BC 1.6)	2	25	
II	Metabolism (BC 2.1)	4	50	Marks : 275
	Bioanalytical Techniques (BC 2.2)	4	50	Credits : 22
	Molecular Biology (BC 2.3)	4	50	
	Microbiology (2.4)	4	50	
	Lab course (BC 2.5)	4	50	
	SEC : Nutritional Biochemistry (BC 2.6)	2	25	
III	Plant Biochemistry (BC 3.1)	4	50	Marks : 300
	Immunology (BC 3.2)	4	50	Credits : 24
	Cell Biology (BC 3.3)	4	50	
	DSE:			

	Neurobiochemistry/Clinical Biochemistry (BC 3.4) Lab course (BC 3.5) GEC : Fundamentals of Biochemistry (BC 3.6)	4 4 4	50 50 50	
IV	Methods in Molecular Biology (BC 4.1) Biotechnology (BC 4.2) Genetics and epigenetics (BC 4.3) DSE: Developmental biology/ Ecological principles (BC 4.4) Dissertation project submission and project presentation (BC 4.5)	4 4 4 4 8	50 50 50 50 100	Marks : 300 Credits : 24

4 credit theoretical courses indicate 4 teaching hours per week, 2 credit theoretical courses indicate 2 teaching hours per week whereas 4 credit laboratory courses indicate 8 teaching hours per week.

Postgraduate CBCS Syllabus of M.Sc. Biochemistry program, WBSU

Program outcome:

M.Sc. in Biochemistry program of WBSU is a laboratory based science subject course exposing the students in the modern areas of interdisciplinary biological and biochemical sciences. This course introduces the post-graduate students to the state of the art methodologies of biochemical, biotechnological and molecular biological sciences. This course is extremely important from the view point of applied field of interdisciplinary biological sciences. The concept of interdisciplinary sciences is gaining momentum these days and the course of M.Sc. Biochemistry aims at establishing such interdisciplinary orientation in biological sciences removing the subject-wise barriers among Physics, Chemistry, Botany, Zoology, Physiology and other life science oriented subjects. This course also opens the door to a variety of careers. After studying M.Sc. in Biochemistry, students can proceed for a research career in the field of interdisciplinary biological and biochemical sciences by doing Ph.D., doing post doctoral studies and possess high chances of being appointed as a faculty in an academic institute. After pursuing M.Sc. in Biochemistry, students have also ample scope to get employment as a biochemist/ analytical chemist/toxicologist in several sectors such as employment in government and industrial laboratories, in forensic science laboratories, opportunities in clinical diagnostic medicine in hospitals and in the numerous companies now providing diagnostic procedures, the pharmaceutical, brewing and food processing industries, monitoring and control of pollution, in the biotechnology industry etc. Biochemistry will continue to have very good prospect for the professions of medicine and pharmacy. Opportunities exist in universities and research institutes for biochemists with higher research degrees. With the development of healthcare infrastructure and improved health care financing, the career scope in M.Sc. in Biochemistry is expected to rise by the year 2020.

Semester –I

Course code BC 1.1

Biomolecules and Cellular organization Credit 4 Marks 50

Course outcome:

This course will familiarize the students with the major basic biomolecules of the living systems. This course is very much essential for the beginner learners in biochemistry. As the students are coming from various fields at this initial semester, they all must be made introduced to the basic concepts of biochemistry that covers the study of major biomolecules.

Course content:

Bio-molecules:

1. **Carbohydrates – S**tructure, reactions and functions of monosaccharides, disaccharides polysaccharides and complex carbohydrates; amino sugars, proteoglycans and glycoproteins.
2. **Lipids -** Classification, structure, properties and functions of fatty acids, essential fatty acids, fats, phospholipids, sphingolipids, cerebrosides, steroids, bile acids, prostaglandins and lipoproteins.
3. **Nucleic acids -** Structure and function of nucleotides. Primary, secondary and tertiary structure of nucleic acids, DNA forms and conformations.
4. **Proteins –** Primary, Secondary, Tertiary and Quaternary structures of proteins.
5. **Enzymes -** Historical perspective, general characteristics, nomenclature, Enzyme classification (specific examples), and Enzyme assays.

Cell Biology: Classification of cell, cell variability (size, shape, complexity, functions). Structural organization of prokaryotic and eukaryotic cells. The ultra structure of cell membrane, nucleus, mitochondria, endoplasmic reticulum (rough and smooth), Golgi apparatus, lysosomes & peroxisomes and their functions. The cytoskeleton – microtubules and microfilaments. Cell movement and chemotaxis.

Course code BC 1.2

Thermodynamic Principles in Biology and Bioenergetics Credit 4 Marks 50

Course outcome:

This course will familiarize the students with the major thermodynamic principles in biology and basic metabolic pathways of the living systems. This course is very much essential for the beginner learners in biochemistry. As the students are coming from various fields at this initial semester, they all must be made introduced to the basic concepts of metabolism and bioenergetics. As this course of metabolism and bioenergentic studies is very vast, we should restrict ourselves only to preliminary level in semester I.

Course content:

1. **Carbohydrates –** Glycolysis, citric acid cycle, its function in energy production and biosynthesis of energy rich bond, pentose phosphate pathway. Gluconeogenesis, glycogenesis and glycogenolysis, glyoxylate and Gamma aminobutyrate shunt pathways, Cori cycle, anaplerotic reactions, Entner-Doudoroff pathway, glucuronate pathway. Metabolism of disaccharides. Hormonal regulation of carbohydrate metabolism. Energetics of metabolic cycle.
2. **Amino Acids –** General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids. Special metabolism of methionine, histidine, phenylalanine, tyrosine, tryptophan, lysine, valine, leucine, isoleucine and polyamines. Urea cycle and its regulation.
3. **Intermediary Metabolism –** Approaches for studying metabolism.
4. **Coenzymes and Cofactors –** Role and mechanism of action of NAD+/NADP+, FAD, lipoic acid, thiamine pyrophosphate, tetrahydrofolate, biotin, pyridoxal phosphate, B12 coenzymes and metal ions with examples.
5. **Bioenergetics –** Concept of free energy, standard free energy, determination of ΔG for a reaction. Relationship between equilibrium constant and standard free energy change, biological standard state & standard free energy change in coupled reactions. Biological oxidation-reduction reactions, redox potentials, relation between standard reduction potentials and free energy change (derivations and numericals included). High energy phosphate compounds – introduction, phosphate group transfer, free energy of hydrolysis of ATP and sugar phosphates along with reasons for high ΔG. Energy charge.

Course code BC 1.3

Systems Biology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the major systems biology of the living systems. This course is very much essential for the beginner learners in biochemistry. As the students are coming from various fields at this initial semester, they all must be made introduced to the preliminary ideas about physiological systems and networking existing in living beings. This knowledge of systems biology will be definitely going to increase the understandability of the students as they move through the different other courses of biochemistry.

Course content:

1. Systems Level Reasoning-Molecules to Pathways
2. Pathways to Networks-Physical forces and electrical activity in cell biology
3. Mathematical representation of cell biological systems
4. Plant system biology

Photosynthesis - Light harvesting complexes; mechanisms of electron transport; photoprotective mechanisms; CO2 fixation-C3, C4 and CAM pathways, Respiration and photorespiration- Citric acid cycle; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; photorespiratory pathway.
Sensory photobiology - Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks.
Stress physiology – Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses.
5. **Animal system biology**
Blood and circulation - Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.
Cardiovascular System: Comparative anatomy of heart structure, myogenic heart, specialized tissue, ECG – its principle and significance, cardiac cycle, heart as a pump, blood pressure, neural and chemical regulation of all above.
Respiratory system - Comparison of respiration in different species, anatomical considerations, transport of gases, exchange of gases, waste elimination, neural and chemical regulation of respiration.
Nervous system - Neurons, action potential, gross neuroanatomy of the brain and spinal cord, central and peripheral nervous system, neural control of muscle tone and posture.
Endocrinology and reproduction - Endocrine glands, basic mechanism of hormone action, hormones and diseases; reproductive processes, gametogenesis, ovulation, neuroendocrine regulation

Course code BC 1.4

Enzymology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the enzyme biochemistry of the living systems. This course is very much essential for the beginner learners in biochemistry. As the students are coming from various fields at this initial semester, they all must be made introduced to the preliminary ideas of enzyme chemistry. This knowledge of enzyme kinetics, mechanism and regulation covers a vast and very important area of biochemistry. Without this knowledge of enzyme chemistry the students cannot pursue other courses of biochemistry.

Course content:

1. **Introduction**– Classification of enzymes (specific examples), enzyme specificity, methods for isolation, purification and characterization of enzymes, tests for homogeneity of enzyme preparation.
2. **Kinetics of enzyme action –** Concept of ES complex, active site, specificity, derivation of Michaelis-Menten equation for uni- substrate reactions. Different plots for the determination of Km & Vmax and their physiological significances. Importance of Kcat/Km. Kinetics of zero & first order reactions. Significance and evaluation of energy of activation. Michaelis – pH functions and their significance. Classification of multi-substrate reactions with examples of each

class. Use of initial velocity, inhibition and exchange studies to differentiate between multi-substrate reaction mechanisms. Competitive, non-competitive, uncompetitive, linear-mixed type inhibitions and their kinetics, determination of Ki and numerical based on these. Suicide inhibitor.

3. **Mechanism of Enzyme Action –** Acid-base catalysis, covalent catalysis, proximity, orientation effect. Strain and distortion theory. Chemical modification of active site groups. Mechanism of action of chymotrypsin, lysozyme, glyceraldehyde 3-phosphate dehydrogenase, aldolase, carboxypeptidase, triose phosphate isomerase and alcohol dehydrogenase.

4. **Enzyme Regulation –** General mechanisms of enzyme regulation, product inhibition. Reversible (glutamine synthase & phosphorylase) and irreversible (proteases) covalent modification of enzymes. Mono-cyclic and multi-cyclic cascade systems with specific examples. Feed back inhibition and feed forward stimulation. Allosteric enzymes, qualitative description of "concerted" & "sequential" models for allosteric enzymes. Half site reactivity, positive and negative co-operativity with special reference to aspartate transcarbamoylase and phosphofructokinase. Protein-ligand binding measurement, analysis of binding isotherms, Hill and Scatchard plots.

5. **Multienzyme system –** Mechanism of action and regulation of pyruvate dehydrogenase complex. Enzyme enzyme interaction, multiple forms of enzymes with special reference to lactate dehydrogenase.

Course code BC 1.5

Laboratory course **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the laboratory techniques of biochemistry. This course is very much essential for providing the students hands on training for carrying out experiments in biochemistry. It opens up the scope of further research in biochemistry. Without this knowledge of practical training the students cannot pursue other courses of biochemistry.

Course content:

Bioinformatics

Module I: Basic Programming (R in biology)
Module II: Simple Text mining for Sequence Data Bases
Module III: Using Structure Databases (PDB) - Relational data bases - Blast Search –Phylogeny
Module IV: Basic biostatistics using R.

Bioorganic preparations

1. An aromatic alpha- and beta-glucoside starting with glucose
2. Dinitrophenyl hydrazone of ascorbic acid or any other ketone
3. Dinitrophenyl derivative of an amino acid
4. Fractionation of egg proteins and its quantification
5. Isolation of casein from milk and its quantification

Practical on Enzymology

1. Protein estimation methods
2. Assay of enzyme activity
3. Time course of enzymatic reaction.
4. Influence of substrate concentration on the rate of enzymatic reaction.
5. Effect of pH and temperature on the rate of enzyme reaction.
6. Specificity of enzyme action.
7. Inhibition of enzyme activity.
8. Determination of Km values.

Course code BC 1.6

AECC (Ability Enhancement Course)

Understanding and presenting scientific literature Credit 2 Marks 25

Course outcome: On completion of this course the students will be (i) familiar with journals in Biochemistry and related disciplines, (ii) Bibliographic and literature search using abstract (Web of Science, etc) and full text database platforms (Scopus, Science Direct), (iii) Bibliographic formatting using proprietary software like End Note or other open source ones. (iv) ability to read review/research papers, understand, and discuss them (v) able to improve presentation skill using ICT tools.

Course content:

Awareness about scientific journals and publishers, Open access, Citation indexes, peer reviewed journals, names of sub discipline specific journals.

Tools for literature searches- abstract and full text, awareness about different databases

Citation styles, formatting tools for references-End Note, MS Word-References and review modes

Current review topics of relevance to be selected for discussion by students moderated by the teacher

Introduction to power point presentations, Tips and guidance for better presentation of scientific topics.

Semester –II

Course code BC 2.1

Metabolism Credit 4 Marks 50

Course outcome:

This course will familiarize the students with the major basic metabolic pathways of the living systems. In metabolism II students will be introduced to more complex metabolic systems existing the living world. This is a very important essential course of classical biochemistry that attracts students both from chemistry and biology. Knowledge acquired in the metabolism course in biochemistry can be considered as keystone of biochemistry course and further concepts of biochemistry will be built upon this basic foundation.

Course content:

1. **Lipids –** Introduction, hydrolysis of tri-acylglycerols, α-, ß- and ω- oxidation of fatty acids. Oxidation of odd numbered fatty acids – fate of propionate, role of carnitine, degradation of complex lipids. Fatty acid biosynthesis, Acetyl CoA carboxylase, fatty acid synthase, ACP structure and function, Lipid biosynthesis, biosynthetic pathway for tri-acylglycerols, phosphoglycerides, sphingomyelin and prostaglandins. Metabolism of cholesterol and its regulation.
2. **Nucleotides –** Biosynthesis and degradation of purine and pyrimidine nucleotides and its regulation. Purine salvage pathway. Role of ribonucleotide reductase. Biosynthesis of deoxyribonucleotides and polynucleotides including inhibitors of nucleic acid biosynthesis.
3. **Biosynthesis of vitamins –** Ascorbic acid, thiamine, pantothenic acid and folic acid.
4. **Biochemistry** of biological nitrogen fixation.
5. **Porphyrins –** Biosynthesis & degradation of porphyrins. Production of bile pigments.
6. **Plant Hormones –** Growth regulating substances and their mode of action, molecular effects of auxin in regulation of cell extension, effects of gibberellic, abscisic acids and cytokinins in the regulation of seed dormancy, germination, growth and development.

Course code BC 2.2

Bioanalytical Techniques **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the state of the art techniques followed in analytical biochemistry. This course is complementary to the laboratory courses. While in laboratory courses the students will be introduced to practical knowledge of the analytical techniques to some extent, this course will provide them theoretical knowledge to understand the rationale behind each analytical methodology.

Course content:

1. **Spectroscopy -** Concepts of spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry. Visible and UV spectroscopy, Fluorescence spectroscopy, Raman spectroscopy.
2. **Biophysical techniques**- ORD, CD, X-ray diffraction and NMR.
3. **Bioseparation techniques**-Principles and applications of paper, thin layer, ion exchange, affinity, gel filtration, adsorption and partition chromatography. HPLC and FPLC, Principle of centrifugation, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, sub-cellular fractionation.
4. **Electrophoretic techniques –** Principles of electrophoresis. Types of electrophoresis including paper, cellulose, acetate/nitrate and gel. DNA, RNA and Protein electrophoretic gels. Pulse field gel electrophoresis.

5. **Bio-imaging techniques–** Principle and techniques of Transmission and Scanning electron microscopy, Phase contrast, Fluorescence and Confocal microscopy, freeze fracture techniques. Different staining procedures in tissue sections.

Course code BC 2.3

Molecular Biology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the all the molecular biology background which has not yet been covered in the syllabus. These areas are very important. Without studying this course the M.Sc. program in biochemistry will remain ever incomplete. This course will impart knowledge about all the aspects of emergent areas of molecular biology and its latest status. This is mainly a research oriented course and increase the visibility of studying biochemistry as a research oriented subject.

Course content:

1. **DNA Replication -** Mechanism of replication, the replicons, origin, primosome and replisomes, properties of prokaryotic and eukaryotic DNA polymerases, synthesis of leading and lagging strands, difference between prokaryotic and eukaryotic replication.
2. **Mechanism of Transcription –** Prokaryotic transcription, promoters, properties of bacterial RNA polymerase; initiation, elongation and termination. Eukaryotic transcription, promoters, enhancers, factors & properties of RNA polymerase I, II, & III. Reverse transcription. Inhibitors of transcription.
3. **Post transcriptional Processing -** Maturation of rRNA, mRNA and tRNA; RNA splicing, introns and exons, consensus sequence function. Poly A tail, 5' capping.
4. **Recombination –** General recombination, site specific recombination and replicative recombination.
5. **Genetic Code –** Deciphering of the codons, reading frame of a sequence, Start/stop codons, degeneracy of the genetic code, Wobble hypothesis, variations to the standard genetic code.
6. **Translation in Pro- and Eukaryotes –** Ribosomes, structure, functional domain and subunit assembly, cell free protein synthesis, direction of protein synthesis (Dintzis experiment), adaptor role of tRNA, formation of initiation complex, chain elongation, translocation & termination, and role of respective factors involved therein. Inhibitors of protein biosynthesis. Comparison of protein biosynthesis in prokaryotes with eukaryotes. Post Translational processing – Proteolytic cleavage, covalent modifications, glycosylation of proteins, disulfide bond formation.
7. **Protein Localization** – Co- and post-translational protein traslocation; chaperones and protein folding, signal sequences, translocons, leader sequences.
8. **Regulation of Transcription and Translation -** Positive and negative control, Repressor & Inducer, concept of operon, lac-, ara-, trp-operons, attenuation, catabolite repression, autogenous regulation, lytic cycle of bacteriophage, stringent response of rRNA synthesis. Hormonal control, transcription factors, steroid receptors. DNA binding motifs in pro- & eukaryotes, helix-turn-helix, zinc fingers, leucine zippers/b zip, helix-loop-helix motifs.

Course code BC 2.4

Microbiology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the biochemistry of microbes. This course is very much essential for the skill enhancement in biochemistry. Knowledge of microbial biochemistry will open up the door for the students for the job positions of microbiologists in pharmacy, medicine and diagnostic laboratory. The course is designed in such a way so that it introduces students to the basic knowledge of microbiology.

Course content:

1. **Microbial Physiology:** Organization and structure of microorganisms: Morphology, cellular genetic information, Stress response, two component signaling system, and survival through the production of spores. Factors influencing bacterial growth: pH, temperature, oxygen, salt, water activity, pressure: Mechanism of survival of acidophiles, alkaliphiles, halophiles, Chemotaxis, Biofilm formation, Quorum sensing.

2.**Growth of bacteria:** Growth of bacteria in liquid medium, methods of measurement of growth, growth kinetics, relation of growth to substrate concentration, the chemostat, synchronized growth, growth on solid medium, uses of solid media, techniques of pure cultures, differential media, selective media, synthetic media.

3.**Staining of bacterial cells:** Stains and Staining, dyes, chromophoric and auxo-chromic groups, classification of biological stains, basic dyes, acid dyes, principle of staining: physical and chemical, mordants, simple staining, Differential staining, Gram staining, Mechanism of Gram and acid- fast staining, Endospore staining.

4. **Control of microorganisms by antibiotics:** Characteristics of an ideal antimicrobial chemical agent and its selection for practical application. Classes of antibiotics and their properties; Structure and mode of action of antimicrobial agents: Aminoglycosides, Carbapenems, macrolids, β-lactam antibiotics, Quinolones and fluoroquinolones, Sulphonamides, Tetracyclines, Chloramphenicol, Chloroquine, Rifampicin, Streptolydigin, Puromycin; Antiviral drug structures and their mode of action, microbiological assay of antibiotics, nonmedical uses of antibiotics.

5. **Transformation:** Discovery of Transformation, Competence, Regulation of competence in *B. subtilis*, Experimental evidence for models of natural transformation, Plasmid transformation and phage transfection of naturally competent bacteria, Role of natural transformation, Importance of natural transformation for forward and reverse genetics, artificially induced competence.

6. **Conjugation:** Classification of self-transmissible plasmids, Mechanism of DNA transfer during conjugation in Gram negative bacteria, Chromosome transfer by plasmids, Formation of Hfr strains, Transfer of chromosomal DNA by integrated plasmids, Chromosome mobilization, Prime factors, mapping genes by interrupted mating, fine structure analysis of genes, Transfer system of Gram positive bacteria, Plasmid attracting pheromones.

7. Horizontal gene transfer mediated by bacteriophages. Specialized and generalized transduction.

8. Evolution of host immune responses against bacteriophages. Innate immunity and the role of altruism in host defensive mechanism. Acquired immunity against bacteriophages – CRISPr-Cas based immunity.

Course code BC 2.5

Laboratory course **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the laboratory techniques of biochemistry. This course is very much essential for providing the students hands on training for carrying out experiments in biochemistry. It opens up the scope of further research in biochemistry. Without this knowledge of practical training the students cannot pursue other courses of biochemistry.

Course content:

Analytical techniques

1. Titration of a weak acid using a pH meter, preparation of buffers
2. Determination of isoelectric point of amino acid
3. Verification of Beer-Lambert's law and estimation of absorption coefficient
4. Paper chromatography – Separation of amino acids and carbohydrates in a mixture
5. Thin layer chromatography of fatty acids.
6. Column chromatography – Separation of a mixture of protein and salt using Sephadex column
7. Electrophoresis

Microbiology and immunology

1. Preparation of stains and reagents
2. Preparation of various culture media
3. Preparation of broth and slants
4. Sterilization of culture media by autoclave method
5. Sterilization of glassware by hot air oven
6. Isolation and propagation of bacteria
7. Staining of bacteria – Simple staining, differential staining, staining of spores and capsules
8. Determination of growth curve of bacteria
9. Biochemical tests and motility for the identification of bacteria
10. Precipitin reaction by double immunodiffusion and radial immunodiffusion (Ouchterlony and Mancini's methods)
11. Detection of antibodies or antigen by ELISA (Indirect and Sandwich ELISA)
12. Detection of antigens by immunoblotting technique

SEC (Skill Enhancement Course)

Course code BC 2.6

Nutritional Biochemistry **Credit 2** **Marks 25**

Course outcome:

This course will familiarize the students with the nutritional biochemistry concepts which are very fundamental to biochemistry. This course is very much essential for the skill enhancement in biochemistry. Knowledge of nutritional biochemistry will open up the door for the students for the job positions of nutritionists or dieticians in hospitals and diagnostic laboratories. The course is designed in such a way so that it introduces students to the basic knowledge of nutrition and food chemistry.

Course content:

1. **Basic concepts -** Function of nutrients. Measurement of the energy values of foods. Direct and indirect calorimetry. Basal metabolic rate; factors affecting BMR, measurement and calculation of BMR. Measurement of energy requirements. Specific dynamic action of proteins. Recommended dietary allowances.
2. **Elements of nutrition –** Dietary requirement of carbohydrates, lipids and proteins. Biological value of proteins. Concepts of protein quality. Protein sparing action of carbohydrates and fats. Essential amino acids, essential fatty acids and their physiological functions.
3. **Vitamins –** Dietary sources, biochemical functions, requirements and deficiency diseases associated with vitamin B complex, C and A, D, E & K vitamins.
4. **Minerals –** Nutritional significance of dietary calcium, phosphorus, magnesium, iron, iodine, zinc and copper.
5. **Malnutrition –** Prevention of malnutrition, improvement of diets.

Semester –III

Course code BC 3.1

Plant Biochemistry **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the major biochemical pathways existing specifically in plant system. This course is very interesting and will introduce students to some unique biochemical system hitherto they have not studied. Knowledge about plant biochemistry is very essential for understanding the basic physiology of plants. This course is lucrative in job market as many agricultural institutes offer the position of plant biochemists. This course will also prepare students for later on higher studies in research in the arena of plant biochemistry.

Course content:

1. **Electron transport system in plants -** Oxidative phosphorylation, mitochondrial respiratory complexes, order and organization of electron carriers, electrochemical gradient, chemiosmotic theory, ATP synthase and mechanism of ATP synthesis.

2. **Nitrate assimilation** - Structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation.
3. **Photosynthesis –** Photosynthetic apparatus, pigments of photosynthesis, role of carotenoids, photosystems I and II, their location; Hill reaction, photosynthetic electron transport and generation of NADPH & ATP, cyclic and non-cyclic photo-phosphorylations, complexes associated with thylakoid membranes; light harvesting complexes, path of carbon in photosynthesis – C3 and C4 pathway of carbon reduction and its regulation, Photorespiration.
4. **Special features of secondary plant metabolism** - Classification, biosynthesis of terpenes, lignin, tannins, pigments, phytochrome, waxes, alkaloids, biosynthesis of nicotine, functions of alkaloids, cell wall components.
5. **Toxins of plant origin –** Mycotoxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins and alkaloids.
6. **Stress metabolism in plants -** Environmental stresses, salinity, water stress, heat, chilling, anaerobiosis, pathogenesis, heavy metals, radiations and their impact on plant growth and metabolism, criteria of stress tolerance.

Course code BC 3.2

Immunology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the basic immunological concepts which are very fundamental to biochemistry. Without the knowledge of diverse immune responses, mechanisms and antigen-antibody interactions, students will lag behind in medical biochemistry. This course on basic immunology is very essential to expose the students in the field of cancer biology and immuno-deficiency diseases, the primary research area of modern day biochemistry.

Course content:

1. **Introduction to immune system –** Innate and acquired immunity. Structure and functions of primary and secondary lymphoid organs.
2. **Cells involved in immune responses –** Lymphoid cells (B-lymphocytes, T-lymphocytes and Null cells), mononuclear cells (phagocytic cells and their killing mechanisms), granulocytic cells (neutrophils, eosinophils and basophils), mast cells and dendritic cell.
3. **Nature of antigen and antibody –** Immunogenicity vs antigenicity, factors influencing immunogenicity, epitopes, haptens, adjuvants and mitogens. Classification, fine structure and functions of immunoglobulins, antigenic determinants on immunoglobulins, isotypic, allotypic and ideotypic variants.
4. **Generation of Diversity in Immune system –** Clonal selection theory - concept of antigen specific receptor. Organization of immunoglobulin genes: generation of antibody diversity, T-cell receptor diversity.
5. **Immune effector Mechanisms –** Kinetics of primary and secondary immune responses, complement activation and its biological consequences, cytokines and co-stimulatory molecules: role in immune responses, Antigen processing and presentation.

6. **Major histocompatibility complex (MHC) genes and products –** Polymorphism of MHC genes, role of MHC antigens in immune responses, MHC antigens in transplantation.
7. **Measurement of antigen–antibody interactions –** Agglutination, precipitation and opsonization, gel diffusion (Ouchterlony double immunodiffusion and Mancini's Radial immunodiffusion), immunoblotting, RIA, ELISA and ELISPOT.
8. **Tolerance vs activation of immune system –** Immune tolerance, hypersensitivity (Types I, II, III, IV).
9. **Disorders of immune system –** Autoimmunity, congenital immunodeficiencies, acquired immunodeficiencies.

Course code BC 3.3

Cell Biology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the advanced aspects of cell biology including cell signaling and cancer biology. These are considered to be the most relevant arenas of biochemistry and gaining state of the art knowledge in these sectors is very much important. Students will be introduced to these very contemporary areas and this knowledge will complement all the other courses so far studied. It will also help the students to decide upon pursuing higher studies in this very much contemporary field.

Course content:

Cellular Communication:
1. Introduction to cell signaling, fundamental commonalities and evolution of signaling pathways; Role of PTMs in signaling; Subcellular localization and signaling molecules; Second messengers, Sensors and effectors ; The modular architecture and evolution of signaling proteins; Methods for studying signaling networks.
2. Signaling enzymes and their allosteric regulation Receptor Tyrosine kinases, Receptor Ser/Thr Kinase Receptor histidine kinases, Heterotrimeric and monomeric and G protein signaling.
3. Lipid modifying enzymes in signaling; Light mediated signaling; Regulated protein degradation mediated signaling.
4. Information transfer across membrane; Information processing and networks.

Cell Cycle, Cancer and Apoptosis:
1. Introduction to the cell cycle, phases, why cells divide, biochemical and physiological hallmarks of each phase; Introduction to Cyclins and CDKs, their discovery, Principles of regulation of CDK activity. Experimental approaches to study cell cycle, Molecular basis of START/Restriction point, Transcriptional regulation of cell cycle, protein degradation and irreversibility of the cell cycle (APC and SCF), spatiotemporal regulation of phase transition. Restriction of replication to once per cell cycle, Cytokinesis.
2. Introduction to checkpoints- sensors and effectors, molecular mechanism of checkpoint activation, DNA damage and replication checkpoints, chromosome segregation checkpoint, spindle orientation and assembly checkpoint. Checkpoint override and outcomes. Cell Junctions, Cell Adhesion and the Extracellular Matrix.

3. Cancer: Introduction, epigenetic and genetic regulation; defective control of cell death and differentiation, cancer stem cell, cancer critical genes,Infection and cancer.
Apoptosis: introduction, caspases, Pro and anti apoptotic genes, Fas mediated apoptosis; Mitochondria dependent pathways, inhibitory pathways of apoptosis, regulation, implication in diseases; Autophagy, senescence.

DSE (Department Specific Elective)

Course code BC 3.4

Neurobiochemistry **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the neurobiochemistry and human physiological biochemistry and enrich their knowledge so that they can compete with the students studying medical biochemistry courses. They will learn the biochemistry associated with different neurological events. It will help them in choosing later careers in medical diagnostics and pharmacy as biochemists.

Course content:

1. **Muscle Biochemistry –** Skeletal muscle structure. Actin, myosin, tropomyosin, troponin. Molecular mechanism of contraction. Functional classification of skeletal muscle fibers. Twitch. The motor unit.
2. **Neuromorphology –** Organisation of neuron, dendrites and axons. Glial cells – astrocytes, oligodendrocytes, ependymal cells, Schwan cells. Nerve fiber types and functions.
3. **Neurophysiology** – Generation and conduction of monophasic action potential, saltatory conduction. Synaptic transmission, Neurotransmitters and their action. Blood Brain barrier.
4. **Transport across membranes –** Types of transport, passive and active transport, co-transport – primary and secondary group translocation, transport ATPases, transport by vesicle formation.
5. **Neurological disorders –** Headache, facial pain, migraine, epilepsy, multiple sclerosis, Myasthenia Gravis.

DSE (Department Specific Elective)

Course code BC 3.4

Clinical Biochemistry **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the medical biochemistry and enrich their knowledge so that they can compete with the students studying medical biochemistry courses.

They will learn the basic biochemistry associated with different diseases and also the biochemical mechanisms associated with the diagnosis of several important diseases. It will help them in choosing later careers in medical diagnostics.

Course content:

1. **Disorders of Carbohydrate Metabolism -** Diabetes mellitus, glucose and galactose tolerance tests, sugar levels in blood, renal threshold for glucose, factors influencing blood glucose level, glycogen storage diseases, pentosuria, galactosemia.
2. **Disorders of Lipids –** Plasma lipoproteins, cholesterol, triglycerides and phospholipids in health and disease, hyperlipidemia, hyperlipoproteinemia, Gaucher's disease, Tay-Sach's and Niemann-Pick disease, ketone bodies, Abetalipoproteinemia.
3. **Inborn Errors of metabolism –** Phenylketonuria, alkaptonuria, albinism, tyrosinosis, maple syrup urine disease, Lesch-Nyhan syndrome, sickle cell anemia, histidinemia.
4. **Digestive diseases –** Maldigestion, malabsorption, creatorrhoea, diarrhoea and steatorrhoea.
5. **Disorders of liver and kidney –** Jaundice, fatty liver, normal and abnormal functions of liver and kidney. Inulin and urea clearance.
6. **Electrolytes and acid-base balance –** Regulation of electrolyte content of body fluids and maintenance of pH, reabsorption of electrolytes.
7. **Diagnostic Enzymes –** Enzymes in health and diseases. Biochemical diagnosis of diseases by enzyme assays – SGOT, SGPT, CPK, cholinesterase, LDH.
8. **Abnormalities in Nitrogen Metabolism –** Uremia, hyperuricemia, porphyria and factors affecting nitrogen balance.
9. **Blood Clotting –** Disturbances in blood clotting mechanism – hemorrhagic disorders – hemophilia, von Willebrand's disease, purpura, Rendu-Osler-Werber disease, thrombotic thrombocytopenic purpura, disseminated intravascular coagulation, acquired prothrombin complex disorders, circulating anticoagulants.
10. **Cancer –** Carcinogenesis, Carcinologen, causes and types of cancer, Cell proliferation and apoptosis, Role of cell cycle proteins in cancer cell proliferation, Cancer diagnosis and cancer therapy.

Course code BC 3.5

Laboratory course **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the laboratory techniques of biochemistry. This course is very much essential for providing the students hands on training for carrying out experiments in biochemistry. It opens up the scope of further research in biochemistry. Without this knowledge of practical training the students cannot pursue other courses of biochemistry.

Course content:

Analytical biochemistry

1. Qualitative analysis, quantitation of glucose and ribose.
2. Qualitative analysis, quantitation of proteins and amino acids.
3. Quantitation of free and bound phosphate.
4. Quantitation of vitamin C.
5. Acid number, saponification and iodine values.

Molecular biology

1. Preparation of competent cells, transformation
2. Isolation of plasmid DNA,
3. Restriction digestion, agarose gel electrophoresis
4. Isolation of genomic DNA
5. Polymerase Chain Reaction
6. mRNA isolation, cDNA preparation and qPCR
7. Recombinant protein expression in *E.coli*.

GEC (General Elective Course)

Course code BC 3.6

Fundamentals of Biochemistry **Credit 4** **Marks 50**

Course outcome:

This course is meant for the students other than the department of Biochemistry. It will familiarize the students with the preliminary concepts of biochemistry. These are considered to be the very primary arenas of biochemistry and gaining state of the art knowledge in these sectors is very much important. It will also help the students of related departments to decide upon pursuing higher studies in related fields.

Course content:

1. **pH and Buffers**: Bronsted-Lowry Concept of Acids and Bases, Buffers: Henderson Hasselbalch equation, Biological buffer systems: The phosphate buffer system, The bicarbonate buffer system, The protein buffer system, The amino acid buffer system, The hemoglobin buffer system.
2. **Biomolecules:**

Carbohydrates: Importance, Nomenclature, Classification, Asymmetry, Optical Isomerism, Mutarotation, General structure of monosaccharide, disaccharide, oligosaccharides, polysaccharides (Lactose, Maltose, Cellobiose, Isomaltose, Trehalose, Starch, Glycogen, Cellulose, Pectin, Chitin, Heparin.

Proteins: Importance, Amino Acids: Structure, Distribution in Proteins, Location in proteins, Physical properties, Electrochemical properties, Classification, Nonprotein Amino Acids, Peptide bonds, Chemical Bonds involved in Protein structure. Protein Configuration: Primary Structure, Secondary Structure, Tertiary Structure, Quaternary Structure. Physical Properties of

Proteins: Shape and Size, Molecular weight, Colloidal nature, Denaturation, Amphoteric nature, Solubility, Optical Activity, Chemical Properties of Protein: Hydrolysis, Reaction involving COOH group, NH2 group, R group, SH group.

Lipids: Importance, Definition, Alcohols and Fatty Acids, Biological roles oflipids,Classification: Simple Lipids and Compound Lipids, Properties of Fats and oils: Solubility, Melting Point, Insulation, Emulsification, Surface Tension, Chemical Properties: Reactions involving COOH group, Hydrolysis, Saponification, Rancidity, Hydrogenation, Halogenation, Oxidation, Oxidative Rancidity, Reactions involving OH group, Dehydration.

Nucleic Acids: Nucleosides, Nucleotides, DNA, Inter nucleotide linkages, Base composition, Evolution of Watson-Crick model; Double helical structure, Denaturation and renaturation, Molecular weight, Length, Shape and Size, Variants of Double helical DNA, DNAs with unusual structures, Single stranded DNA, RNA. Differences with DNA, Ribosomal RNA, Transfer RNA, Messenger RNA, Heterogeneous nuclear RNA.

Semester –IV

Course code BC 4.1

Methods in Molecular Biology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the theoretical background of molecular biology that will help them later in following the laboratory classes on molecular biology. Molecular biological methods will expose the students with most of the state of the art of knowledge on molecular biology which is basically an interdisciplinary science. It will promote the research oriented rationales in student's mind and encourage them towards higher studies. Research options are very much open in the field of molecular biology.

Course content:

1. **Recombinant DNA methods –** Features of commonly used vectors, strategies for cloning in various vectors and Identification of bacterial colonies containing recombinant plasmids, and bacteriophage vectors. Restriction enzymes.
2. **Construction and analysis of c-DNA and genomic libraries** - Protocols and strategies for c-DNA cloning, analysis of genomic DNA by southern hybridization, amplification of DNA by the polymerase chain reaction, preparation of radio-labeled DNA and RNA probes, synthetic oligonucleotide probes, expression of cloned genes in cultured cells, screening expression with antibodies and oligonucleotides.
3. **DNA sequencing –** Rapid DNA sequencing methods; Maxam-Gilbert technique, Sanger's Dideoxynucleotide sequencing, gene walking, foot printing, RNA sequencing.
4. **Application of recombinant technology –** production of insulin, drug, vaccines, diagnostic probe of genetic diseases. Gene therapy.
5. **Chromatin –** Heterochromatin, euchromatin. Histone and non-histone proteins, general properties of histone, packing density, nucleosomes, size, variable linkers, solenoid structure, packaging of DNA, satellite DNA.

6. **Genes –** Prokaryotic and eukaryotic genes, pseudogenes, split genes, super gene family, transposons, C value paradox. Reassociation kinetics.
7. **Mutation –** Types of mutations, mechanism of mutation, mutagenic agents. DNA repair: UV repair system in *E. coli*.

Course code BC 4.2

Biotechnology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the latest biotechnological background which has not yet been covered in the syllabus. These areas are very important. Without studying this course the M.Sc. program in biochemistry will remain ever incomplete. This course will impart knowledge about all the aspects of emergent areas of biotechnology and its latest status. This is mainly an application oriented course and opens up the opportunity of the students to choose career in biotechnology in industries and academic institutes.

Course content:

1. **Plant genetic engineering** - Prospects of improving crop productivity, gene isolation, gene transfer systems, Ti plasmid, plant virus vectors, electroporation, microinjection, microprojectile technology, gene expression, regeneration. Application in relation to protein quality, photosynthetic efficacy, nitrogen fixation efficiency and resistance to environmental stresses.
2. **Tissue culture –** Plant tissue culture, anther and pollen culture, protoplast culture, protoplast fusion, embryo rescue, animal cell lines and organ culture.
3. **Transgenic plants and animals** – Advances in producing transgenics, transgenic animals.
4. **Fermentation technology –** Fermentors, general design of fermentor, fermentation processes, production of alcohols, antibiotics, steroids and enzymes; biotransformation, biomass & production of single cell protein.
5. **Hybridoma technology –** Monoclonal antibodies, selection of hybrids, hybridomas, purification and application of monoclonal antibodies.
6. **Xenobiotic metabolism –** Biodegradation, detoxification of xenobiotics by micro-organisms, biodegradation of hydrocarbons, pesticides, surfactants, polyaromatic hydrocarbons, dyes; role of cytochrome P450 in detoxification.
7. **Proteomics –** Genome to Proteome, steps and tools for proteome analysis, 2 D-Electrophoresis, BNPAGE.
8. **Enzyme Technology -** Large scale production of enzymes, enzyme reactors, immobilization of enzymes by chemical and physical methods. Synzymes, enzyme electrodes and biosensors.

Course code BC 4.3

Genetics and Epigenetics Credit 4 Marks 50

Course outcome:

This course will familiarize the students with the latest knowledge about Mendelian genetics, human genetics, bacterial and viral genetics and epigenetics. This knowledge is complementary to the earlier molecular biology courses covered in the syllabus. This course is an important component of M.Sc. Biochemistry program. This course will impart knowledge about all the aspects of emergent areas of genetics and its latest status. This is mainly research oriented course and pursuing this course will make the students more apt towards taking decisions about research career.

Course content:

1. **Mendelian principles:** Dominance, segregation, independent assortment.
2. **Concept of gene:** Allele, multiple alleles, pseudoallele, complementation tests
3. **Extensions of Mendelian principles :** Codominance, incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters.
4. **Gene mapping methods:** Linkage maps, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.
5. **Extra chromosomal inheritance:** Inheritance of Mitochondrial and chloroplast genes, maternal inheritance.
6. **Bacteriophage genetics**: Basics concepts of bacteriophage growth and assay methods. Classical concepts of gene structure and function derived from bacteriophage genetics. (2)
7. **Host-phage interaction mechanisms.** Understanding gene regulatory circuits using bacteriophages as model systems. Decision making modules that control fate of lysogenic bacteriophages such as. Re-appropriation of host metabolism by bacteriophages using T4 as the model system.
8. **Human genetics:** Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.
9. Quantitative genetics: Polygenic inheritance, heritability and its measurements, QTL mapping.
10. Mutation: Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants, insertional mutagenesis.
11. Structural and numerical alterations of chromosomes: Deletion, duplication, inversion, translocation, ploidy and their genetic implications.
12. Recombination: Homologous and non-homologous recombination including transposition.
13. Epigenetics: DNA methylation, histone modifications, chromatin modifications, epigenetic regulation of gene expression, gene silencing in fungi, yeast and plant system, non-coding RNAs in epigenetic regulation, epigenetics and imprinting, X inactivation, epigenetics and human disease (cancer), epigenetic inheritance, differences between Mendelian and epigenetic inheritance, phenotypic plasticity: epigenetics and environment, epigenetic biomarkers.

DSE (Department Specific Elective)

Course code BC 4.4

Developmental biology **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the advanced aspects of developmental biology in plants and animals. This preliminary knowledge of developmental biology is very much essential for the students to qualify in CSIR-UGC NET examinations as questions are very frequently made from this part of the syllabus. Developmental biology is an emergent subject and this course will introduce students to a very preliminary level to build up basic concepts in this arena.

Course content:

1. **Basic concepts of development :** Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development
2. **Gametogenesis, fertilization and early development:** Production of gametes, cell surface molecules in sperm-egg recognition in animals; embryo sac development and double fertilization in plants; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; embryogenesis, establishment of symmetry in plants; seed formation and germination.
3. **Morphogenesis and organogenesis in animals :** Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia and chick; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.
4. **Morphogenesis and organogenesis in plants:** Organization of shoot and root apical meristem; shoot and root development; leaf development and phyllotaxy; transition to flowering, floral meristems and floral development in *Arabidopsis* and *Antirrhinum*
5. **Programmed cell death, aging and senescence:** Basic concepts, types of cell death, PCD in life cycles of plants and animals, metabolic changes associated with senescence and its regulation; influence of hormones and environmental factors on senescence.
6. **Developmental processes:** Embryonic development, Morphogen gradient, asymmetric cell division;Maternal effect genes, Polarity development (dorsoventral and anterior-posterior): Dorsal (ventral), Dpp (dorsal), Bicoid (anterior), Hunchback (anterior), Nanos (posterior);Pattern formation: Notch-Delta (lateral inhibition), Hedgehog, Wnt.

DSE (Department Specific Elective)

Course code BC 4.4

Ecological principles **Credit 4** **Marks 50**

Course outcome:

This course will familiarize the students with the basic principles of ecology. This preliminary knowledge of ecology is very much essential for the students to qualify in CSIR-UGC NET examinations as questions are very frequently made from this part of the syllabus. Ecology is an integrated interdisciplinary science and students from all background must be exposed to a very preliminary level to build up basic concepts in this arena. Study of ecology is very closely related to environmental protection and conservation which are very contemporary study areas in the field of environmental sciences.

Course content:

1. **Habitat and Niche:** Concept of habitat and niche; niche width and overlap; fundamental and realized niche; resource partitioning; character displacement.
2. **Population Ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal, interdemic extinctions, age structured populations.
3. **Species Interactions:** Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.
4. **Community Ecology:** Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.
5. **Ecological Succession:** Types; mechanisms; changes involved in succession; concept of climax.
6. **Ecosystem Ecology:** Ecosystem structure; ecosystem function; energy flow and mineral cycling (C,N,P); primary production and decomposition; structure and function of some Indian ecosystems: terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine).
7. **Applied Ecology:** Environmental pollution; global environmental change; biodiversity: status, monitoring and documentation; biodiversity indices; major drivers of biodiversity change; biodiversity management approaches.
8. **Conservation Biology:** Principles of conservation, key stone, umbrella, flagship, indicator species concept, IUCN categories of threatened species and its characteristics, major approaches to management, Indian case studies on conservation/management strategy (Project Tiger, Biosphere reserves).
9. **Metagenomics** – Introduction; Pure culture and in consortium; Cultivable and Non-cultivable microbial analysis; Molecular fingerprinting techniques (RFLP, T-RFLP, ARISA, DGGE, 16S rDNA based library screening, and FISH); Stable isotope probing (SIP); Microarrays & Metagenome sequencing; Next-generation sequencing approaches to metagenomics, Sequence-based Metagenomics Analysis and Function based Metagenomics Analysis; Phylogenetic analysis

10. **Metagenomic case studies-** Metagenomic analysis of soil microbial communities; Metagenomic analysis of marine, microbial communities; Metagenome of the Microbial Community in Acid Mine Drainage, Human Microbiome, Bioprospecting of Novel Genes.

Dissertation project submission and project presentation (BC 4.5)

Credit 8 Marks 100

Course outcome:

This course will familiarize the students with the laboratory techniques of biochemistry. This course is very much essential for providing the students hands on training for carrying out experiments in biochemistry. It opens up the scope of further research in biochemistry. Without this knowledge of practical training the students cannot pursue other courses of biochemistry.

Course content:

Students will have to carry out a 2-month duration project work supervised by any faculty of any recognized institute in the field of biochemistry and prepare a dissertation project for submission and evaluation. Students will also deliver a power-point presentation to face the critical evaluation.