Annex - 2

Hemvati Nandan Bahuguna Garhwal University
(A Central University)

Department Of Biochemistry
NEP-Based Program Framework For
M. Sc. Biochemistry

P.G. (First Year)- First semester

Entry requirement	3-year bachelor's degree (120 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations.					
Course Code	Course category		Course title	Credits		Total Credit
				T	P	
SOLS/BCM-DSC-01	Discipline Specific Core	DSC-1	Biomolecules	5	-	5
SOLS/BCM-DSC-02		DSC -2	Human Physiology	5		5
SOLS/BCM-DSC-03		DSC -3	Plant Biochemistry	5	-	5
SOLS/BCM-DSCP-01	DSC Practical		Lab Course I	-	3	3
SOLS/BCM-DSE-01	Discipline Specific Elective (Any 1 out of Minimum 2 electives)		Analytical Techniques in Biochemistry	4	-	4
SOLS/BCM-DSE-02			Biosafety, Laboratory safety and IPR	4	-	4
SOLS/BCM-DSEP-01	Elective Practical		Lab Course II	-	2	2
Total				19	5	24

P.G. (First Year)- Second semester

Course Code	Course category		Course title	Credits		Total Credit
				T	P	
SOLS/BCM-DSC-04	Discipline Specific Core	DSC-1	Metabolic Pathways and Bioenergetics	5	-	5
SOLS/BCM-DSC-05		DSC -2	Basic Microbiology and Industrial Bioprocesses	5		5
SOLS/BCM-DSC-06		DSC -3	Advanced Nutritional Biochemistry	5	-	5
SOLS/BCM-DSCP-02	DSC Practical		Lab Course III	-	3	3
SOLS/BCM-DSE-03	Discipline Specific Elective (Any 1 out of Minimum 2 electives)		Neurobiochemistry	4	-	4
SOLS/BCM-DSE-04			Cancer Pathogenesis & Therapy	4	-	4
SOLS/BCM-DSE-05			Food Microbiology and Food Safety https://onlinecourses.swayam2.ac.in/cec25_ge05/preview	4	-	4
SOLS/BCM-DSEP-02			Lab Course IV	-	2	2
SOLS/BCM-DSEP-03			*Assignment Based Seminar I **(based on elective papers)**	-	2	2
Total				19	5	24
NHEQF Level-6	***Student on exit after successfully completing first year of two-year PG programme (i.e., securing minimum required 48 credits will be awarded "Postgraduate Diploma" of one year, in related field/discipline/subject.***					

Note: *Students may opt for an assignment-based seminar as a substitute for the Second Semester "**Elective Practical**" components. In such cases, where a SWAYAM course is opted as a DSE, the assignment-based seminar will be assessed as the practical component of the paper.

P.G. (Second Year)

- **Third semester (for Two-year program-** ***P.G. first-year passed students)***
- **First semester (For one-year program-*U.G. 4 years passed students)***

4-year bachelor's degree (160 credits), and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations Or P.G. First year with 48 credits					
Course Code	**Course category**	**Course title**	**Credits**		**Total Credit**
			T	**P**	
SOLS/BCM-DSC-07	**Discipline Specific Core** **DSC-1**	Fundamentals of Molecular Biology	**5**	-	**5**
SOLS/BCM-DSC-08	**DSC-2**	Molecular Mechanisms of Gene Regulation	**5**		**5**
SOLS/BCM-DSC-09	**DSC-3**	Advanced Enzymology	**5**	-	**5**
SOLS/BCM-DSCP-03	**DSC Practical**	Lab Course V	-	3	3
SOLS/BCM-DSE-05	**Discipline Specific Elective** (Any 1 out of Minimum 2 electives)	Molecular Cell Biology	**4**	-	4
SOLS/BCM-DSE-06		Applied Plant and Animal Biotechnology	**4**	-	4
SOLS/BCM-DSE-07		Research Methodology https://onlinecourses.swayam2.ac.in/cec25_lw04/preview	**4**	-	4
SOLS/BCM-DSEP-04		Lab Course VI	-	2	2
SOLS/BCM-DSEP-05		*Assignment Based Seminar II **(based on any Research/Review paper)**	-	2	2
Total			**19**	5	24

Note: *Students may opt for an assignment-based seminar as a substitute for the Third Semester "**Elective Practical**" components. In such cases, where a SWAYAM course is opted as a DSE, the assignment-based seminar will be assessed as the practical component of the paper.

P.G. (Second Year)

- **Fourth semester (for two year program-*P.G. first year passed students)***
- **Second semester (For one year program-*U.G. 4 years passed students)***

Course Code	Course category		Course title	Credits		Total Credit
				T	P	
SOLS/BCM-DSC-10	Discipline Specific Core	DSC-1	Genetic Engineering	5	-	5
SOLS/BCM-DSC-11		DSC-2	Immunology	5		5
SOLS/BCM-DSC-12		DSC-3	Clinical Biochemistry	5	-	5
SOLS/BCM-DSCP-04	DSC Practical		Lab Course VII	-	3	3
SOLS/BCM-DSE-07	Discipline Specific Elective (Any 1 out of Minimum 2 electives)		Dissertation			6
SOLS/BCM-DSE-08			Environmental Biochemistry & Toxicology	4	-	4
SOLS/BCM-DSE-09			Bio-statistics, Bio-informatics & Quality Management	4	-	4
SOLS/BCM-DSEP-06			Lab Course VIII	-	2	2
Total				19	5	24
NHEQF Level- 6.5	*Student on successfully completing two-year PG programme (i.e., securing minimum required 96 credits will be awarded "Postgraduate Degree", in related field/discipline/subject.*					

Note: ***In lieu of elective (Theory and practical= 4+2 credits), the departments may offer any one course, i.e. dissertation/project work of 6 credits***

P.G. (FIRST YEAR)- FIRST SEMESTER

Biomolecules SOLS/BCM-DSC-01

Course Objectives:

1. Extend comprehensive knowledge about the structure and properties of the cell's biomolecules (monomeric units).
2. To teach the students how monomeric molecules of carbohydrates, amino acids, lipids and nucleotides form covalent linkages to form polymers.
3. How these polymers of biomolecules assemble with each other to form supramolecular assemblies having structural and functional roles in cells.

Course Outcomes: At the end of the course, a student should be able to

1. Know about the structure and properties of the cell's biomolecules (monomeric units).
2. Understand how monomeric molecules of carbohydrates, amino acids, lipids and nucleotides form covalent linkages to form polymers.
3. Understand how these biomolecule polymers assemble to form supramolecular assemblies with structural and functional roles in cells.

Unit I

Carbohydrates: Classification and properties of simple carbohydrates, monosaccharides, disaccharides and polysaccharides. Structural polysaccharides: cellulose and chitin; storage polysaccharides: starch and glycogen; glycosaminoglycans; glycoconjugates: proteoglycans, glycoproteins and glycolipids

Unit II

Fatty Acids and Lipids: Structure, classification and properties of fatty acids, structure and functions of lipids: Triacylglycerides, phosphoglycerides, sphingolipids, cholesterol, steroids, eicosanoids, Lipoproteins

Unit III

Amino acids and proteins: Classification, chemical structure and general properties of amino acids. Standard and non-standard amino acids found in proteins. The peptide bond and its characteristics.

Unit IV

Structure and functions of DNA: Base pairing: Watson-crick, Hoogsteen and Wobble base pairs, The salient features of the Watson-Crick model of B-DNA, The structure and helical parameters of B-DNA, A-DNA, and Z-DNA. Melting temperature (T_m), Forces stabilizing the B-DNA.

Unit V

Structure and functions of RNA: Physicochemical properties of RNA, classification, structure and functions of different types of RNAs. The clover leaf and L-shaped structures of tRNA.

Suggested Readings:

- Biochemistry by Voet B and Voet JG, Wiley Publishers, USA

- Biochemistry 5th Revised edition by LubertStryer, Jeremy M. Berg, John L. Tymoczko, Macmillan Publishers, USA
- D.L. Nelson and M.M. Cox Lehninger Principles of Biochemistry, Publisher: WH Freeman; 8th ed.NewYork

Human Physiology SOLS/BCM-DSC-02

Course Objectives:

1. To provide a foundational understanding of human physiological systems and their biochemical mechanisms.
2. To explain homeostatic regulation, organ system interactions, and disease-related physiological dysfunctions.
3. To develop analytical and practical skills in physiological assessments and biomedical research.

Course Outcomes: At the end of the course, a student should be able to

1. Demonstrate knowledge of major physiological systems and their functions.
2. Apply physiological concepts to understand disease mechanisms and clinical conditions.
3. Perform laboratory experiments and analyse physiological data for research and diagnostics.

Unit I

Blood and Circulatory System - Composition and functions of plasma, Blood groups, Rh Factor, erythrocytes including Hb, Leucocytes and thrombocytes, and plasma proteins. Blood Coagulation – mechanism and regulation. Structure of the Heart and Blood Vessels, Cardiac Cycle and Heart Sounds, Regulation of Blood Pressure and Circulatory Disorders

Unit II

Digestive system – Composition and functions of saliva, gastric, pancreatic, intestinal and bile secretions. Digestion and absorption of carbohydrates, lipids, proteins, & nucleic acids. Role of Microbiota in Digestion, Nutritional Disorders (Obesity, Malnutrition)

Unit III

Respiration – Air passages and fine structure of alveoli, pulmonary volumes, alveolar surface tension, work of breathing and its regulation. Exchange of gases, transport of O_2 and CO_2 in blood, O_2 and CO_2, dissociation curves, role of 2, 3-diphosphoglycerate, Bohr effect and chloride shift, control and regulation of respiration, disorders associated with respiration system (Asthma, COPD, Respiratory Acidosis/Alkalosis)

Unit IV

Endocrine system – Secretion and functions of hormones of thyroid, pituitary and gonads. Mechanism of action of hormones.

Unit V

Excretory system – Structure of nephron, glomerular filtration, tubular reabsorption of glucose, water and electrolytes. Tubular secretion. Homeostatic regulation of water and electrolytes, Acid-base balance.

Suggested Readings:

1. Hall, J. E. (2020). *Guyton and Hall Textbook of Medical Physiology* (14th ed.). Elsevier. ISBN: 978-0323672801.
2. Barrett, K. E., Barman, S. M., Brooks, H. L., & Yuan, J. X. (2019). *Ganong's Review of Medical Physiology* (26th ed.). McGraw Hill. ISBN: 978-1260122404.
3. Silverthorn, D. U. (2018). *Human Physiology: An Integrated Approach* (8th ed.). Pearson. ISBN: 978-0134605197.

Plant Biochemistry SOLS/BCM-DSC-03

Course Objectives:

1. To understand the biochemical principles of photosynthesis, carbon fixation, and nitrogen and sulphur metabolism in plants.
2. To explore secondary metabolism, plant-derived toxins, and their ecological significance.
3. To analyze plant responses to environmental stress and defence mechanisms at the molecular level.

Course Outcomes: At the end of the course, a student should be able to

1. Explain the biochemical processes of photosynthesis, carbon fixation, and photorespiration.
2. Describe nitrogen and sulphur assimilation, secondary metabolites, and plant-derived toxins.
3. Evaluate plant stress responses, defence mechanisms, and antioxidative defence systems

Unit I

Photosynthesis: General Principles and structural background: Energetic principles, system architecture and chlorophyll biosynthesis. Elements of chloroplast-nucleus dialogue and the role of chlorophyll biosynthesis intermediates

Photosynthetic energy transduction: Electron transport, light energy conversion and its control of carbon fixation. Points of cross-talk between electron transport and carbon fixation pathway

Unit II

Carbon fixation: carbon fixation/assimilation through C3 (Calvin cycle) and control of metabolite flux through the cycle. Details of rubisco structure, assembly catalysis and regulation. Other regulatory enzymes of Calvin cycle. Light regulation of Cavin cycle

Photorespiration: Photorespiration and carbon concentrating mechanisms (C4 metabolism and CAM). Role of metabolite transporters in regulating inter-organellar carbon flux.

Unit III

Nitrate assimilation - Structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation. Sulphate assimilation: Free and bound pathways of assimilation of sulphate into cysteine. Glutathione and its role in sulphur metabolism.

Unit IV

Special features of secondary plant metabolism - Terpenes (classification, biosynthesis), lignin, tannins, pigments, phytochrome, waxes, alkaloids, biosynthesis of nicotine, functions of alkaloids, cell wall components.

Toxins of plant origin – Mycotoxins, phytohemagglutinins, lathyrogens, nitriles, protease inhibitors, protein toxins.

Unit V

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.

Plant defence: Mechanism of plant defence against pathogens, Genetic basis of plant-pathogen interaction, R-Avr gene interaction and isolation of R genes, Hypersensitive response (HR), systemic acquired resistance (SAR) and induced systemic resistance (ISR) Antioxidative defence system in plants – Reactive oxygen species and their generation, enzymic and non-enzymic components of antioxidative defence mechanism.

Suggested Readings:

1. Handbook of photosynthesis (ed) Mohammad Pe sarakle, Marcel Dekkar, Inc. NY Basel, Hong Kong 1997.
2. Introduction to plant biochemistry (1983) T.W. Goodwin and EI Mercer. Pergaman Press, Oxford, NY, Toronto, Sydney, Paris, Frankfurt.
3. Seed: physiology of development and germination (2nd ed. 1994) J.D. Bewley and M. Black Plenum Press NY.
4. Biochemistry of energy utilization i plants D.T. dennis Blackie, Glasgow and Lodnon 1987.
5. Plant Biochemistry by P.M. Dey and J.B. Harborne. Harcourt Asia PTE Ltd., Singapore.

Lab Course I. SOLS/BCM-DSCP-01

1. Identifying reducing and non-reducing sugars using Benedict's, Barfoed's, and Molisch's tests.
2. Identification of Proteins in unknown sample
3. Identifying amino acids in a mixture based on their Rf values.
4. Isolating lipids from biological samples and quantifying them using a colorimetric method.
5. Estimating DNA concentration using the diphenylamine reaction.
6. Isolation of casein from milk and its quantification
7. Fats: Acid number, saponification and iodine values.
8. Isolation and estimation of starch content in a given plant material.
9. Identification of Blood Group in the given blood sample.
10. Analysis of Urine for Abnormal Constituents – Detection of glucose, proteins, ketone bodies, and bile pigments in urine.
11. Estimation of Serum Cholesterol – Determining cholesterol levels using enzymatic methods.
12. Determination of Hemoglobin (Hb) Concentration – Using Sahli's or a colorimetric method to measure Hb levels.
13. Estimation of Blood Glucose by Glucose Oxidase Method – Determining glucose levels in blood samples
14. Estimation of Chlorophyll in Plant Leaves – Measuring chlorophyll a and b using spectrophotometry.
15. Extraction and Estimation of Total Phenolics – Determining phenolic content in plant samples.
16. Estimation of Nitrate Reductase Activity in Leaves – Measuring enzyme activity involved in nitrogen assimilation.
17. Quantification of Proline under Stress Conditions – Evaluating proline accumulation in plants under water or salt stress.
18. Isolation of Plant Pigments by Thin Layer Chromatography (TLC) – Separating and identifying plant pigments like carotenoids, chlorophylls, and flavonoids.
19. Detection of Secondary Metabolites (Alkaloids, Tannins, Saponins) – Using chemical tests to identify secondary metabolites in plant extracts.
20. To extract and estimate lycopene present in tomatoes.
21. Quantitation of ascorbic acid content in a given sample.
22. Estimation of carotenoids in the given leaf sample.

Any other practical as per the facility in the department

Analytical Techniques in Biochemistry (SOLS/BCM-DSE-01)

Course Objectives:

1. To introduce fundamental analytical techniques for biomolecular separation, identification, and characterisation.
2. To familiarize students with chromatography, electrophoresis, spectroscopy, centrifugation, and biosensor technologies.
3. To develop hands-on skills in biochemical instrumentation for research and clinical applications.

Course Outcomes: At the end of the course, a student should be able to

1. Demonstrate knowledge of biochemical analytical techniques and their principles.
2. Apply various separation and detection methods for biomolecule analysis.
3. Utilise advanced instrumentation for qualitative and quantitative biochemical investigations.

Unit I

Electrochemistry: Ionization of water and its interaction with acids and bases, Buffers and buffering capacity. Determination of pH: theory and instrumentation.
Electrophoresis: Separation of biomolecules on electrophoretic gels: PAGE and agarose gels. Native PAGE, SDS-PAGE, Isoelectric focusing, 2D-PAGE,

Unit II

Centrifugation: Basic principle of sedimentation, centrifuge and their uses. Rotors. Preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, molecular weight determination and subcellular fractionation.

Unit III

Chromatography: Principles and applications of Gel filtration chromatography, Ion exchange chromatography, Affinity chromatography, Paper chromatography, Thin layer chromatography, Fundamentals of high-performance chromatography.

Unit IV

Spectroscopic techniques: Basic concepts of spectroscopy. Visible and UV spectroscopy, Principle and applications of NMR, ESR, Raman, Mass spectroscopy and X-ray crystallography. Transmission and scanning EM, freeze-fracture techniques and specific staining of biological materials

Unit V

Optical methods for determination of molecular structure: Absorption of polarized light, optical rotatory dispersion, hypochromism, circular dichroism in relation to composition and structure of biomolecules.
Tracer techniques: Detection and measurement of isotopes and applications of liquid scintillation counting (LSC), gamma counting and autoradiography.

Suggested Readings:

1. Wilson, K., & Walker, J. (2018). *Principles and Techniques of Biochemistry and Molecular Biology* (8th ed.). Cambridge University Press. ISBN: 978-1107162273.
2. Upadhyay, A., Upadhyay, K., & Nath, N. (2016). *Biophysical Chemistry: Principles and Techniques* (5th ed.). Himalaya Publishing House. ISBN: 978-9352023634.
3. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2017). *Fundamentals of Analytical Chemistry* (10th ed.). Cengage Learning. ISBN: 978-1305587182.
4. Miller, J. M. (2005). *Chromatography: Concepts and Contrasts* (2nd ed.). Wiley-Interscience. ISBN: 978-0471472070.
5. Hammes, G. G. (2005). *Spectroscopy for the Biological Sciences*. Wiley-Interscience. ISBN: 978-0471733546.

Biosafety, Laboratory safety and IPR (SOLS/BCM-DSE-02)

Course Objectives

1. To provide fundamental knowledge on biosafety, bioethics, and risk management in biological research.
2. To familiarise students with laboratory safety protocols, regulatory guidelines, and intellectual property rights (IPR).
3. To understand patent filing, infringement, and research patenting in biotechnology.

Course Outcomes: At the end of the course, a student should be able to

1. Demonstrate an understanding of biosafety regulations, ethical concerns, and risk management in biotechnological research.
2. Apply laboratory safety guidelines and understand accreditation and certification standards.
3. Analyse intellectual property rights, patent filing processes, and case studies on patenting biological products.

Unit-I

Biosafety: Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC, etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.

Bioethics: Introduction to bioethics, Ethical concerns in genetic modifications, GMOs, stem cell research, cloning (human/animal), drug testing, and human genome project implications.

Unit-II

Laboratory Safety and Risk Management: General Laboratory Safety Rules and Regulations, Chemical, Biological, and Radiation Safety. Safe Handling, Storage, and Disposal of Hazardous Materials. Personal Protective Equipment (PPE) and Emergency Response Procedures. Good Laboratory Practices (GLP) and Standard Operating Procedures (SOPs). Institutional Biosafety Committees (IBCs) , Role of Regulatory Agencies (DBT, ICMR, FDA, EPA) in Biochemical Research. Laboratory Accreditation and Certification (ISO, NABL)

Unit III

Intellectual Property Rights (IPR): Introduction to patents, types of patents, the process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international treaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS.

Patent databases: Searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patenting disclosure/non-disclosure; procedure for filing a PCT application.

Unit-IV

Patent filing and infringement: Patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, International patenting-requirement, financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US.

Unit V

Research Patenting: Patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, Case studies on patents (basmati rice, turmeric, neem, etc.), and patent infringement.

Suggested Readings:

- P Ganguly, Intellectual Property Rights, Tata McGraw Hill, 2007.
  Thomas J.A., Fush R.L., (2002), Biotechnology & safety Assessment (3rdEd.), Academic press.
  Fleming D.A., Hunt D.L., (2002), Biological safety Principles &practices(3rd Ed.) ASM Press, Washington.
- Biotechnology- A Comprehensive treatise (Vol 12), Legal economic & ethical Dimensions VCH.
- Sasson A, Biotechnologies & Development, UNESCO Publications.
- Singh K, Intellectual Property Rights on Biotechnology, BCIL, New Delhi.
- Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.
- Biotechnologies and Development, Sasson A, UNESCO Publications, 1988
- Biotechnologies in developing countries present and future, Sasson A, UNESCO Publications, 1993
- Intellectual property rights on Biotechnology, Singh K, BCIL, New Delhi

Lab Course II (SOLS/BCM-DSEP-01)

Analytical Techniques in Biochemistry

1. Preparation of normal, molar, percent solutions and different buffers.
2. Determination of pKa value of acetic acid, aspartic acid and glycine.
3. Separation, identification and Quantitation of amino acids by TLC.
4. Separation of amino acids/ sugars by paper chromatography.
5. Verification of Beer- Lambert Law.
6. Separation of plant pigments using thin-layer chromatography (TLC).
7. Separation of proteins by SDS-PAGE.
8. Estimation of biomolecules using UV-Vis spectrophotometry.
9. Determination of protein concentration using Bradford/Lowry assay.

Biosafety, Laboratory safety and IPR

1. Demonstration of biosafety levels and laboratory containment measures.
2. Demonstration of biosafety cabinet operation and decontamination methods.
3. Preparation of Standard Operating Procedures (SOPs) for handling biological samples.
4. Searching for patents in national and international databases.
5. Case study analysis on famous biotechnological patents (e.g., Basmati rice, turmeric, neem).
6. Case discussions on ethical issues in genetic engineering and stem cell research.
7. Debate on GMO regulations and their societal impact.
8. Understanding national and international biosafety guidelines.

Any other practical as per the facility in the department

P.G. (FIRST YEAR)- SECOND SEMESTER

Metabolic Pathways and Bioenergetics (SOLS/BCM-DSC-04)

Course Objectives:

1. To provide a comprehensive understanding of metabolic pathways and their regulation.
2. To explore bioenergetic principles and their role in energy production and utilization.
3. To analyze the biochemical basis of metabolic disorders and their physiological implications.

Course Outcomes: At the end of the course, students should be able to:

1. Explain the principles of metabolism and energy transformations in biological systems.
2. Analyze the biochemical pathways of carbohydrates, lipids, amino acids, and nucleotides.
3. Apply metabolic concepts to understand disease mechanisms and clinical applications.

Unit I

Intermediary Metabolism – Approaches for studying metabolism.
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, coupled reactions. 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.

Unit II

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 ketone bodies - Formation, utilization, excretion and clinical significance. Metabolism of cholesterol and its regulation.

Unit III

Metabolism of Nucleic acids - Nucleotide biosynthesis - de novo and salvage pathways for purine and pyrimidine biosynthesis. Mechanism of feedback regulation. Biosynthesis of deoxyribonucleotides and polynucleotides, including inhibitors of nucleic acid biosynthesis. Biosynthesis of coenzymes: Coenzyme A, NAD and NADP, FMN and FAD.

Unit IV

Carbohydrates – Glycolysis, various forms of fermentations in micro-organisms, citric acid cycle, its function in energy generation, pentose phosphate pathway and its regulation. 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.

Unit V

Amino Acids – General reactions of amino acid metabolism - Transamination, decarboxylation, oxidative and non-oxidative deamination of amino acids. Catabolism of amino acid carbon skeleton- glucogenic and ketogenic amino acids. Conversion of amino acids to specialized products (bioactive amines): Histamine, Serotonin, epinephrine and nor-epinephrine. Urea cycle and its regulation.

Suggested Readings:

1. Lehinnger's Principles of Biochemistry (2nd edn. 2000) by D.L. Nelson and M.M. Cox, Macmillan, worth Pub. Inc., NY.
2. Biochemistry (4th edn. 1992) by Lubert Stryer WH Freeman & Co., NY.
3. Harper's Biochemistry (25th ed.) by R.K. Murray and others. Appleton and Lange, Stanford.

Basic Microbiology and Industrial Bioprocesses (SOLS/BCM-DSC-05)

Course Objectives:

1. To introduce fundamental concepts of microbiology, including microbial diversity, structure, classification, and cultivation techniques.
2. To understand microbial physiology, growth dynamics, and control methods for industrial and clinical applications.
3. To explore the role of microorganisms in biotechnology, fermentation technology, and industrial microbiological processes.

Course Outcomes: By the end of this course, students will be able to:

1. Demonstrate knowledge of microbial diversity, classification, and structural organisation.
2. Apply microbiological techniques for microbial cultivation, growth measurement, and control in laboratory and industrial settings.
3. Analyse the role of microorganisms in industrial applications, including fermentation, enzyme production, and biotechnological advancements.

Unit I

History of Microbiology: Discovery of Microorganisms. Spontaneous generation versus biogenesis. Establishment of role of microorganisms in diseases, transformation of organic and inorganic matter and soil transformation. Contributions of various Microbiologists. Microscopy: Light (Bright-field, Dark-field, Phase-contrast, Fluorescence) and Electron microscopy (SEM, TEM, Cryo-EM).

Unit II

Morphology and ultrastructure of bacteria: General morphology of the bacterial cell, morphological types of bacteria. Ultrastructure of the bacterial cell. Cell wall of Gram-negative and Gram-positive bacteria and archaebacteria. Structure and function of cell membranes flagella, cilia, gas vesicles, bacterial genomes, plasmids, capsule-spore and cysts. Classification of bacteria, Whittaker's five kingdom concept, three-domain concept of Carl Woes. Modern bases of classification DNA - DNA hybridization, 16SrRNA sequencing. Bergey's system of classification.

Unit III

Bacterial growth and cultivation: Cultivation of aerobic and anaerobic bacteria, nutritional types, culture media. Bacterial growth curve and generation time, growth kinetics, measurement of growth, factors affecting growth, Control of microbial growth: physical and chemical methods, disinfectants and radiations. Emerging antimicrobial resistance and mitigation strategies

Unit IV

Viruses, Fungi and Protozoa: Viruses - Morphology and ultrastructure, capsids and their arrangements. Chemical composition, viral genome. Bacteriophages. Emerging viral diseases and vaccine development. Classification and general features, of major fungal divisions, their

morphology nutrition and reproductive methods. Protozoa - morphology, nutrition, encystment, locomotory organs and reproduction.

Unit V

Fermentation Technology: Shake flask culture, batch, fed-batch and continuous cultures. Fermenter design - basic stirred tank bioreactor and other different types of fermenters. Instrumentation and control. Aeration and agitation, mass transfer and oxygen transfer. Downstream processing. Primary and secondary metabolites. Industrial production of antibiotics (β-lactam), ethanol, enzymes: lipases, protease, cellulose and amylases. Microbial biotechnology in bioremediation, probiotics, and synthetic biology.

Suggested Reading:

1. Microbial World (5th edn, 1987) R Y Stanier, Hampshire-Macmillan Press.
2. Medical Microbiology (12th edn. 1973) Cruckishank R and others, ELBS Press, London.
3. Microbiology (1967) B D Davis, R Delbecco, H M Eisent H S Ginsberg, Hoeber Med Divn. NY
4. Microbiology (5th ed 2000) Michael J Pelczar (Jr) ESC Chan, N R Kreig, Tata McGraw Hill.

Advanced Nutritional Biochemistry (SOLS/BCM-DSC-06)

Course Objectives:

1. To understand the biochemical and physiological roles of nutrients in human health.
2. To explore the impact of food components, antinutrients, and metabolic adaptations in nutrition-related disorders.
3. To analyze clinical nutritional strategies for disease prevention and management.
4. To evaluate the role of gut microbiota, nutraceuticals, and functional foods in nutrition and health.

Course Outcomes:

1. Students will be able to explain the biochemical and metabolic functions of nutrients and energy balance.
2. They will gain knowledge of foodborne toxins, antinutrients, and metabolic disorders.
3. They will be equipped to apply clinical nutrition principles in the management of metabolic and lifestyle disorders.
4. They will be able to critically assess dietary patterns, functional foods, and personalized nutrition approaches.

Unit I

Fundamentals of Nutritional Biochemistry

- Overview of macronutrients and micronutrients.
- Dietary fibres and their physiological significance.
- The energy content of foods and energy balance.
- Measurement of energy expenditure: Direct and indirect calorimetry.

- Basal Metabolic Rate (BMR), Specific Dynamic Action (SDA), and factors affecting them.
- Thermogenic effects of food.
- Role of gut microbiota in nutrition and metabolism.

Unit II

Antinutrients and Food Additives

- *Naturally occurring foodborne toxicants.*
- Antinutrients: Protease inhibitors, hemagglutinins, hepatotoxins, allergens, oxalates, toxins from mushrooms, seafood, and animal-based foods.
- Food additives: Antioxidants, antimicrobial agents, non-nutritive sweeteners, stabilizers, and thickeners.
- Role of genetically modified foods and their nutritional implications.

Unit III

Metabolic Disorders and Malnutrition

- Protein-energy malnutrition (PEM): Etiology, clinical features, metabolic impact, and management of Marasmus and Kwashiorkor.
- Starvation: Mechanisms, metabolic adaptations, and protein metabolism during prolonged fasting.
- Protein-sparing treatments during fasting.
- Nutritional requirements and deficiencies in different life stages.
- Metabolic syndromes: Insulin resistance, diabetes, and cardiovascular diseases.

Unit IV

Obesity and Nutritional Diseases

- Definition, classification, and assessment of obesity.
- Genetic and environmental factors contributing to obesity.
- Obesity-related metabolic disorders and health risks.
- Management of obesity: Dietary interventions, lifestyle modifications, and medical approaches.
- Nutritive value of common Indian foods: Cereals, millets, pulses, legumes, oilseeds, nuts, and animal-origin foods.
- Impact of ultra-processed foods and dietary patterns on health.

Unit V

Clinical Nutrition and Disease Management

- Role of diet and nutrition in disease prevention and treatment.
- Nutritional considerations in:
  - Dental caries and fluorosis.
  - Renal failure, hyperlipidemia, atherosclerosis, and rheumatic disorders.
  - Inherited metabolic disorders: Phenylketonuria, Maple syrup urine disease, homocystinuria, and gout.
  - Nutritional interventions in cancer therapy.
  - Role of functional foods and nutraceuticals in health management.

Suggested Readings:

1. Burtis, C. A., & Ashwood, E. R. (2001). *Tietz Fundamentals of Clinical Chemistry* (5th ed.). Saunders WB Co.
2. Whitby, L. G., Smith, A. F., Beckett, G. J., & Walker, S. M. (2001). *Notes on Clinical Chemistry*. Blackwell Sci Inc.
3. Harrison, T. R. (1983). *Principles of Internal Medicine*. McGraw Hill, NY.
4. Guyton, A. C., & Hall, J. E. (2001). *Textbook of Medical Physiology* (10th ed.). Harcourt Asia.
5. Shils, M. E., Shike, M., & Ross, A. C. (2006). *Modern Nutrition in Health and Disease*. Lippincott Williams & Wilkins.
6. Lanham-New, S. A., & MacDonald, I. A. (2011). *Nutrition and Metabolism*. Wiley-Blackwell.
7. Bagchi, D., & Preuss, H. G. (2008). *Functional Foods and Nutraceuticals in Metabolic and Health Disorders*. CRC Press.
8. Haller, D. (2017). *The Gut Microbiome in Health and Disease*. Springer.

Lab Course III (**SOLS/BCM-DSCP-02**)

1. Quantitative Estimation of Glucose Using GOD-POD Method.
2. Extraction and Estimation of Lipids from Biological Samples.
3. Determination of Ketone Bodies in Urine Samples.
4. Estimation of Cholesterol Using Enzymatic Methods.
5. Enzyme Kinetics Study of Lipase or Protease.
6. Aseptic Techniques & Sterilization Methods – Demonstration of autoclaving, filtration, and chemical sterilisation.
7. Simple staining, Gram staining, and special staining (capsule, spore, flagella staining).
8. Extraction and electrophoresis of bacterial plasmid DNA.
9. Preparation and Sterilization of Culture Media – Nutrient broth, agar plates, and selective media.
10. Serial Dilution and Spread Plate Method – Determination of bacterial count (CFU/mL) from a liquid culture.
11. Determination of bacterial growth phases using a spectrophotometer.
12. Effect of pH, Temperature, and Salinity on Bacterial Growth – Culturing bacteria under different conditions.
13. Effect of Temperature, pH, and Salt on Bacterial Growth – Analysis of environmental factors affecting growth.
14. Antimicrobial Sensitivity Test – Kirby-Bauer method for testing the efficacy of antibiotics.
15. Streak plate technique for isolating pure colonies of bacteria from a mixed culture.
16. Isolation and Cultivation of Bacteria from Different Sources.
17. Biochemical Tests for Bacterial Identification: IMViC, Catalase, Urease, Nitrate Reduction.
18. Antibiotic Sensitivity Test (Kirby-Bauer Method).
19. Fermentation Studies: Ethanol and Lactic Acid Fermentation.
20. Production of Industrial Enzymes (Amylase or Protease) Using Microbial Culture.
21. Microscopy of Bacteria, Fungi, and Protozoa.

22. Estimation of Protein in Food Samples by Lowry's/Biuret Method.
23. Estimation of Carbohydrates by Anthrone/Spectrophotometric Method.
24. Estimation of Serum Cholesterol by Enzymatic Methods.
25. Quantitative Estimation of Vitamin C in Fruits and Vegetables.
26. Determination of Energy Content in Food by Bomb Calorimetry.
27. Analysis of Electrolytes (Sodium, Potassium) in Body Fluids.
28. Glycemic Index Measurement of Common Indian Foods.
29. Effect of Dietary Interventions on Blood Glucose Levels
30. Uric acid estimation from biological fluids using colorimetric methods.
31. Detection of oxalates, phytates, and protease inhibitors in food samples using chemical tests.
32. Estimation of serum ketone bodies and nitrogen balance in urine samples.
33. Determination of cholesterol, triglycerides, LDL, and HDL in serum
34. Analysis of fibre content in cereals, pulses, and vegetables.

Any other practical as per the facility in the department

Neurobiochemistry (SOLS/BCM-DSE-03)

Course Objectives:

1. To understand the biochemical and molecular mechanisms underlying neuronal structure, function, and communication.
2. To explore neurobiology's physiological and pathological aspects, including neurological disorders and their biochemical basis.
3. To develop an in-depth understanding of membrane transport, synaptic transmission, and muscle biochemistry in relation to neurophysiology.

Course Outcomes: Upon completion of this course, students will be able to:

1. Explain the structure and function of neurons, skeletal muscle, and glial cells in the nervous system.
2. Analyze the biochemical and physiological aspects of synaptic transmission, neurotransmitter action, and signal conduction.
3. Identify and discuss the biochemical basis of common neurological disorders and therapeutic approaches.

Unit I

Muscle Biochemistry – Skeletal muscle structure. Actin, myosin, tropomyosin, troponin. Molecular mechanism of contraction. Functional classification of skeletal muscle fibers. Twitch. The motor unit. Role of calmodulin.

Unit II

Neuromorphology – Organisation of neuron, dendrites and axons. Glial cells – astrocytes, oligodendrocytes, ependymal cells, Schwan cells.

Unit III

Neurophysiology – Generation and conduction of monophasic action potential, saltatory conduction and role of myelination. Synaptic transmission, Neurotransmitters and their action. Blood Brain CSF barrier – Characteristics.

Unit IV

Transport across membranes – Types of transport (simple diffusion, passive-facilitated diffusion), active transport – primary and secondary group translocation, transport ATPases, transport by vesicle formation.

Unit V

Neurological disorders and Neurodegeneration– Headache, facial pain, migraine, epilepsy, multiple sclerosis, Myasthenia Gravis, Parkinson's disease, Alzheimer's disease, Huntington's disease. Neuroinflammation and oxidative stress in neurodegenerative diseases. Biochemical and pharmacological approaches to treatment.

Suggested Readings:

1. Siegel, G. J., Agranoff, B. W., Albers, R. W., Fisher, S. K., & Uhler, M. D. (2006). *Basic Neurochemistry: Molecular, Cellular and Medical Aspects*. 7th Edition, Elsevier.
2. Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A.-S., McNamara, J. O., & White, L. E. (2018). *Neuroscience*. 6th Edition, Sinauer Associates.
3. Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2021). *Principles of Neural Science*. 6th Edition, McGraw-Hill.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell*. 6th Edition, Garland Science.
5. Stryer, L., Berg, J. M., & Tymoczko, J. L. (2019). *Biochemistry*. 9th Edition, W. H. Freeman.

Cancer Pathogenesis & Therapy (SOLS/BCM-DSE-04)

Course Objectives:

1. To provide a fundamental understanding of the molecular and cellular mechanisms underlying cancer development and progression.
2. To explore the role of genetic and epigenetic alterations in oncogenesis and tumor progression.
3. To introduce modern cancer diagnosis and therapeutic strategies, including personalized medicine and targeted therapies.

Course Outcomes: Upon completion of this course, students will be able to:

1. Understand the molecular and cellular basis of cancer initiation, progression, and metastasis.
2. Analyze the impact of genetic and epigenetic changes on cancer development and therapy resistance.

Unit III

Neurophysiology – Generation and conduction of monophasic action potential, saltatory conduction and role of myelination. Synaptic transmission, Neurotransmitters and their action. Blood Brain CSF barrier – Characteristics.

Unit IV

Transport across membranes – Types of transport (simple diffusion, passive-facilitated diffusion), active transport – primary and secondary group translocation, transport ATPases, transport by vesicle formation.

Unit V

Neurological disorders and Neurodegeneration– Headache, facial pain, migraine, epilepsy, multiple sclerosis, Myasthenia Gravis, Parkinson's disease, Alzheimer's disease, Huntington's disease. Neuroinflammation and oxidative stress in neurodegenerative diseases. Biochemical and pharmacological approaches to treatment.

Suggested Readings:

1. Siegel, G. J., Agranoff, B. W., Albers, R. W., Fisher, S. K., & Uhler, M. D. (2006). *Basic Neurochemistry: Molecular, Cellular and Medical Aspects*. 7th Edition, Elsevier.
2. Purves, D., Augustine, G. J., Fitzpatrick, D., Hall, W. C., LaMantia, A.-S., McNamara, J. O., & White, L. E. (2018). *Neuroscience*. 6th Edition, Sinauer Associates.
3. Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (2021). *Principles of Neural Science*. 6th Edition, McGraw-Hill.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell*. 6th Edition, Garland Science.
5. Stryer, L., Berg, J. M., & Tymoczko, J. L. (2019). *Biochemistry*. 9th Edition, W. H. Freeman.

Cancer Pathogenesis & Therapy (SOLS/BCM-DSE-04)

Course Objectives:

1. To provide a fundamental understanding of the molecular and cellular mechanisms underlying cancer development and progression.
2. To explore the role of genetic and epigenetic alterations in oncogenesis and tumor progression.
3. To introduce modern cancer diagnosis and therapeutic strategies, including personalized medicine and targeted therapies.

Course Outcomes: Upon completion of this course, students will be able to:

1. Understand the molecular and cellular basis of cancer initiation, progression, and metastasis.
2. Analyze the impact of genetic and epigenetic changes on cancer development and therapy resistance.

3. Evaluate conventional and modern therapeutic approaches for cancer treatment, including immunotherapy and nanomedicine.

Unit I

Cancer Facts and Classification

- Definition, causes, and risk factors of cancer
- Global and Indian cancer prevalence
- Classification of cancers:
- Genetic and hereditary aspects:
    - Sporadic vs. familial cancers
- Cellular hallmarks of cancer and tumor heterogeneity

Unit II

Cancer Pathogenesis and Regulation

- Oncogenes and proto-oncogenes
- Cellular transformation and regulation of normal cell growth
- Cancer cell proliferation and cell cycle regulation
- Cell death mechanisms in cancer
- Epithelial-mesenchymal transition (EMT), invasion, and intravasation
- Angiogenesis and metastasis:
    - Role of VEGF, HIF, and TGF-β in tumor progression

Unit III

Cancer Genetics and Molecular Regulation

- Epigenetic modifications in cancer:
    - DNA methylation and histone modifications
- Role of microRNAs in cancer progression and therapy resistance
- Key cancer signaling pathways:
    - WNT/β-catenin
    - TP53
    - MAPKs
    - PI3K-Akt-mTOR

Unit IV

Cancer Diagnosis and Therapeutic Approaches

- Diagnostic techniques:
    - Biopsy, colonoscopy, mammography, Pap test, CT-MRI
    - Biomarker-based diagnostics, liquid biopsy, next-generation sequencing (NGS)
- Conventional therapies:
    - Surgery, radiotherapy, combination therapies
- Chemotherapy and anticancer drug development:
    - Synthetic and natural sources

Unit V

Advanced and Cellular Therapies

- Immunotherapy and targeted therapy fundamentals
- Monoclonal antibodies and immune checkpoint inhibitors
- Cellular therapies:
  - Dendritic cell therapy
  - CAR-T cell therapy
- Tumor microenvironment and cancer stem cell therapeutics
- Nanomedicine in cancer therapy:
  - Nanoparticles, liposomal drug delivery, nanocarriers

Suggested Readings:

1. Weinberg, R. A. (2013). *The Biology of Cancer*. 2nd Edition, Garland Science.
2. Pezzella, F., Tavassol, M., & Kerr, D. J. (2019). *Oxford Textbook of Cancer Biology (Oxford Textbooks in Oncology)*. Oxford University Press.
3. Schulz, W. A. (2005). *Molecular Biology of Human Cancers - An Advanced Student's Textbook*. Springer Dordrecht.
4. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2022). *Molecular Biology of the Cell*. 7th Edition, Garland Science Publishing.
5. Hanahan, D., & Weinberg, R. A. (2011). *Hallmarks of Cancer: The Next Generation*. Cell, 144(5), 646-674.
6. Vogelstein, B., & Kinzler, K. W. (2002). *The Genetic Basis of Human Cancer*. 2nd Edition, McGraw-Hill.
7. DeVita, V. T., Lawrence, T. S., & Rosenberg, S. A. (2020). *DeVita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology*. 11th Edition, Wolters Kluwer.

SOLS/BCM-DSE-05

Food Microbiology and Food Safety
https://onlinecourses.swayam2.ac.in/cec25_ge05/preview

Students may opt for a SWAYAM course as their Discipline Specific Elective (DSE). The internal assessment will be based on a series of assignments and quizzes conducted by SWAYAM throughout the course duration. A proctored examination, covering the entire syllabus, will be conducted at the end of the course and may be considered as the external examination. This external exam may be conducted either by the University or by SWAYAM. Students may choose any option; however, a certificate from SWAYAM will be awarded only if the student opts for the SWAYAM-conducted external evaluation.
In such cases, where a SWAYAM course is opted as a DSE, the assignment-based seminar will be assessed as the practical component of the paper.

Lab Course IV (SOLS/BCM-DSEP-02)

Neurobiochemistry – Practicals

1. Histological Study of Neuronal and Glial Cells Using Microscopy.
2. Estimation of Acetylcholinesterase Activity in Brain Extracts.
3. Estimation of Dopamine and Serotonin Levels Using Spectrophotometry.
4. Analysis of Myelin Sheath Composition by Lipid Extraction and Estimation.

5. Effect of Neurotransmitters on Muscle Contraction Using Bioassay Methods.
6. Electrophysiology Study of Action Potential and Nerve Conduction.
7. Blood-Brain Barrier Permeability Analysis Using Dye Penetration.
8. Determination of Oxidative Stress Markers in Neurodegenerative Conditions.
9. Study of Membrane Transport by Measuring Na^+/K^+-ATPase Activity.
10. Experimental Study of Neurotoxicity Using Cell Culture Models.

Cancer Pathogenesis & Therapy– Practicals

1. Detection of Cancer Biomarkers in Blood Samples Using ELISA.
2. Histopathological Staining of Cancerous and Normal Tissues.
3. Analysis of Cell Cycle Progression Using Flow Cytometry.
4. Apoptosis Assay in Cancer Cells Using Annexin V Staining.
5. Study of Oncogene Expression by RT-PCR.
6. DNA Fragmentation Assay for Apoptosis in Cancer Cells.
7. Measurement of Angiogenesis Markers (VEGF) Using Immunoassay.
8. Cell Viability and Cytotoxicity Assay of Anticancer Drugs (MTT Assay).
9. In-vitro Study of Cancer Cell Migration Using Wound Healing Assay.
10. Nanoparticle-Mediated Drug Delivery Study in Cancer Cells.

Any other practical as per the facility in the department

Assignment-Based Seminar I (In Lieu of Lab Course IV) (SOLS/BCM-DSEP-03)

Students may opt for an assignment-based seminar as a substitute for the Second Semester "**Elective Practical**" components. In this case, students must deliver a seminar based on an assigned topic from the elective papers of that semester. The seminar will be evaluated by an external examiner appointed by the university, carrying a weightage of 60 marks. An internal assessment will also be conducted, contributing 40 marks to the total evaluation.

P.G. (SECOND YEAR)

- **Third semester (for two-year program-*P.G. first year passed students)***
- **First semester (For one year program-*U.G. 4 years passed students)***

Fundamentals of Molecular Biology (SOLS/BCM-DSC-07)

Course Objectives:

1. To comprehensively understand chromatin dynamics, DNA topology, and genetic information processing.
2. To explore the molecular mechanisms underlying DNA replication, transcription, and translation in prokaryotic and eukaryotic cells.
3. To familiarise students with DNA repair mechanisms, gene regulation, and post-translational modifications essential for cellular function.

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

1. Explain chromatin's structural and functional properties, DNA topology, and transposable elements.
2. Analyse the mechanisms of DNA replication, transcription, and translation and their regulatory controls.
3. Apply molecular biology concepts in genome stability, gene expression regulation, and biotechnological applications.

Unit I

DNA Topology and Chromatin Organization

- DNA supercoiling: Linking number, twist, and writhe.
- Chromosomal DNA organization: Chromatin structure, nucleosome assembly, histone-DNA interactions.
- DNA melting and reassociation kinetics: Cot curves, classes of DNA sequences, DNA complexity.
- Transposable elements:
    - Bacterial transposons: Insertion sequences (IS), composite transposons, Tn transposons.
    - Eukaryotic transposons: P and copia elements in *Drosophila*, Ac/Ds elements in maize, retrotransposons.

Unit II

DNA Replication and Genome Stability

- Modes of DNA replication: Conservative, semiconservative, and dispersive models.
- Replisome components and their functions: Topoisomerase, helicase, SSB proteins, primase, DNA polymerase, ligase.
- Replication origins:
    - *Prokaryotic origin of replication and regulation.*
    - *Eukaryotic replication origins, licensing factors, and replication control.*
- DNA damage and repair mechanisms:
    - Photoreactivation, nucleotide excision repair, mismatch repair, SOS repair.

Unit III

Transcription in Prokaryotes

- Introduction to transcription and RNA synthesis.
- Prokaryotic promoter architecture.
- RNA polymerase structure and function.
- Role of sigma factor in transcription initiation.
- Alternative sigma factors and their physiological significance.
- Termination mechanisms of transcription (Rho-dependent and independent).

Unit IV

Transcription in Eukaryotes

- General transcription factors and their role.
- RNA polymerases and promoter structures: RNA Pol I, II, and III.
- Initiation, elongation, and termination of transcription.
- Regulatory elements: Enhancers, silencers, activators, inhibitors.
- Post-transcriptional modifications (5' capping, polyadenylation, splicing).

Unit V

Genetic Code and Translation

- Universal properties of the genetic code, codon degeneracy, wobble hypothesis.
- Mitochondrial genetic code variations.
- Translation process:
  - Adaptor role of tRNA and aminoacyl-tRNA synthetases.
  - Ribosomal sites (A, P, E) and their function.
  - Prokaryotic translation: Formation of the 70S initiation complex, initiation factors, elongation factors, peptidyl transferase, and termination factors.
  - Eukaryotic translation and regulation.
  - Inhibitors of protein synthesis and their applications.
- Post-translational modifications: Proteolytic cleavage, covalent modifications, glycosylation, disulfide bond formation.

Suggested Readings:

1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene (7th ed.). Pearson, USA.
2. Lewin, B. (2018). Genes XII. Jones and Bartlett Publishers.
3. Voet, D., & Voet, J. G. (2016). Biochemistry (4th ed.). Wiley, USA.
4. Stryer, L., Berg, J. M., & Tymoczko, J. L. (2019). Biochemistry (9th ed.). W. H. Freeman.
5. Nelson, D. L., & Cox, M. M. (2021). Lehninger Principles of Biochemistry (8th ed.). W. H. Freeman, USA.
6. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). Molecular Biology of the Cell (6th ed.). Garland Science, USA.
7. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Scott, M. P. (2021). Molecular Cell Biology (9th ed.). W. H. Freeman.

Molecular Mechanisms of Gene Regulation (SOLS/BCM-DSC-08)

Course Objectives

1. To understand the fundamental mechanisms that regulate gene expression in prokaryotes and eukaryotes.
2. To explore the molecular mechanisms controlling transcription, RNA processing, and chromatin remodelling.

3. To develop an understanding of experimental techniques used to study gene regulation.

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

1. Demonstrate knowledge of different regulatory strategies in gene expression across prokaryotes and eukaryotes.
2. Analyze the role of transcription factors, DNA-protein interactions, and histone modifications in gene regulation.
3. Apply molecular biology techniques for studying gene regulation mechanisms.

Unit I

Basics of Gene Regulation

- Concept and necessity of gene expression regulation in prokaryotes and eukaryotes.
- Principle levels of gene regulation.
- Regulation of gene expression in prokaryotes by substitution of σ factor and antitermination of transcription.
- Operon concept: Circuits of regulation of operons.
- **lac** operon: Repressor control and catabolite repression.
- **trp** operon: Repressor control and attenuation.

Unit II

Post-Transcriptional Regulation

- Maturation of 5' and 3' ends of eukaryotic mRNA: Capping, cleavage, and polyadenylation.
- Role of cap and poly-A tail in mRNA stability and gene expression regulation.
- mRNA splicing and its regulation: Exons, introns, and types of introns.
- Autocatalytic splicing: Group I and Group II introns.
- Splicing of nuclear pre-mRNA introns.
- Alternative splicing, mechanism, and regulation.

Unit III

Transcriptional Regulation

- Activation of transcription factors and their classification.
- Mechanisms of transcription factor activation.
- Regulation of multiple genes by a single transcription factor.
- Regulation of a single gene through different circuits (combinatorial gene expression).
- Role of DNA methylation and CpG islands in gene regulation.

Unit IV

DNA-Protein Interactions and Experimental Techniques

- Physicochemical properties of DNA-protein interactions.
- DNA binding motifs: Homeodomain, zinc fingers, b/zip, b/HLH, and b/HLH/zip motifs.
- Experimental techniques for studying DNA-protein interactions:
    - Gel retardation assay

- DNase I footprinting
- Modification protection assay
- Modification interference assay

Unit V

Epigenetic Regulation and Genomic Domains

- Histone modifications and gene expression: Acetylation, deacetylation, and methylation.
- Chromatin remodelling and chromatin remodelling complexes.
- Genomic regulatory domains: Regulation of gene clusters, Locus Control Regions (LCRs).
- Insulators: Structure, function, and role
- Genomic imprinting: **Igf-2** and **H-19** genes.

Suggested Readings

1. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). *Lewin's Genes XII.* Jones & Bartlett Learning, Burlington, MA, USA.
2. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular Biology of the Gene* (7th ed.). Pearson Publishers, USA.
3. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.). Garland Science, New York, USA.

Advanced Enzymology (SOLS/BCM-DSC-09)

Course Objectives:

1. To provide an in-depth understanding of enzyme structure, classification, and catalysis mechanisms.
2. To explore the kinetics of enzyme-catalyzed reactions, including single- and multi-substrate mechanisms and enzyme inhibition.
3. To introduce modern techniques for enzyme characterisation, regulation, and mechanistic studies.

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

1. Gain knowledge of enzyme classification, nomenclature, and factors affecting enzymatic reactions.
2. Understand enzyme kinetics, regulatory mechanisms, and inhibition models.
3. Apply modern biochemical techniques to study enzyme mechanisms and applications.

Unit I

Fundamentals of Enzymology

- Enzyme definition, nomenclature, and classification.

- Characteristics of enzymes and factors affecting catalytic efficiency (pH, temperature, etc.).
- isolation, purification, and characterisation of enzymes.
- Enzyme-specific activity, units of enzyme activity.
- Isozymes and multiple forms of enzymes.

Unit II

Enzyme Kinetics and Mechanisms

- Types of enzyme catalysis: Acid-base catalysis, covalent catalysis, proximity, and orientation effects.
- Strain and distortion theory.
- Michaelis-Menten kinetics: Equilibrium and steady-state approaches.
- Kinetic parameters (Vmax, Km, Kcat) and their significance.
- Methods for determination of Km and Vmax.
- Lineweaver-Burk plot and derivation of Michaelis-Menten equation.

Unit III

Multi-Substrate Kinetics and Enzyme Inhibition

- Cleland representation for multi-substrate reactions.
- Kinetics of random, ordered, and ping-pong bi-substrate mechanisms.
- Use of primary and secondary plots to distinguish between different bisubstrate mechanisms.
- Enzyme inhibition: Competitive, noncompetitive, and uncompetitive inhibition.
- Derivation of kinetic equations for enzyme inhibitors.
- Determination of inhibitor constant (Ki), Suicide inhibitors.

Unit IV

Enzyme Regulation

- General mechanisms of enzyme regulation.
- Reversible and irreversible covalent modifications of enzymes.
- Feedback inhibition and product inhibition.
- Allosteric regulation of enzyme activity: Models for allosteric enzymes (concerted & sequential).
- Positive and negative cooperativity, half-site reactivity.
- Hill and Scatchard plots in enzyme regulation.

Unit V

Mechanistic Studies and Enzyme Applications

- Techniques for studying enzyme mechanisms:
  - Chemical modification of active site residues.
  - Site-directed mutagenesis.
- Physicochemical properties and mechanisms of action of key enzymes:
  - Chymotrypsin, Lysozyme, Hexokinase, Alcohol Dehydrogenase.

Suggested Readings:

1. Laidler, K. J., & Bunting, P. S. (1973). *The Chemical Kinetics of Enzyme Action.* Oxford University Press, London.
2. Dixon, M., & Webb, E. C. (1979). *Enzymes*. Longman, London.
3. Fersht, A. (1999). *Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Folding*. W. H. Freeman, USA.
4. Walsh, C. (1979). *Enzymatic Reaction Mechanisms*. W. H. Freeman, San Francisco.
5. Chibata, I. (1978). *Immobilized Enzymes*. Halsted Press, New York.
6. Blackburn, S. (1976). *Enzyme Structure and Function*. Marcel Dekker, Inc., New York.
7. Price, N. C., & Stevens, L. (1999). *Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins*. Oxford University Press, London.

Lab Course V (SOLS/BCM-DSCP-03)

1. Extraction of DNA from bacterial and eukaryotic cells.
2. DNA quantification using spectrophotometry (A260/A280).
3. Visualization of genomic and plasmid DNA by Agarose Gel Electrophoresis
4. Restriction digestion and fragment analysis.
5. Extraction of total RNA from bacterial and eukaryotic cells.
6. RNA quantification and integrity analysis using agarose gel electrophoresis.
7. Enzyme activity assay at different pH levels.
8. Thermostability and temperature dependence of enzymatic reactions.
9. Spectrophotometric assay of alkaline phosphatase or amylase.
10. Calculation of kinetic parameters (Km and Vmax).
11. To determine the achromic point of salivary amylase using the starch-iodine test
12. Studying activation and inhibition effects of Ca^{2+}, Mg^{2+}, and EDTA on amylase function.
13. Effect of substrate concentration on the activity of salivary amylase
14. Purification of Enzymes using Ammonium Sulfate Precipitation and Dialysis

Any other practical as per the facility in the department.

Molecular Cell Biology (SOLS/BCM-DSE-05)

Course Objectives:

1. To provide an advanced understanding of the molecular mechanisms governing cellular functions and organization.
2. To introduce experimental techniques for studying cellular processes, including membrane dynamics, protein trafficking, and signal transduction.
3. To explore cell cycle regulation, apoptosis, and cancer biology, focusing on molecular mechanisms and therapeutic implications.

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

1. Develop a strong conceptual foundation in membrane biology, intracellular trafficking, and cellular signalling.
2. Gain knowledge of the molecular control of cell division, apoptosis, and their roles in health and disease.
3. Acquire skills to analyze and apply modern molecular biology techniques in cell biology research.

Unit I

Biological Membranes and Techniques

- Concept of membrane fluidity and factors affecting it.
- Role of membrane proteins in modulating lipid fluidity and membrane asymmetry.
- Lipid rafts and their functional significance.
- Techniques to study membranes:
    - Fluorescence recovery after photobleaching (FRAP).
    - Spin labelling and polarity-dependent fluorescence probes for membrane state analysis.

Unit II

Intracellular Vesicular Trafficking and Protein Localization

- Protein import into the endoplasmic reticulum (ER), processing in ER and Golgi.
- Mechanisms of vesicle formation and fusion.
- Protein import into chloroplasts and mitochondria.
- Techniques to track protein localization:
    - Use of recombinant fluorescent proteins.
    - Vesicle fusion studies via patch clamping.
    - Protein import tracking into organelles.

Unit III

Membrane Transport and Cell Signalling

- Transport mechanisms: Channels, transporters, and pumps.
- Active vs. passive transport, P-type and F-type pumps, ABC transporters.
- Gated ion channels: Voltage-, ligand-, and mechanically-gated.
- Patch clamp techniques to study ion channels.
- Principles of cell signaling:
    - G-protein coupled receptors (GPCRs) and receptor tyrosine kinase (RTK) pathways.
    - Role of calcium flux and calcium-binding proteins.
- Molecular probes:
    - Use of Förster resonance energy transfer (FRET) for live-cell molecular interaction studies.

Unit IV

Cell Cycle and Apoptosis

- Cell cycle regulation, Checkpoints and their role in cell cycle control.
- Apoptosis:
  - Role in tissue homeostasis and development.
  - Molecular pathways and caspase activation.

Unit V

Cancer Biology and Cell Monitoring Techniques

- Transition from normal to cancerous cell growth.
- Role of genetic instability and mutations in cancer development.
- Oncogenes, retroviruses, and tumor suppressors (e.g., p53).
- Techniques for cell monitoring:
  - Flow cytometry for cell cycle and apoptosis analysis.

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.). Garland Science.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., & Martin, K. C. (2021). *Molecular Cell Biology* (9th ed.). W. H. Freeman.
3. Lewin, B. (2007). *Cells* (2nd ed.). Jones & Bartlett Learning.
4. Hardin, J., Bertoni, G., & Kleinsmith, L. J. (2020). *Becker's World of the Cell* (10th ed.). Pearson.
5. Cooper, G. M., & Hausman, R. E. (2019). *The Cell: A Molecular Approach* (8th ed.). Sinauer Associates.

Applied Plant and Animal Biotechnology (SOLS/BCM-DSE-06)

Course Objectives:

1. To understand the fundamental principles of plant and animal biotechnology, including genetic transformation and tissue culture techniques.
2. To explore the applications of transgenic plants and animals in agriculture, medicine, and industry.
3. To familiarise students with molecular markers and gene transfer techniques used for crop improvement and therapeutic advancements.

Course Outcomes:

1. Students will gain knowledge of plant and animal tissue culture techniques and their applications in biotechnology.
2. Students can analyse and apply genetic engineering techniques to develop transgenic plants and animals.
3. Students will develop practical skills in molecular markers and their use in breeding and genetic improvement.

Unit I

Cloning in Plants

- Biology of *Agrobacterium tumefaciens*: Structure of Ti-plasmid, T-DNA, and gene transfer mechanisms.
- Major and minor methods for gene transfer in plants: Gene gun, Electroporation, *In planta* transformation, etc.
- Selection marker and reporter genes.
- Applications of transgenic plants in phytoremediation, biopesticides, biodegradable plastics, pesticide and herbicide resistance, and improvement of horticultural and nutritional value of plants.

Unit II

Plant Tissue Culture

- Historical perspective and general techniques for plant tissue culture.
- Components of tissue culture media, media preparation, and sterilization techniques.
- Explants for tissue culture: Shoot tip, axillary buds, leaf discs, cotyledons, inflorescence, and floral organs.
- Callus culture: Initiation and maintenance.
- Micropropagation, protoplast isolation and culture, somatic hybridization, and haploid production.

Unit III

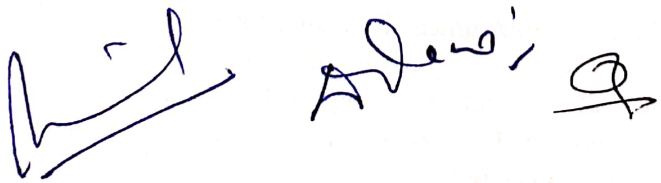
Animal Cell Culture

- Historical perspective and general techniques for animal cell culture.
- Cell lines, cell culture media, and maintenance.
- Cryopreservation, detection of contamination, and laboratory management.
- Monolayer culture techniques: Dispersion and tissue disruption, growth and viability measurement.
- Overview of stem cell technology: Types and applications.

Unit IV

Cloning in Animal Cells

- Cloning vectors in animal cells: SV40-based vectors, retrovirus-based vectors, etc.
- Genetic engineering of mammalian cells: Mammalian cell lines and gene transfer techniques.
- Gene knockout technology and its applications.
- Somatic cell nuclear transfer and transgenic animals.



Unit V

Molecular Markers

- RFLP maps, RAPD markers, STS, microsatellites, SCAR (Sequence Characterized Amplified Regions), SSCP (Single-Strand Conformational Polymorphism), AFLP, and QTL mapping.
- Map-based cloning and molecular marker-assisted selection.

Suggested Readings:

1. Bhojwani, S. S., & Razdan, M. K. (2004). *Plant Tissue Culture: Theory and Practice (A Revised Edition)*. Elsevier.
2. Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). *Biochemistry & Molecular Biology of Plants*. John Wiley & Sons.
3. Brown, T. A. (2006). *Gene Cloning and DNA Analysis: An Introduction*. Blackwell Publishing.
4. Freshney, R. I. (2010). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th Ed.)*. Wiley-Blackwell.
5. Davis, J. M. (2008). *Basic Cell Culture: A Practical Approach*. Oxford University Press.

SOLS/BCM-DSE-07
Research Methodology: https://onlinecourses.swayam2.ac.in/cec25_lw04/preview

Students may opt for a SWAYAM course as their Discipline Specific Elective (DSE). The internal assessment will be based on a series of assignments and quizzes conducted by SWAYAM throughout the course duration. A proctored examination, covering the entire syllabus, will be conducted at the end of the course and may be considered as the external examination. This external exam may be conducted either by the University or by SWAYAM. Students may choose any option; however, a certificate from SWAYAM will be awarded only if the student opts for the SWAYAM-conducted external evaluation.
In such cases, where a SWAYAM course is opted as a DSE, the assignment-based seminar will be assessed as the practical component of the paper.

Lab Course VI (SOLS/BCM-DSEP-04)

Molecular Cell Biology - Practicals

1. Isolation of Membrane Fractions from Animal and Plant Cells
2. Effect of Detergents on Membrane Permeability Using Spectrophotometry
3. Live Cell Imaging of Protein Localization using GFP Fusion Proteins
4. Separation of ER and Golgi Fractions using Differential Centrifugation
5. Flow Cytometry Analysis of Cell Cycle Stages using Propidium Iodide Staining
6. Detection of Apoptotic Cells using Annexin V/PI Assay
7. Caspase Activity Assay in Apoptotic Cells
8. Western Blotting for Apoptosis Markers (Cleaved Caspase-3, Bcl-2, Bax)
9. Colony Formation Assay to Assess Tumorigenic Potential
10. Soft Agar Assay for Anchorage-Independent Growth in Cancer Cells
11. Measurement of Cell Proliferation using MTT Assay

12. Quantification of DNA Damage using Diphenylamine assay
13. Demonstration of DNA laddering by agarose gel electrophoresis

Applied Plant and Animal Biotechnology - Practicals

1. Agrobacterium-Mediated Transformation of Plant Cells
2. PCR-based Confirmation of Transgene Integration in Plants
3. Expression Analysis of Transgenic Plants using RT-PCR
4. Preparation of Plant Tissue Culture Media (Murashige and Skoog Medium)
5. Micropropagation of Plants through Shoot Tip Culture
6. Callus Induction and Differentiation from Leaf Explants
7. Protoplast Isolation and Fusion Techniques
8. Preparation and Sterilization of Animal Cell Culture Media
9. Subculturing and Maintenance of Mammalian Cell Lines
10. Cryopreservation and Revival of Animal Cells
11. Cell Viability Assay using Trypan Blue Staining
12. Genomic DNA Isolation from Plants and Animals

Any other practical as per the facility in the department

Assignment-Based Seminar II (In Lieu of Lab Course VI) (SOLS/BCM-DSEP-05)

Students may opt for an assignment-based seminar as a substitute for the Third Semester "**Elective Practical**" components. In this case, students must deliver a seminar based on any Research Or Review Paper. The seminar will be evaluated by an external examiner appointed by the university, carrying a weightage of 60 marks. An internal assessment will also be conducted, contributing 40 marks to the total evaluation.

P.G. (Second Year)-

- **Fourth semester (for two year program-*P.G. first year passed students)***
- **Second semester (For one year program-*U.G. 4 years passed students)***

Genetic Engineering (SOLS/BCM-DSC-10)

Course Objectives:

1. To provide foundational knowledge on recombinant DNA techniques and their applications.
2. To introduce students to different types of cloning vectors and gene transfer techniques.
3. To equip students with skills in screening methods, gene expression, and sequencing technologies.

Course Outcomes:

1. Students will understand the principles and applications of recombinant DNA technology.

2. Students can analyze cloning strategies, vector selection, and gene expression techniques.
3. Students will develop proficiency in modern gene-editing technologies and their applications in biotechnology.

Unit I

Recombinant DNA Technology

- Historical perspective of recombinant DNA technology.
- DNA modification and restriction: Restriction endonuclease (Types I, II, III), mode of action, and DNA methylation.
- Enzymes used in recombinant DNA technology: DNA polymerases, ligases, nucleases, etc.
- PCR and its variants (RT-PCR, nested PCR, inverse PCR, multiplex PCR, digital PCR, etc.).
- Transcript expression analysis using real-time PCR.

Unit II

Cloning Vectors

- Plasmids: Types, properties, and control of copy number.
- Phage-based vectors: Lambda and M13 vectors.
- Hybrid vectors: Cosmids, Phagemids.
- Yeast-based vectors: YAC, YEP, YRP, YCP, YIP.

Unit III

Cloning and Screening of Recombinants

- Formation of recombinant DNA using restriction enzymes, linkers, and adaptors.
- Selection and screening methods: Genetic, phenotypic, immunochemical, nucleic acid hybridization, HART/HRT.
- Construction of genomic and cDNA libraries.

Unit IV

Blotting, Hybridization, and Sequencing

- Blotting techniques: Southern, Northern, Western, Eastern, colony, dot blotting.
- DNA probe labelling, autoradiography, and detection methods.
- DNA sequencing: Sanger's method, Maxam-Gilbert method, automated sequencing, and Next-Generation Sequencing (NGS).

Unit V

Gene Silencing and Applications

- Gene silencing: siRNA, miRNA, antisense RNA technology.
- CRISPR-Cas gene editing technology.
- Applications of recombinant DNA technology in agriculture, medicine, and industry.
- Ethical concerns and safety aspects of genetically modified organisms (GMOs).

Suggested Readings:

1. Rastogi, S., & Pathak, N. (2010). *Genetic Engineering.* Oxford University Press.
2. Nicholl, D. S. T. (2008). *An Introduction to Genetic Engineering (3rd Ed.).* Cambridge University Press.
3. Brown, T. A. (2016). *Gene Cloning and DNA Analysis: An Introduction (7th Ed.).* Wiley-Blackwell.
4. Primrose, S. B., & Twyman, R. M. (2013). *Principles of Gene Manipulation and Genomics (7th Ed.).* John Wiley & Sons.
5. Freshney, R. I. (2010). *Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th Ed.).* Wiley-Blackwell.

Immunology (SOLS/BCM-DSC-11)

Course Objectives:

1. To understand the fundamental principles of the immune system and immune responses.
2. To explore antigen-antibody interactions and immune effector mechanisms.
3. To introduce students to immunological techniques used in diagnostics and research.

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

1. Students will develop knowledge of innate and adaptive immunity, immune cells, and lymphoid organs.
2. Students will be able to analyze antigen-antibody interactions, immune tolerance, and hypersensitivity.
3. Students will gain proficiency in immunological techniques for disease diagnosis and immunotherapy.

Unit I

Immune System and Cells

- Innate and acquired immunity.
- Structure and functions of primary and secondary lymphoid organs.
- Cells involved in immune responses: B-lymphocytes, T-lymphocytes, phagocytes, granulocytes, mast cells, dendritic cells.

Unit II

Antigens and Immunoglobulins

- Immunogenicity vs. antigenicity, epitopes, haptens, adjuvants, mitogens.
- Structure, classification, and function of immunoglobulins.
- Antibody diversity: Clonal selection theory, organization of immunoglobulin genes, T-cell receptor diversity.

Unit III

Immune Effector Mechanisms

- Kinetics of primary and secondary immune responses.
- Complement activation and biological consequences.
- Cytokines and their role in immune responses.
- Antigen processing and presentation.

Unit IV

MHC, Transplantation, and Tolerance

- Major Histocompatibility Complex (MHC): Structure, function, and polymorphism.
- Role of MHC in immune responses and transplantation.
- Mechanisms of graft rejection and immune evasion strategies.
- Immune tolerance and hypersensitivity (Type I-IV).

Unit V

Immunological Techniques and Disorders

- Antigen-antibody interactions: Agglutination, precipitation, opsonisation, ELISA, Western blotting, Flow cytometry.
- Autoimmunity and immunodeficiencies (congenital and acquired).
- Applications of immunology in disease diagnosis and immunotherapy.

Suggested Readings:

1. Roitt, I., Brostoff, J., & Male, D. (1998). *Immunology (4th Ed.).* Mosby Times Mirror International Publishers.
2. Roitt, I. (1997). *Essential Immunology (9th Ed.).* Blackwell Science Ltd.
3. Kuby, J. (1992). *Immunology.* W. H. Freeman and Co.
4. Golub, E. S. (1991). *Immunology (2nd Ed.).* Sinauer Associates.

Clinical Biochemistry (SOLS/BCM-DSC-12)

Course Objectives:

1. To provide an understanding of biochemical principles underlying clinical laboratory tests and disease diagnostics.
2. To study the biochemical basis of metabolic disorders and their clinical significance.
3. To familiarise students with diagnostic enzymology, biochemical markers, and emerging trends in clinical biochemistry.

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

1. Analyze and interpret biochemical parameters for disease diagnosis and patient management.
2. Understand the metabolic basis of disorders affecting carbohydrates, lipids, proteins, and enzymes.

3. Gain proficiency in clinical laboratory techniques and quality control measures for accurate diagnostics.

Unit I

Quality Control and Specimen Collection

- Concepts of accuracy, precision, reproducibility, and reliability in quality control.
- Normal biochemical values.
- Specimen collection and processing:
  - Blood collection (venipuncture, skin puncture, arterial puncture) and anticoagulants.
  - Urine collection and analysis (normal and abnormal components, preservatives).
  - Clinical significance of sugars, proteins, ketone bodies, bilirubin, and porphyrins in urine.
  - Cerebrospinal fluid (CSF) and amniotic fluid: collection, composition, and analysis.
- Inborn Errors of Metabolism: Phenylketonuria, Alkaptonuria, Albinism, Tyrosinosis, Maple Syrup Urine Disease, Lesch-Nyhan Syndrome, Sickle Cell Anemia, Histidinemia.

Unit II

Disorders of Lipid Metabolism

- Plasma lipoproteins, cholesterol, triglycerides, phospholipids in health and disease.
- Hyperlipidemia, hyperlipoproteinemia.
- Metabolic disorders: Gaucher's disease, Tay-Sachs disease, Niemann-Pick disease.
- Ketone bodies and Abetalipoproteinemia.

Unit III

Disorders of Carbohydrate Metabolism

- Diabetes mellitus: types, biochemical basis, diagnosis, and management.
- Glucose and galactose tolerance tests, renal threshold for glucose.
- Factors affecting blood glucose levels.
- Glycogen storage diseases, pentosuria, galactosemia.

Unit IV

Liver and Kidney Disorders, Electrolyte Balance

- Liver function and disorders: jaundice, fatty liver, liver function tests.
- Kidney function: normal and abnormal parameters, inulin and urea clearance tests.
- Electrolytes and acid-base balance: regulation of electrolyte content, pH maintenance, and reabsorption mechanisms.

Unit V

Diagnostic Enzymes, Viral Infections, and Cancer

- Enzymes as biomarkers: role in disease diagnosis.
- Enzyme assays in clinical diagnosis: SGOT, SGPT, CPK, cholinesterase, LDH.
- Coronavirus Pandemic:
  - Modes of spread and transmission.
  - Mechanism of infection and immune response.
  - Treatment, vaccination strategies, and preventive measures.
- Cancer Biology and Diagnosis:
  - Carcinogens and molecular basis of cancer.
  - Diagnostic methods: biopsy, colonoscopy, mammography, Pap test, CT, MRI.
  - Cancer therapies: chemotherapy, radiotherapy, immunotherapy.

Suggested Readings:

1. Burtis, C. A., & Ashwood, E. R. (2012). *Tietz Fundamentals of Clinical Chemistry (7th Ed.)*. Elsevier.
2. Devlin, T. M. (2019). *Textbook of Biochemistry with Clinical Correlation (7th Ed.)*. Wiley.
3. Gaw, A. (2000). *Bioquímica Clínica*. Elsevier - Health Sciences Division.
4. Murray, R. K., Granner, D. K., Mayes, P. A., & Rodwell, V. W. (2018). *Harper's Illustrated Biochemistry (31st Ed.)*. McGraw Hill.
5. Whitby, L. G., Smith, A. F., Beckett, G. J., & Walker, S. M. (1993). *Notes on Clinical Chemistry*. Blackwell Scientific Publications.

Lab Course VII (SOLS/BCM-DSCP-04)

1. Digestion of plasmid/genomic DNA using restriction enzymes and analysis via agarose gel electrophoresis.
2. Performing conventional and real-time PCR (RT-PCR) for gene amplification.
3. Ligation of DNA into a plasmid vector and transformation into bacterial cells.
4. Blue-white screening and colony PCR for identification of recombinant clones.
5. SDS-PAGE analysis of recombinant protein expression.
6. Total Leukocyte and Differential Leukocyte Count – Microscopic examination of blood smear.
7. Determination of ABO and Rh blood group using antisera.
8. Antigen-Antibody Agglutination Test – Slide agglutination and latex agglutination assays.
9. Detection of antigens or antibodies using ELISA.
10. Protein separation, transfer, and detection using specific antibodies.
11. Flow Cytometry (Demonstration) – Analysis of immune cells based on surface markers.
12. Isolation of Peripheral Blood Mononuclear Cells (PBMCs) – Density gradient centrifugation.
13. Hypersensitivity Testing – Observation of Type I hypersensitivity reaction (e.g., skin prick test).
14. Estimation of Blood Glucose – Using glucose oxidase-peroxidase (GOD-POD) method.
15. Lipid Profile Analysis – Estimation of cholesterol, triglycerides, HDL, and LDL.
16. Protein Estimation in Serum – Using Biuret or Lowry's method.

17. Liver Function Tests – Analysis of bilirubin, SGOT, SGPT, and alkaline phosphatase levels.
18. Kidney Function Tests – Estimation of urea, creatinine, and uric acid in serum.
19. Urine Analysis – Detection of sugars, proteins, ketones, and bilirubin.
20. Enzyme Assays – Determination of SGOT, SGPT, LDH, and alkaline phosphatase activity.
21. COVID-19 Diagnostic Test (Demonstration) – Understanding RT-PCR and rapid antigen tests.

Any other practical as per the facility in the department

Environmental Biochemistry & Toxicology (SOLS/BCM-DSE-08)

Course Objectives:

1. Understand the principles of toxicology, including dose-response relationships and factors influencing toxicity.
2. Comprehend the mechanisms of xenobiotic metabolism and the biochemical basis of toxicity.
3. Analyse toxicity testing protocols and their applications in environmental and industrial health.

Course Outcomes: Upon completion of this course, students will be able to:

1. Apply principles of toxicology to assess environmental hazards and pollutant impact.
2. Evaluate xenobiotic metabolism and its role in toxicant detoxification.
3. Interpret toxicity testing results for risk assessment and regulatory compliance.

Unit I

Introduction to Toxicology

- Definition and scope of toxicology: Eco-toxicology and its environmental significance.
- Toxic effects: Classification, nature, and mechanisms.
- Dose-response relationships: Synergism, Antagonism, ED50, LD50.
- Acute and chronic exposures, factors influencing toxicity.

Unit II

Xenobiotic Metabolism

- Absorption, distribution, and excretion of xenobiotics.
- Phase I reactions: Oxidation, Reduction, Hydrolysis, Hydration.
- Phase II reactions: Methylation, Glutathione, and Amino Acid Conjugations.

Unit III

Biochemical Basis of Toxicity

- Mechanisms of toxicity: Membrane dysfunction, altered calcium homeostasis, covalent binding, and genotoxicity.
- Pesticide and metal toxicity, environmental factors affecting toxicity (light, temperature, pH).
- Industrial effluent toxicology and environmental health concerns.

Unit IV

Toxicity Testing Methods

- Acute toxicity testing principles and regulatory guidelines.
- Genetic toxicity testing and mutagenesis assays.
- In vitro test systems: Ames test, bacterial reversion tests, eukaryotic mutation assays.
- In vivo tests: Host-mediated assay, dominant lethal test, Drosophila in toxicity testing.

Unit V

Environmental and Industrial Toxicology

- Health hazards of industrial pollutants and regulatory standards.
- Biochemical impact of air, water, and soil pollution.
- Toxicity assessment strategies and sustainable environmental management.

Suggested Readings:

1. Mars, T., & Turner, L. (1995). *General and Applied Toxicology*. Macmillan Press Ltd.
2. Corkerhem, L. G., & Shane, B. S. (1994). *Basic Environmental Toxicology*. CRC Press Inc.
3. Shibarnato, T., & Bzeldanes, L. F. *Introduction to Food Technology*.
4. Glick, B. R., & Pasternak, J. J. (1994). *Molecular Biotechnology (2nd ed.)*.

Biostatistics, Bioinformatics & Quality Management (SOLS/BCM-DSE-09)

Course Objectives:

1. Develop an understanding of biostatistical methods and their applications in biological research.
2. Gain insights into bioinformatics tools and computational techniques for data analysis.
3. Understand quality management systems and their applications in research and industry.

Course Outcomes: Upon completion of this course, students will be able to:

1. Apply statistical techniques for data interpretation and decision-making in biological research.
2. Utilise bioinformatics tools for sequence analysis, data visualisation, and database management.

3. Implement quality management principles in laboratory and industrial settings.

Unit I

Biostatistics Fundamentals

- Scope and importance of biostatistics.
- Data presentation: frequency distribution, graphical representation (histograms, frequency curves, cumulative frequency curves).
- Measures of central tendency and dispersion: Mean, Median, Mode, Standard Deviation, Coefficient of Variation.

Unit II

Statistical Analysis & Experimental Design

- Correlation and regression analysis.
- Tests of significance: t-test, z-test, chi-square test, F-test.
- Analysis of variance (ANOVA) and principles of experimental designs (randomized block, Latin square design).

Unit III

Bioinformatics & Computational Tools

- Introduction to computers: classification, microprocessors, input/output devices.
- Data representation: binary, octal, hexadecimal systems.
- Basics of programming languages (C++, Python).
- Introduction to software applications: MS Office (Word, Excel, PowerPoint), databases, internet protocols (HTTP, URL, WWW).

Unit IV

Quality Management Systems

- Introduction to Quality Management Systems (QMS), Environmental Management Systems (EMS), Occupational Health and Safety Assessment Series (OHSAS).
- ISO standards: ISO 9001:2000 (QMS), ISO 14001 (EMS), OHSAS 18001.
- Quality planning, documentation, corrective and preventive actions, and statistical quality control.

Unit V

Global Issues & Modern Management Concepts

- Environmental concerns: acid rain, ozone depletion, deforestation, desertification, water resource depletion, persistent organic pollutants.
- Risk assessment and hazard identification.
- Introduction to 5S and modern housekeeping concepts.

Suggested Readings:

1. Daniel, W. W. (1999). *Biostatistics: A Foundation for Analysis in the Health Sciences (7th ed.)*. John Wiley & Sons Inc., New York.
2. Mount, D. W. (2004). *Bioinformatics: Sequence and Genome Analysis.* Cold Spring Harbor Laboratory Press.
3. Montgomery, D. C. (2017). *Introduction to Statistical Quality Control (7th ed.).* John Wiley & Sons.
4. Gupta, S. C. & Kapoor, V. K. (2014). *Fundamentals of Mathematical Statistics.* Sultan Chand & Sons.

Dissertation (SOLS/BCM-DSE-07)

The dissertation would allow students to undertake independent, in-depth study in a specific area of biochemistry. Students may choose to pursue for Experimental Research involving laboratory-based investigations, or Academic/Literature Review Writing involves critically analysing and synthesising existing scientific literature on a focused topic. Each student will work under the guidance of a faculty supervisor to prepare a comprehensive dissertation, which will be evaluated through written submission and Presentation/viva voce by an External examiner appointed by the University.

Lab Course VIII (SOLS/BCM-DSEP-06)

Environmental Biochemistry & Toxicology - Practicals

1. Determination of LD50 & ED50 – Understanding dose-response relationships using bioassays.
2. Effect of Xenobiotics on Enzyme Activity – Assessing liver enzymes (e.g., cytochrome P450) after exposure to a toxicant.
3. Toxicity Testing in Aquatic Organisms – Studying the effect of pollutants on Daphnia or fish models.
4. Pesticide Residue Analysis – Detection of pesticide residues in food samples using chromatography.
5. Heavy Metal Toxicity Testing – Estimation of lead, cadmium, and arsenic in water samples.
6. Ames Test for Mutagenicity – Testing chemical mutagenicity using bacterial strains.
7. Comet Assay (Single-Cell Gel Electrophoresis) – Detecting DNA damage in exposed cells.
8. Microbial Bioremediation of Pollutants – Using bacteria/fungi for detoxification of pollutants.
9. Industrial Effluent Analysis – Determination of COD, BOD, and heavy metals in effluent samples.

10. Histopathological Examination – Microscopic analysis of organ damage due to toxic exposure.

Biostatistics, Bioinformatics & Quality Management – Practicals

1. Graphical Representation of Data – Construction of histograms, pie charts, and frequency curves.
2. Calculation of Central Tendency & Dispersion Measures – Mean, median, mode, standard deviation, and coefficient of variation.
3. Application of t-test, chi-square test, and ANOVA – Statistical analysis using real-life biological datasets.
4. Regression & Correlation Analysis – Studying relationships between variables in experimental data.
5. Sequence Alignment using Bioinformatics Tools – Performing BLAST and ClustalW for nucleotide/protein sequences.
6. Gene and Protein Structure Analysis – Using Swiss-Prot, PDB, and ExPASy software.
7. Introduction to Python for Data Analysis – Writing basic Python programs for statistical analysis.
8. Quality Control in Biochemical Assays – Statistical quality control charts and error analysis.
9. ISO 9001 Documentation & Quality Audits – Practical case studies on QMS implementation.
10. Environmental Risk Assessment – Evaluating hazard impacts and mitigation strategies.

Any other practical as per the facility in the department