Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

BTCH/ZOO-CC-101 **Fundamentals of Biochemistry**
Time: 60 Hours **Credits: 04**

UNIT I: Carbohydrates & Lipids (15 Lectures)

Carbohydrates: Classification, Nomenclature, Structure and properties. Structure and conformation of sugars, Stereo- and optical isomerisms. Structure and function of homo- and heteropolysaccharides, Mucopolysaccharides and proteoglycans. Chemical reactions of functional groups present in carbohydrates.

Lipids: Classification of lipids. Classification, nomenclature and properties of fatty acids, essential fatty acids. Nomenclature and properties of saturated and unsaturated fatty acids. Properties and functions of phosphoglycerides and sphingolipids. Structure and functions of steroids (cholesterol and bile acids).

UNIT II: Amino acids & Proteins (15 Lectures)

Amino acids: Structures, classification, physical properties and functions of amino acids. Amino acid titration, essential and non-essential amino acids, characteristics of a peptide bond, oligo-peptides and polypeptides.

Proteins: Different levels of structural organization of a protein (primary, secondary, tertiary, quaternary). Forces stabilizing protein structure and shape, elucidation of primary structure, types of proteins (fibrous and globular), Protein denaturation and renaturation.

UNIT III: Enzymes (15 Lectures)

Enzymes: Nomenclature and classification of Enzymes. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, metalloenzymes, monomeric & oligomeric enzymes. Activation energy and transition state, enzyme activity, common features of active sites. Enzyme specificity: types & theories.

UNIT IV: Nucleic acids (15 Lectures)

Nucleic acids: Primary, secondary and tertiary structure of DNA.Various forms of DNA, Properties of DNA, Denaturation and annealing of DNA, Cot Curve. Primary, secondary and tertiary structure of RNA. Functions of various types of RNA

Suggested Readings:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay, McGraw Hill College.
3. Biochemistry by Lubert Stryer, WH Freeman and Co.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

CHM-CC-103 **General Chemistry**
Time: 60 Hours **Credits: 04**

UNIT I: Acid, Bases & Buffers (15 Lectures)

Theories of acids and bases. Relation between initial acid concentration, pKa and pH, Henderson-Hasselbalch equation, dependence of ionization on pH of solution, uses of the H-H equation, titration of strong and weak acids with strong base. Exact treatment of the ionization of diprotic acid. Exact treatment of Bronsted lowery type monobase. Salt hydrolysis. Buffer mixtures (buffering range, buffering capacity). pH indicators, Biological relevance of pH: buffering in living organism, effect of pH on protoplasmic components.

UNIT II: Atomic Structure & Periodicity (15 Lectures)

Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need for the quantum mechanical approach to atomic structure. Time independent Schrodinger equation and meaning of various terms in it. Significance of quantum numbers, Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals. Anomalous electronic configurations. Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electronegativity scales. Concept of unusual oxidation states, inert pair effect, diagonal relationship. Effective nuclear charge and its calculation using Slater rules.

UNIT III: Properties of Aqueous Solutions (15 Lectures)

Type of solution, Concentration terms, Roult's law, activity and activity coefficient Colligative properties (elevation of boiling point; depression of freezing point, osmotic pressure) van't Hoff theory of dilution, determination of molecular weight. Solubility of salts, Thermodynamic and apparent solubility products, salt or electrolyte effect, common ion effect.

UNIT IV: Electron displacements & Stereochemistry (15 Lectures)

Electron displacements: Inductive Effect, Electromeric Effect, Conjugation and Hyper-conjugation. Aromaticity: Criteria of aromaticity, Huckel's rule, Molecular orbital description of aromatic, non-aromatic and anti-aromatic systems. Aromaticity of benzenoid and non-benzenoid systems.

Conformational Isomerism: Conformational analysis of ethane, butane and cyclohexane. Interconversion of Wedge, Newman, Sawhorse and Fischer projections.

Configurational Isomerism: Geometrical isomerism, E-Z system nomenclature. Chirality, isomerism in systems with more than one chiral centres. Enantiomerism, Diastereomerism and Meso compounds. Threo & Erythro, D & L, R & S systems of nomenclature.

Suggested Readings:

1. A New Concise Inorganic Chemistry, E.L.B.S. by J. D. Lee.
2. Basic Inorganic Chemistry, John Wiley, by F.A. Cotton & G. Wilkinson.
3. Inorganic Chemistry, Oxford University Press by D. F. Shriver and P. W. Atkins.
4. Inorganic Chemistry, Viva Books Pvt. Ltd. by Gary Wulfsberg.
5. Organic Chemistry, Ed. John Wiley and Sons by T. W. Graham Solomon.
6. A Guide Book to Mechanism in Organic Chemistry, Orient Longman by Peter Sykes.
7. Stereochemistry of Carbon Compounds, Tata McGraw Hill by E. L. Eliel.
8. Organic Chemistry, Prentice Hall by R. T. Morrison & R. N. Boyd.
9. Advanced Organic Chemistry, S. Chand
10. Advanced Organic Chemistry, S. Chand by Arun Bahl and B. S. Bahl.
11. Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall by A.I. Vogel.
12. Practical Organic Chemistry, Orient Longman (1960) by F. G. Mann & B. C. Saunders.
13. Advanced Practical Organic Chemistry, N. K. Vishnoi, Vikas Publishing House Pvt Ltd, 1996.
14. Laboratory manual in Organic Chemistry, R.K. Bansal, (Wiley Eastern).

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

BTCH/ZOO-CC-104 **Lab Course Based on BTCH/ZOO-CC-101**
Time: 30 Hours **Credits: 02**

1. Concept of various concentration terms, pH and buffers.
2. Preparation of solutions and buffers.
3. Qualitative tests for carbohydrates.
4. Qualitative tests for amino acids.
5. Amino acid titration.
6. Quantitative estimation of proteins.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

CHM-CC-106 **Lab Course Based on CHM-CC-103**
Time: 30 Hours **Credits: 02**

1. Preparation of solutions of different concentration (Molar and Normal).
2. Preparation of buffers and pH determination.
3. Volumetric analysis for
   a) Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
   b) Estimation of oxalic acid by titrating it against $KMnO_4$.
   c) Estimation of water of crystallization in Mohr's salt by titrating against $KMnO_4$.
   d) Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
   e) Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.
4. Detection of N, S, Cl, Br, I in organic compounds.
5. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
6. Criteria of Purity: Determination of melting and boiling points.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester–I)

BTCH-GE-101 **Food Technology**
Time: 30 Hours **Credits: 02**

UNIT I: Principles of Food Processing (7 Lectures)
Thermal Processing–canning, sterilization, pasteurization, dehydration. Preservation by chemicals, irradiation, aseptic processing, membrane processing. Refrigeration and frozen storage. Controlled atmospheric storage.

UNIT II: Food Packaging (8 Lectures)
Definition and functions of packaging, Shelf life studies of packaged food, Metals: Tinplate containers, tinning process. Metal corrosion and lacquering. Biodegradable packaging, types, advantages and disadvantages. Concept of green plastics. Edible films and coatings and their application. Packaging requirements of fruits, meat, dairy products, spices, fats and oils.

UNIT III: Food Spoilage (8 Lectures)
Types of microorganism associated with food: Mold-general characteristics, morphological features, physiological requirements, common molds associated with foods. Bacteria: Morphological & structural features of Gram +ve & Gram –ve bacteria. Physiological characteristics, important food spoilage and pathogenic bacteria associated with foods.

UNIT IV: Food Related Diseases (7 Lectures)
Spores and their significance. Spoilage of processed foods. Food borne disease–staphylococcal gastroenteritis, botulism, listeriosis, salmonellasis, shigillosis. Toxicants of microbial origin – aflatoxins, ochratoxins, patulin and enterotoxins.

Suggested Readings:

1. Food Processing Technology by P. Fellows.
2. The Technology of Food Preservation by Desrosier.
3. Food Microbiology by Frazier.
4. Food Packaging Principles by Gorden Robertson.
5. Modern Food Microbiology by James Jay.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

BOT-GE-103 **Plant Physiology**
Time: 60 Hours **Credits: 02**

UNIT I: Plant Water Relations (8 Lectures)

Physical properties of water, Importance of water to plant life. Diffusion, imbibition and osmosis; concept & components of water potential. Absorption and transport of water, Ascent of sap, Translocation of organic solutes, mechanism of phloem transport, source-sink relationship. Transpiration, types of transpiration, opening and closing of stomata, mechanism of transpiration.

UNIT II: Mineral Nutrition and Enzymes (7 Lectures)

Mineral Nutrition**:** Essential elements (macro and micronutrients) and their role in plant metabolism, deficiency symptoms. Mineral ion uptake (active and passive transport). Nitrogen metabolism- biological nitrogen fixation in *Rhizobium*.

Enzymes**:** General characteristics, mechanism of enzyme action and factors regulating enzyme action, classification of proteins based on structure and solubility.

UNIT III: Photosynthesis (8 Lectures)

Photosynthesis: Absorption & action spectra, enhancement effect; Photosynthetic pigments, Role of chlorophylls and accessory pigments, photosynthetic light reactions, photophosphorylation, carbon assimilation pathways: C3, C4, and CAM. Factors affecting CO_2 reduction. Photorespiration and its significance.

UNIT IV: Growth and Development (7 Lecture)

Growth and development: phases and kinetics of growth. Physiological effects of phytohormones - Auxins, Gibberellins, Cytokinins, ABA, Ethylene and Brassinosteroids. Physiology of flowering -photoperiodism, role of phytochrome in flowering, vernalization. Seed dormancy and seed germination. Physiology of senescence and ageing.

Suggested Readings:

1. Plant Physiology, Lincoln Taiz and Eduardo Zeiger
2. Plant Physiology, Salisbury & Ross.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-I)

AECC- 101 **Communicative English**
Time : 60 Hours **Credits: 04**

UNIT I: **(15 Lectures)**

Spoken English: Practice in the correct pronunciation of English vowels and consonants, syllables and accent, International Phonetic Alphabet (IPA) basics – to enable the students to consult an English pronouncing dictionary.

UNIT II: **(15 Lectures)**

Usage of English Language: Vocabulary development, word structure, word order and phrasal verbs

UNIT III: **(15 Lectures)**

Comprehension: Listening and Reading Comprehension, Written Communication and Composition: Paragraph writing, précis writing, dicto composition, letter writing, writing a term paper, writing book reviews.

UNIT IV: **(15 Lectures)**

Essentials of Grammar: Remedial exercises in parts of speech, structure of sentences, sequence of tenses, use of articles and modes of reporting.
In addition to these components, students would be involved in performing communicative tasks such as making short speeches, interpreting visual presentations, role play and group discussions.

Suggested Readings:

Effective English Communication by Mohan, Krishna, Raman and Meenakshi, New Delhi: Tata McGraw Hill, 2000.
Communicative English by Anuradha and Meenal, Nirmal Publishing House, 2016.
A Communicative Grammar of English by Leech, Geoffery and Jan Svartvik, Rougledge 2003.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-II)

BTCH/ZOO-CC-201 **Basic Cell Biology**
Time: 60 Hours **Credits: 04**

UNIT I: Cell Membrane **(15 Lectures)**

Introduction and classification of organisms by cell structure. Compartmentalization of eukaryotic cells. Cell-fractionation. Cell membrane and Permeability: chemical components of biological membranes. Organization and Fluid mosaic model, membrane as a dynamic entity, cell recognition and membrane transport. Lipid rafts.

UNIT II: Cell Organelles **(15 Lectures)**

Endoplasmic reticulum: structure, function including role in protein segregation/ trafficking. Golgi complex: structure, and functions including role in protein secretion. Nucleus: structure and function, Ribosomes: structures and role in protein synthesis. Mitochondria: structure, function and biogenesis. Chloroplasts: structure, function and biogenesis. Lysosomes. Peroxisomes. Vacuoles and Microbodies: structure and functions. Brief idea of vesicle transport. Endocytosis, pinocytosis and phagocytosis.

UNIT III: Cytoskeleton & Cell-Cell interactions **(15 Lectures)**

Structure and function of microtubules, microfilaments, intermediate filaments. Cell-matrix interactions and cell-cell interactions. Adherence junctions, tight junctions, gap junctions, desmosomes, hemidesmosomes, focal adhesions and plasmodesmata.

UNIT IV: Cell Cycle & Cell Signaling **(15 Lectures)**

Cell division: Mitosis and Meiosis, Cell cycle and its regulation. Cell signaling: role of signal transduction, autocrine, paracrine and endocrine signaling. Molecular mechanism of action of hormones, Types of receptors and action. Second messengers: cAMP, Ca^{2+}, NO (role in cell signaling).

Suggested Readings:

1. Cell and Molecular Biology: Concepts and Experiments. 6th Edition by Karp, G. John Wiley & Sons.Inc.
2. Cell and Molecular Biology: 8th edition by De Robertis, E.D.P. and De Robertis, E.M.F. Lippincott Williams and Wilkins, Philadelphia.
3. The Cell: A Molecular Approach: 5th edition by Cooper, G.M. and Hausman, R.E.. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. The World of the Cell. 7th edition: by Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. Pearson Benjamin Cummings Publishing, San Francisco.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-II)

CHM-CC-203 **Inorganic Chemistry**
Time: 60 Hours **Credits: 04**

UNIT I: Ionic & Covalent Bonding **(15 Lectures)**

Energy considerations in ionic bonding. Lattice energy, solvation energy and their importance. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, Polarazibility. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Valence Bond theory, Shapes of some inorganic molecules on the basis of VSEPR theory. Rules for the LCAO method, bonding and antibonding MO's and their characteristics for *s-s*, *s-p* and *p-p* combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules (idea of *s-p* mixing) and hetero-nuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

UNIT II: Transition & Inner Transition Elements: **(15 Lectures)**

Variation in atomic and ionic sizes, Ionization enthalpies, Variable oxidation states. Standard electrode potentials of M^{2+}/M and M^{3+}/M^{2+} systems. Ionic/Covalent and Acidic/Basic character of transition metal compounds in various oxidation states. Spectral and Magnetic properties, calculation and use of magnetic moment value. Biological functions of transition metals, uptake and storage of transition metals. Oxidation states, Magnetic properties and complexing behaviour of inner transition elements. Cause and consequences of Lanthanoid/Actinoid Contraction. Separation of Lanthanides: Fractional Crystallization, Ion-exchange and Solvent extraction methods.

UNIT III: Coordination Chemistry **(15 Lectures)**

Werner's theory. Effective Atomic number: Concept and its significance. Stereochemistry of Coordination compounds (with numbers 2-6), Optical and Geometrical isomers of MA_4B_2, MA_3B_3 and MABCD type Complexes. Bonding in Complexes, Crystal field theory, comparison of valence bond and Crystal field theory. Factors affecting magnitude of Δ, pairing energy and CFSE of weak and strong field ligands. Chelating effects and applications of chelating agents in detoxification. The Chemistry of Vitamin B_{12} and Model Compounds. General applications of Coordination Compounds in Biology.

UNIT IV: Organometallic Chemistry **(15 Lectures)**

Nomenclature of and general classification of organometallic compounds. Ligands (Heptacity), 18 electron rule, 16 electron rule and counting electrons in complexes. Metal carbonyls, Classification and synergistic effect. Structure of Zeiss's salt, Ferrocene and their bio-conjugates. Application of Organometallic compounds in catalytic reactions (Wilkinson's Catalyst, Wackers process, Hydroformylation). Use of Organometallics compounds in research arena (anti-cancer, anti-malarial etc.)

Suggested Readings:

1. Advanced Inorganic Chemistry, 6th ed- F.A. Cotton, G. Wilkinson, Wiley 1999
2. Inorganic Chemistry, 4th ed. - J.E. Huheey, E.A. Keiter, Harpis and Row
3. Chemistry of the Elements 2nd ed. – N.N. Greenwood, A. Earnshaw, Pergamen
4. Mechanisms of Inorganic Reactions – D. Katakis, G. Gordon (Wiley, 1987).
5. Concise Inorganic Chemistry; J.D. Lee; ELBS.
6. Advanced Inorganic Chemistry; Volume 1; S. Prakash; G.D. Tuli; S.K. Basu & R.D. Madan; S.Chand & Company Ltd.
7. Coordination Chemistry; D. Banerjee; Tata McGraw Hill.
8. Concise Coordination Chemistry; R. Gopalan & V. Ramalingam; Vikas.
9. Inorganic Chemistry; D.E Shriver; P.W. Atkins & C.H. Langford; Oxford.
10. Inorganic Chemistry; Gary Wulfsberg; Viva; 2002.
11. Vogel’s Text of Quantitative Inorganic Analysis; J. Bassett; R.C. Denny; ELBS.
12. Analytical Chemistry; G.D. Christian; 5th edn.; Wiley; 2001
13. Vogel's Qualitative Inorganic Analysis; 6th edn; Svehla (Longman, 1994)
14. Chromatographic Methods; 3rd ed; Stock & Rice (Chapman & Hall, 1980).

Syllabus for 5-Year Integrated B.Sc.-M.Sc. Program in Biotechnology Under CBCS (Semester-II)

BTCH/ZOO-CC-204 **Lab Course Based on BTCH/ZOO-CC-201**
Time: 30 Hours **Credits: 02**

1. Study of prokaryotic and eukaryotic cell.
2. Preparation of temporary mount to show mitotic cell division.
3. Preparation of temporary mount to show meiotic cell division.
4. Preparation of temporary mount of polytene chromosome from salivary glands of Drosophila larva.
5. Buccal–Smear identification of Barr body.
6. Preparation of Nuclear, mitochondrial and cytoplasmic fractions.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-II)

CHM-CC-206 **Lab Course Based on CHM-CC-203**
Time: 30 hours **Credits: 02**

1. To estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg^{2+} (ii) Zn^{2+} by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.
4. Estimation of Ca^{2+} in solution by (substitution method) using Erio-chrome Black-T as indicator.
5. Estimation of Ca/Mg in drugs and Biological samples.
6. Estimation of Cl^- (i) By Mohr's method, (ii) By Vohlard's method, (iii) By Fajan's method.
7. Paper Chromatographic separation of Ni(II) and Co(II); Cu(II) and Cd (II).
8. Preparation of coordination compounds.
9. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-II)

BTCH-GE-201 **Plant Biochemistry & Biotechnology**
Time: 60 Hours **Credits: 04**

UNIT I: Physiology of Plants (15 Lectures)
Water & mineral transport. Water potential. Mechanism of opening and closing of stomata. ATP-the biological energy currency. Aerobic and anaerobic respiration. Electron transport system, oxidative phosphorylation. Glyoxalate cycle. Secondary metabolites and introduction to alkaloids, phenolics, plant terpenes, phytoalexins, sesquiterpenes and sterols. Carbon assimilation pathways, C3, C4 & CAM and Photorespiration.

UNIT II: Plant Cell and Tissue Culture (15 Lectures)
Plant tissue culture – Plasticity and totipotency. Sterilization techniques, plant cell culture media, plant growth regulators. Callus, cell suspension culture, protoplast culture, root cultures, shoot tip and meristem culture, embryo culture, microspore culture. Plant regeneration.

UNIT III: Growth and Development (15 Lectures)
Growth and development: definition, phases and kinetics of growth. Physiological effects of phytohormones-Auxins, Gibberellins, Cytokinins, ABA, Ethylene and Brassinosteroids. Physiology of flowering -photoperiodism, role of phytochrome in flowering, vernalization. Seed dormancy and seed germination. Physiology of senescence and ageing.

Unit IV: Stress, Disease Resistance & Biotechnological Intervention (15 Lectures)
Abiotic stress–Physiological and molecular responses of plants to water stress, salinity stress, temperature stress, genetic engineering approaches for biotic stress resistance–miRNA in abiotic stress.
Biotic stress-plant interaction with bacterial, viral and fungal pathogens–biochemical and molecular basis of host plant resistance–gene for gene hypothesis–genetic engineering approaches for biotic stress resistance–gene pyramiding.

Suggested Readings:

1. Plant Physiology, Lincoln Taiz and Eduardo Zeiger.
2. Plant Physiology, Salisbury & Ross.
3. Plant Biotechnology: the genetic manipulation of plants, Adrian Slater, Nigel W. Scott, Mark R. Fowler.
4. Introduction to plant biotechnology, HS Chawla.
5. U. Chakraborty, Bishwanath Chakraborty, Stress biology, Vidhyasekaran, Narosa Publishing House.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester - II)

BOT-GE-203 **Developmental Botany**
Time: 60 Hours **Credits: 04**

UNIT I: Angiosperm Morphology (15 Lectures)

Characteristic functions and types of root system – Modification for storage, support and vital functions- (Respiratory, Photosynthetic, Haustorial and Epipyhtic).

UNIT II: Stem and Leaf (15 Lectures)

Stem–Characteristics and functions. Types of underground, Aerial and Sub-Aerial modifications. Leaf – Structure and functions, types of phyllotaxy, venation, types of leaves (simple and compound), modifications (stipule and leaf), insectivorus plants (Drosera, Utricularia and Nepenthes).

UNIT III: Flower (15 Lectures)

Inflorescence- Types of inflorescence (Racemose, Cymose and special type–Cyathium, Hypanthodium and Verticellaster).

Flowers–Bract, Calyx, Corolla–Aestivation, Androceium, Gynoecium, Placentation and types of flowers.

Fruits – Classification and types.

UNIT II: Embryology (15 Lectures)

Anther structure, micro sporogenesis and development of male gametophyte. Ovule structure and types -Megasporogenesis, development of Monosporic, Bisporic and Tetrasporic types (*Peperomia, Drusa, Adoxa*) of embryo sacs. Pollination and fertilization, endosperm development and types. Development of Dicot and Monocot embryos, Polyembryony.

Suggested Readings:

1. AC Datta College Botany, Manzar Khan Oxford University, Press Kolkatta.
2. Gangulee Das and Dutta – College Botany Vol- I, New central Book Agency, Kolkatta.
3. Swamy. B.G.L. & Krishnamoorthy. K.V., Fromflower to fruit. Tata McGraw Hill Publishing Co., Ltd., New Delhi.
4. Maheswari, P., An Introduction to the Embryology of Angiosperms. Tata McGraw Hill Publishing Co.,Ltd., New Delhi.
5. Bhojwani, S.S.& Bhatnagar, S.P.,The Embryology of Angiosperms (4thEdition) Vikas Publishing House(P)Ltd., UBS Publisher's Distributors, New Delhi.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

BTCH/ZOO-CC-301 **Introduction to Molecular Biology**
Time: 60 Hours **Credits: 04**

UNIT I: DNA Structure (15 Lectures)

DNA Structure–features of double helix. DNA as heredity unit. Building blocks of DNA. Physical and chemical structure of B-DNA, A-DNA and Z- DNA. Alternate DNA structures like H-, G- DNA loops; D-loop, R-loop cruciforms, hairpin loops etc. DNA as genetic material (key experiments). Central Dogma. Genome size and C-value paradox. Denaturation and renaturation. Repetitive & non-repetitive DNAs. Organization of prokaryotic and eukaryotic genomes. Organelle genomes–Mitochondria and Chloroplast. Transposable elements.

UNIT II: Replication & Repair (15 Lectures)

Replication of DNA in prokaryotes and eukaryotes: Semi-conservative nature of DNA replication, Bi-directional replication, Rolling circle replication, Unique aspects of eukaryotic chromosome replication, Fidelity of replication. Mechanism of DNA repair: Photoreactivation repair, Base excision repair, Nucleotide excision repair, Mismatch repair and Recombinational repair.

UNIT III: RNA Structure & Transcription (15 Lectures)

RNA structure and types of RNA. Transcription in Prokaryotes and Eukaryotes, Initiation, elongation and termination of RNA chains. Prokaryotic and Eukaryotic RNA polymerases, Promoters, Enhancers and Transcription factors. Transcription inhibitors.

UNIT IV: Translation (15 Lectures)

Genetic code and its characteristics. Prokaryotic and Eukaryotic translation, Mechanism of initiation, elongation and termination of polypeptides. Ribosome structure and assembly, Structure of tRNA, Charging of tRNA, Aminoacyl tRNAsynthetases, Translational inhibitors.

Suggested Readings:

1. Genes XII by Goldstein, Kilpatrick, Krebs Lewin's Jones & Bartlett Publishers.
2. Molecular Biology of the Gene (VI Edition.) by Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R., Cold Spring Harbour Lab. Press, Pearson Pub.
3. Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser Monty Krieger, Anthony Bretscher, W H Freeman & Co.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

CHM-CC-303 **Organic Chemistry**
Time: 60 Hours **Credits: 04**

UNIT I: Aliphatic & Aromatic Hydrocarbons (15 Lectures)

Alkanes: General mechanism of free radical substitution reactions, stereochemistry of free radical substitution in n-butane. Halogenation at allylic and benzylic positions. Free radical reactions in biological systems.

Alkenes: *Synthesis*: dehydrohalogenation of alkyl halides, dehydration of alcohols-Mechanism and Orientation. *Reactions*: Mechanism, regioselectivity and stereochemical implications of hydroxylation ($KMnO_4$), addition of HX, Br_2, H_2O, Oxymercuration/Demercuration, Hydroboration, Epoxidation and Ozonolysis.

Alkynes: Synthesis of alkynes from CaC_2 and of higher alkynes from acetylides, dehalogenation of tetra halides and vicinal dihalides. *Reactions*: Partial catalytic reduction to *cis* & *trans* alkenes. Addition of HX, H_2O, halogens and $KMnO_4$ oxidation.

Aromatic Hydrocarbons: General mechanism of electrophilic substitution reactions. The 2^{nd} substitution, effect of substituents on orientation and reactivity, Birch reduction, side chain oxidation of alkyl benzenes.

Polynuclear aromatic hydrocarbons and cancer.

UNIT II: Alkyl & Aryl Halides, Alcohols & Phenols (15 Lectures)

Alkyl Halides: Synthesis from alkenes and alcohols. *Reactions:* General Overview of S_N1, S_N2 and S_Ni reactions. Substitution vs elimination, Mechanism and stereochemistry of E1 and E2 reactions (Hoffmann-Saytzeff rule). Conversion to nitrite, nitro, nitrile & isonitrile. Williamson's ether synthesis. Few examples of S_N reactions in biological processes.

Aryl Halides: Synthesis: From phenol, through Sandmeyer & Gattermann reactions. *Reactions:* Aromatic nucleophilic substitution: S_NAr and Benzyne mechanisms.

Alcohols: Synthesis: From addition of Grignard reagent and reduction of carbonyl compounds. *Reactions*: Oxidation with PCC, chromic acid and Jones regent. Oppeneauer oxidation and Pinacol-Pinacolone rearrangement. Biological oxidation of alcohols.

Phenols: Synthesis by Cumene hydroperoxide method and from diazonium salts. *Reactions:* Reimer Tiemann and Gattermann-Koch reactions and Houben–Hoesch condensation.

UNIT III: Aldehydes & Ketones (15 Lectures)

Structure and Reactivity of carbonyl groups, Synthesis: Reduction of acyl chloride, nitrile and esters to aldehydes. Synthesis of ketones from nitriles and through Friedel-Crafts acylation. *Reactions:* Acetal and Hemiacetal formation in biomolecules. Mechanisms involved in Aldol, Benzoin, Claisen, Knoevenagel and Mannich condensations. Robinson annulations, Clemmenson and Wolf Kishner reductions. Aldol and Claisen condensations in biological systems, Enol-Keto tautomerization in carbohydrates.

UNIT IV: Carboxylic Acids & Amines (15 Lectures)

Carboxylic acids: Factors affecting acidity of carboxylic acids. *Synthesis:* Oxidation of primary alcohols and aldehydes, Malonic ester synthesis and carboxylation of Grignard reagent. *Reactions:* Conversion to acid chlorides, esters, anhydrides, amides and comparative study of their nucleophilicity. Trans-esterification, HVZ reaction, Reformatsky and Perkin condensations. Biological importance of carboxylic acids.

Amines: Structure and factors affecting basicity of amines. *Synthesis:* reduction of nitriles, Gabriel Phthalimide synthesis and Hoffmann bromamide degradation. *Reactions:* alkylation and acylation of amines, reactions of primary and secondary amines with nitrous acid. Biogenic amines and their importance in food. Biological transamination.

Suggested Readings:

1. Fundamentals of Organic chemistry; 5th edn.; Solomons; John-wiley.
2. Organic chemistry; Vol I, II & III; Singh; Mukherji & R. P. Kapoor; Wiley-Eastern
3. Text book of Organic Chemistry; R.K.Bansal; Wiley- Eastern; 1997.
4. Advanced Organic Chemistry; B.S.Bahl and ArunBahl; (S.Chand; 1996)
5. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes: Orient Longman.
6. Organic reaction Mechanism by V.K Alluwalia.
7. Advanced Organic Chemistry, Francis A. Carey, Richard A. Sundberg, 2007 ISBN-13: 978-0-387-44897-8 Springer
8. Organic Chemistry, Paula Y. Bruice, 6th Edition, 2010, ISBN: 978-0-321-66313-9 Prentice Hall
9. Organic Chemistry, Jonathan Clayden, Nick Geeves, Stuart Warren, 2nd Edition, 2012, ISBN: 978-0199270293, Oxford University Press.
10. B.C. Practical Organic Chemistry Mann, F.G. & Saunders, Orient-Longman, 1960.
11. A. Senior Practical Physical Chemistry, Khosla, B. D.; Garg, V. C. & Gulati, R. Chand & Co.: New Delhi (2011).

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

BTCH/ZOO-CC-304 **Lab Course Based on BTCH/ZOO-CC-301**
Time: 30 Hours **Credits: 02**

1. Isolation of chromosomal DNA from bacterial cells.
2. Isolation of RNA from cells.
3. Quantitative estimation of RNA and DNA by spectrophotometry.
4. DNA denaturation and renaturation curves and calculation of Tm.
5. Qualitative analysis of DNA by agarose gel electrophoresis.
6. Qualitative analysis of RNA by agarose gel electrophoresis.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

CHM-CC-306 **Lab Course Based on CHM-CC-303**
Time: 30 Hours **Credits: 02**

1. Differentiation between a reducing and a non-reducing sugar.
2. Identification of organic compounds on the basis of functional group determination, boiling point and confirmatory tests.
3. Acetylation of one of the following compounds: amines (aniline, o-,m-, p-toluidines and o-,m-,p- anisidine) and phenols (β-naphthol, vanillin, salicylic acid).
4. Benzolyation of one of the following compounds: amines (aniline, o-m-, p-toluidines and o-m-, p-anisidine) and phenols (β-naphthol, resorcinol, p-cresol) by Schotten Baumann reaction.
5. Hydrolysis of amides and esters to obtain benzoic acid.
6. Aldol condensation between benzaldehyde and acetone.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

BTCH-GE-301 **Principles of Genetics**
Time: 60 Hours **Credits: 04**

UNIT I: Mendelian & Non-Mendelian Genetics (15 Lectures)
History, Mendelian laws, allelic and non-allelic interactions, essential and lethal genes. Penetrance and expressivity. Linkage and crossing over. One gene one polypeptide hypothesis. Polygenic inheritance. Epigenetics.

UNIT II: Chromosome Structure & Morphology (15 Lectures)
Structural organisation of the chromosomes, Euchromatin and heterochromatin, Giant chromosomes (Polytene and Lampbrush chromosomes). Karyotyping, banding pattern of human chromosomes.

UNIT III: Mutations & Chromosomal abnormalities (15 Lectures)
Types of mutation, mutagens - physical and chemical, detection of mutations. Structural and numerical aberration of chromosomes. Hereditary defects–(Klinefelter, Turner, Cri-du-chat, and Downs syndromes).

UNIT IV: Population Genetics & Inheritance (15 Lectures)
Genetic variation (Hardy-Weinberg Law), genetic drift, pedigree analysis. Cytoplasmic inheritance. Sex determination (man and other animals) and sex linkage. Sex limited gene expression, sex linked inheritance. Genetic polymorphism.

Suggested Readings:

1. Principles of Genetics VIII ed. by Gardner EJ, Simmons MJ, and Snustad DP. Wiley India.
2. Russel PJ. Genetics- A Molecular Approach. III ed. By Benjamin Cummings.
3. Concepts of Genetics. XI ed. by Klug WS, Cummings MR, Spencer CA. John Wiley and Sons Inc.
4. Molecular Biotechnology- Principles and Applications of Recombinant DNA by Glick BR, Pasternak JJ. ASM Press, Washington.
5. Genetics: A Conceptual Approach by Benjamin A.Pierce. W. H. Freeman

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

BOT-GE-303 **Microbes, Algae & Fungi**
Time: 60 Hours **Credits: 04**

UNIT I: Microbial Diversity (15 Lectures)

Discovery of microorganisms, origin of life, spontaneous, biogenesis, Pasteur experiments, germ theory of disease. Classification of microorganisms – R.H. Whittaker's five kingdom concept, Carl Woese's- Domain system. Brief account of special groups of bacteria- Archae bacteria, mycoplasma, chlamydia, actinomycetes, rickettsias and cyanobacteria.

UNIT II: Viruses and Bacteria (15 Lectures)

Viruses - general account, structure and replication of T4 Phage (Lytic and Lysogenic) and TMV, viroids, prions. Plant diseases caused by viruses– symptoms, transmission and control measures. Study of Tobacco Mosaic and Bhendi Vein clearing.

Bacteria - General characteristics, cell structure and nutrition. Reproduction- asexual and bacterial recombination (Conjugation, Transformation, Transduction). Economic importance of Bacteria.

UNIT III: Algae (15 Lectures)

General account - thallus organization and reproduction in Algae. Fritsch classification of Algae (up to classes only) and economic importance. Structure, reproduction and life history of *Oedogonium, Ectocarpus* and *Polysiphonia.*

UNIT IV: Fungi (15 Lectures)

General characteristics and outline classification (Ainsworth). Structure, reproduction and life history of *Rhizopus* (Zygomycota), *Penicillium* (Ascomycota), and *Puccinia* (Basidiomycota). Lichens-structure and reproduction; ecological and economic importance. Endophytes-Biology & importance.

Suggested Readings:

1. Oladele Ogunseitan, Microbial Diversity: Form and Function in Prokaryotes Wiley-Blackwell.
2. Pelczar, M.J., Microbiology, 5th edition, Tata Mc Graw-Hill Co, New Delhi.
3. Presscott, L. Harley, J. and Klein, D., Microbiology, 6th edition, Tata Mc Graw- Hill Co. New Delhi.
4. Fritsch F.E., The Structure & Reproduction of Algae, Cambridge University Press Cambridge, U.K. Vol. I, Vol. II.
5. Smith, G.M., CryptogamicBotany (Vol. I Algae, Fungi, & Lichens) McGraw-Hill Book Co., New York.
6. Ian Morris, An Introduction to the Algae, Hutchinson, London.

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-III)

BTCH-SEC-301 **Biotechnology in Agriculture**
Time: 30 Hours **Credits: 02**

UNIT I: Vermiculture **(7 Lectures)**
Introduction and initiation of vermicuture in India, materials for vermicomposting. Selection and basic characteristic of suitable species. Advantages and types of vermicomposting

UNIT II: Organic Farming **(8 Lectures)**
Organic farming-scope and importance, components of organic farming. Bacterial Bio-fertilizers–Rhizobium, Azospirillum, Phosphobacteria. Fungal Bio-fertilizers–Ecto and Endomychorizae, Azolla. Method of application for different bio fertilizers.

UNIT III: Seed Production Technology **(7 Lectures)**
Classes of quality seeds, seed production- isolation, seed crop, cultivation. Seed processing–drying, cleaning, gardening, testing, treating, bagging and labelling.

UNIT IV: Processes of Value Additions **(8 Lectures)**
Genetic manipulation of composition and content of starch, amino acids (lysine and sulfur containing) and oil. Vitamin A and minerals (Iron and Zinc). Plants as biofactories, biodegradable plastics. Genetic manipulation of flavonoid and terpenoid pathways.

Suggested Readings:

1. Vermiculture-The biology of Earthworm by Sultan A. Ismail, Orient Longman, Hyderabad.
2. Earthworm Cinderella of Organic Farming by T. V. Sathe, Daya Publishing House.
3. Organic Farming for Sustainable Agriculture by A. K. Dahama, Agribios (India).
4. Techniques in Seed Science and Technology by Agarwal, P. K Dadlani. South Asian Publishers, New Dehli.
5. Principles of Plant Breeding by Allard, R. W. John Wiley and Sons Inc, New York.
6. Raghuvan. Developmental Biology of Flowering Plants. Springer.

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

BTCH/ZOO-CC-401 **Introduction to Biotechniques**
Time: 60 hours **Credits: 04**

UNIT I: Electrophoresis & Blottings **(15 Lectures)**

Basic principle and applications of native polyacrylamide gel electrophoresis, SDS-polyacrylamide gel electrophoresis (PAGE), Urea-PAGE, 2D gel electrophoresis, Isoelectric focusing, Pulse field gel electrophoresis and Agarose gel electrophoresis. Blotting techniques: Southern, Northern, Western, South-western and their applications.

UNIT II: Chromatography **(15 Lectures)**

Introduction to different types of chromatography- Paper, Thin Layer, Column, Size exclusion, Ion-exchange, Affinity, High Performance Liquid Chromatography (HPLC) and Fast Protein Liquid Chromatography (FPLC).

UNIT III: Centrifugation & Radioactivity **(15 Lectures)**

Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient. Principle and application of differential centrifugation, density gradient centrifugation and ultracentrifugation.

Radioactivity and radioisotopes, rate of decay, units of radioactivity, specific activity. Detection and measurement of different types of radioisotopes normally used in biology, incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.

UNIT IV: Microscopy **(15 Lectures)**

Cryo-Techniques for fixing specimens for microscopic observation. Principle & applications of light, Brightfield and darkfield microscopy, Fluorescence microscopy, Phase contrast Microscopy, Confocal Microscopy. Microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for electron microscopy.

Suggested Readings:

1. Physical Biochemistry 2nd edition by Freifelder, D. W.H. Freeman and Co., N.Y.USA.
2. Principles and Techniques of Biochemistry and Molecular Biolog by Wilson & Walker Cambridge University Press.
3. Physical Biochemistry: Principles and Applications 2nd ed., Sheehan, D. Wiley Blackwell

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

CHM-CC-403 **Physical Chemistry**
Time: 60 Hours **Credits: 04**

Unit I: Chemical Kinetics (**15 Lectures)**

Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Collision theory and Activated Complex theory of bimolecular reactions. Kinetics of enzyme catalysed reactions, Effect of substrate concentration, temperature and pH. Enzyme inhibition

Unit II: Thermodynamics (**15 Lectures)**

First Laws of thermodynamics: Heat capacity, heat capacities at constant volume and constant pressure and their relationship. Calculation of ΔU &ΔH for the expansion of ideal gases under isothermal and adiabatic conditions. Second law of thermodynamics: Need for the law, entropy as a function of V&T, and as a function of P&T. Third law of thermodynamics: Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities,ΔG &ΔA as criteria for thermodynamic equilibrium and spontaneity their advantage over entropy change. Variation of G and A with P, V and T, Gibbs-Helmholtz equation. Gibb's Helmholtz equation-Derivation. Clausius-Clapeyron equation. Nernst Heat Theorem. Thermodynamic laws in biological systems

Unit III: Electrochemistry (**15 Lectures)**

Migration of ions and Kohlrausch's law, Arrhenius theory of electrolyte dissociation. Debye-Huckel-Onsager's equation for strong electrolytes. Transport number, determination of degree of dissociation. Conductometric & potentiometric titrations. Reversible & reference electrodes. Nernst equation and cell E.M.F. Electrochemical series and its significance. Measurement of EMF of a cell. Concentration cells with and without transport. Determination of thermodynamic functions of cell reactions (ΔG, ΔH and K) and activity coefficient. Some applications of electrochemistry in biomedical chemistry.

Unit IV: States of Matter (**15 Lectures)**

*Solid state***:** Laws of crystallography (i) Law of constancy of interfacial angles (ii) Law of rational indices and (iii) Law of symmetry. Miller indices. Derivation of Bragg's equation and its application. Interplanar distances in terms of miller indices. Systematic absence of diffraction lines in the X-ray pattern of cubic crystals with reference to NaCl & KCl.

Liquid state: Vapour pressure, surface tension and viscosity (qualitative idea). Concept of colloids, emulsions and gels.

Gaseous state: Deviation of gases from ideal behaviour, van-der Waal's equation of state. Critical Phenomenon: PV isotherms of real gases. Relationship between critical constants and

van-der Waal's constants. Molecular velocities: Root mean square, average and most probable velocities. Collision number, mean free path and collision diameter.

Suggested Readings:

1. Physical Chemistry; G. M. Barrow; McGraw-Hill; International Student edition.
3. Physical Chemistry; R. A. Alberty; Wiley, Eastern Ltd.
4. Essentials of Physical Chemistry Vols III & IV; K. L. Kapoor; Macmillan India Ltd.
5. Principals of Physical Chemistry; Puri, Sharma and Pathania ; S. Nagin Chand &Co.
6. Physical Chemistry through Problems; S. K. Dogra; Wiley Eastern Ltd.
7. University general Chemistry; C. N. R. Rao; MacMillan.
8. Physical Chemistry 8th Ed., Atkins, P. W. & Paula, Oxford University Press.
9. Quantitative Chemical Analysis, Mendham, J. Vogel's, Pearson, 2009.
10. A. Senior Practical Physical Chemistry, Khosla, B. D.; Garg, V. C. & Gulati, R. Chand & Co.: New Delhi (2011).
11. Practical Physical Chemistry, Findley, Kitchener, Longman, 1977.
12. Advanced Practical. Physical Chemistry, Yadav, Goel Pub, 1994.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

BTCH/ZOO-CC-404 **Lab Course Based on BTCH/ZOO-CC-401**
Time: 30 hours **Credits: 02**

1. Estimation of DNA, RNA and protein by using spectrophotometer.
2. Agarose gel electrophoresis of DNA.
3. Agarose gel electrophoresis of RNA.
4. Native-polyacrylamide gel electrophoresis.
5. SDS-polyacrylamide gel electrophoresis of proteins.
6. Demonstration of different types of Chromatography/Density gradient centrifugation /Microscopy experiments.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

CHM-CC-406 **Lab Course Based on CHM-CC-403**
Time: 30 Hours **Credits: 02**

1. Determination of the density using specific gravity bottle and viscosity of a liquid using Ostwald's Viscometer.
2. Determination of surface tension of different liquids by Stalagmometer.
3. Study of the variation of viscosity of an aqueous solution with concentration of solute.
4. Acid hydrolysis of methyl acetate with hydrochloric acid.
5. Conductometric and pH metric titrations of i) strong acid and strong base (ii) weak acid and strong base
6. Determination of the composition of a mixture of HCl and CH_3COOH by titration with standard NaOH.
7. Determination of heat of neutralisation of a strong acid with a strong base.
8. Determination of heat of neutralisation of a weak acid with a strong base.
9. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc Program in Biotechnology (Under CBCS)
(Semester-IV)

BTCH-GE-401 **Environmental & Marine Biotechnology**
Time: 60 Hours **Credits: 04**

UNIT I: Environmental Monitoring (15 Lectures)
Environmental pollutants–Sampling, chemical analysis, biological analysis. Determination of biodegradable organic material, monitoring pollution, bioindicators, biomarkers, toxicity testing using biological material, biosensors.

UNIT II: Sewage Treatment & Bioremediation (15 Lectures)
Sewage treatment methods–Modifications to existing processes, sludge treatment and disposal, anaerobic digestion, agriculture waste, industrial waste, synthetic compounds, inorganic wastes. Bioremediation strategies–Bioremediation techniques in situ, bioremediation techniques ex situ, phytoremediation, metal bioremediation, gaseous bioremediation, biochemical pathways of biodegradation.

UNIT III: Marine Pollution & Applied Methods (15 Lectures)
Major marine pollutants – Monitoring methods, bioindicators, bioaccumulators and hot spots. Toxicology–Bioconcentration, bioaccumulation and biomagnification in marine environment, methods of toxicity testing, role of microcosms & mesocosms. Oil pollution – Composition, sources and fate of spilled oil, biodegradation, biological impact of oil on marine organisms.

UNIT IV: Marine Resources & Technology (15 Lectures)
Seaweed culture – Isolation, purification and identification of compounds. Economically important marine animals – Finfishes, shrimps, crabs, edible oysters and pearl oysters. Crab culture. Cray fish culture. Molluscan culture – Oysters, pearl oysters and mussels. Marine pearl production.

Suggested Readings:

1. Environmental Biotechnology, Alan Scragg
2. Environmental Biotechnology: A Biosystems Approach, Daniel A. Vallero.
3. Pollution and the Biological Resources of the Oceans by Pantin, S.A., 1982. Butterworth Scientific Co., London.
4. Marine Pollution. 3rd edition by Clark, R.B. Clavendon Press, Oxford, UK.
5. Biotechnology. Vol. I. Pharmaceutical and Bioactive Natural Products by David H. Attaway and R. Oskar, Marine Plenum Press, New York & London, 500 pp.

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

BOT-GE-403 **Archegoniate & Plant Genetic Resources**
Time: 60 Hours **Credits: 04**

UNIT I: Bryophytes **(15 Lectures)**

Bryophytes: characters, classification (up to classes), structure, reproduction and life history of Marchantia, and Funaria. Evolution of Sporophyte in Bryophytes.

UNIT II: Pteridophytes **(15 Lectures)**

Pteridophytes: characters, classification (up to Classes), structure, reproduction and life history of Lycopodium, and Marsilea. Heterospory and seed habit. Evolution of stele in Pteridophytes.

UNIT III: Gymnosperms (**15 Lectures)**

Gymnosperms: General characters, classification (up to classes), morphology, anatomy, reproduction and life history of Pinus and Gnetum, economic importance with reference to wood, essential oils and drugs

UNIT IV: Plant Genetic Resource Management **(15 Lectures)**

Concept of germplasm, importance of germplasm conservation, conservation of genetic resources of economic plants. in- Situ & ex-situ, (National parks, Field gene banks, Seed banks, Tissue culture and cryopreservation).Brief study of national and international organizations concerned with exploration, collection and conservation such as BSI (Botanical Survey of India), NBPGR (National Bureau of Plant Genetic Resources), CGAIR (Consultative Group for Indian Agricultural Research).

Suggested Readings:

1. Cavers, Frank, The inter-relationships of the Bryophytes, New Phytologist, Indian Reprint.
2. Smith, G.M., Cryptogamic Botany Vol. II., (Bryophytes & Pteridophytes) Tata McGraw Hill Publishing Co., New Delhi.
3. Parihar, N.S. An Introduction to embryophyta – Vol.II. BryophytaCentral Book Depot, Allahabad.
4. Watson, E.V., British Mosses & Liverworts Cambridge University Press, U.K
5. Eames, A.J., Morphology of Vascular Plants (Lower Groups), McGraw Hill, N.Y.
6. Parihar, N.S. An Introduction to EmbryophytaVol.IIPteridophyta, Central Book Depot., Allahabad.
7. Smith, G.M., Cryptogamic Botany Vol.II (Bryophytes &Pteridophytes) Tata McGraw Hill Publishing Co., New Delhi.
8. Sporne, K.R., The Morphology of Pteridophytes (The Structure ofFerns and Allied Plants) Hutchinson University Library, London

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IV)

BTCH-OGE-401 **Biotechnology & Society**
Time: 30 Hours **Credits: 02**

UNIT I: Introduction & Applications (7 Lectures)

Importance of Biotechnology in everyday life. Basic biotechnological skills, tools & their utilities. Significance in health & disease, detection of genetic diseases, disease diagnosis & treatment.

UNIT II: Biotechnology & Waste Management (8 Lectures)

Conventional fuels and their environmental impact. Microbial hydrogen production. Conversion of sugar to alcohol as biofuel. Treatment of municipal waste and Industrial effluents. Degradation of lignin and cellulose using microbes. Degradation of pesticides and other toxic chemicals by micro-organisms. Degradation of aromatic and chlorinates spills using microbes.

UNIT III: Biotechnology & Human Welfare (7 Lectures)

Biotechnology in human resource development. Significance of genetically modified microbes. Bio-fertilizers. Role of symbiotic and asymbiotic nitrogen fixing bacteria in the enrichment of soil. Biotechnology for solving violent crimes such as murder, rape, paternity and theft.

UNIT IV: Biotechnology & Food Production (8 Lectures)

Basic skills in domestic animals for upscaling milk, meat and hides etc. Intervention of technology for nutrient enrichment of animal, agriculture based foods. Production of high productivity & disease resistant livestock breeds & seed strains.

Suggested Readings:

1. Building Biotechnology by Yali Friedman, published in United States of America.
2. Biotech, LLC, Washington.
3. Career Development in Bioengineering and Biotechnology by Guru Prasad Madhavan.
4. Luis Kun, Barbara Oakley, Springer Publishers.
5. Biotechnology by B. D. Singh, Kalyan Publishers.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-V)

BTCH-CC-501 **Human Physiology**
Time: 60 Hours **Credits: 04**

UNIT I: Digestion & Respiration (15 Lectures)

Composition of bile, saliva, pancreatic, gastric and intestinal juice. Mechanism of digestion & absorption of carbohydrates, proteins, lipids and nucleic acids.

Mechanism of breathing, ventilation, regulation of respiration, exchange of gases, transport of O_2 and CO_2, oxyhemoglobin dissociation curve and carbon dioxide dissociation curve.

UNIT II: Blood & Circulation (15 Lectures)

Composition of blood and plasma & their role. Blood cells-granulocytes and agranulocytes, macrophage system, mechanism of coagulation of blood, hematopoiesis, erythropoiesis, anemias, hemostasis, blood groups.

Functional anatomy of the heart, cardiac output, cardiac cycle & circadian rhythms, properties of cardiac muscles, conducting system of the heart, pressure changes during cardiac cycles, capillary circulation, arterial and venous blood pressure.

UNIT III: Muscular System & Renal Physiology (15 Lectures)

Structure of cardiac, smooth & skeletal muscle. Threshold stimulus, all or none rule, single muscle twitch, muscle tone, isotonic and isometric contraction. Physical, chemical & electrical events of mechanism of muscle contraction.

Excretion: modes of excretion, urea cycle, structure of kidneys, nephrons, juxtra glomerular filtrate, reabsorption, secretion-mechanism of secretion, concentrating and diluting mechanism of urine, dialysis.

UNIT IV: Nerve-transmission & Endocrine System (15 Lectures)

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, neurotransmitters.

Mechanism of action of hormones (insulin and steroids), different endocrine glands– hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid, gonads and adrenals, disorders of endocrine system: hypo & hyper-secretions.

Suggested Readings:

1. Textbook of Medical Physiology by John E. Hall, Guyton and Hall, Saunders.
2. Principles of Anatomy & Physiology by Tortora, G.J. & Grabowski, S. John wiley & sons,Inc.
3. Human Physiology by Stuart Ira Fox. McGraw-Hill Higher Education.
4. Vander's Human Physiology by Eric P. Widmaier, Hershel Raff, Kevin T. Strang.Mc Graw-Hill Education.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-V)

BTCH-CC-502 **Concepts in Microbiology & Immunology**
Time: 60 Hours **Credits: 04**

UNIT I: Bacteriology (15 Lectures)

Spontaneous generation, biogenesis, germ theory of diseases, Koch's Postulates. Classification of organisms on the basis of their cell wall, structure of a typical prokaryotic cell and archae-bacteria, methods of isolation, purification and preservation of microbes, transformation, transduction and conjugation in bacteria, biofilms. Disease causing gram positive and gram negative bacteria-their pathogenesis, diagnosis and preventive measures. Methods for controlling microbial growth (physical & chemical), chemotherapeutic agents.

UNIT II: Virology (15 Lectures)

Structure, classification and morphology of viruses, Replication, viral protein synthesis, host-cell reactions, cell destruction-cytocidal, necrosis and non-cytocidal infection, laboratory diagnosis: isolation by culturing, direct detection, biochemical amplification and serodiagnosis. Latent infection, oncoviruses and DNA tumour viruses. Specific and nonspecific immune defence mechanisms against viruses.

UNIT III: Overview of Immune System (15 Lectures)

Historical perspective, types of immunity, components of innate and acquired immunity, haematopoiesis, cell mediated and humoral immunity, cells and tissues of immune system, cytokines, clonal selection theory, major histocompatibility complex, antigen processing and presentation.

UNIT IV: Mechanisms & Functions of Immune System (15 Lectures)

Immunogens and antigens, requirements for immunogenicity, major classes of antigens, haptens, adjuvants. Immunoglobulins: basic structure, classes, subclasses and functions, allotypes, isotype & idiotypes. Antigen-antibody interactions: precipitation & agglutination. Complement system: activation pathways, functions and regulation. Hypersensitivity reactions and types. Vaccine technology: vaccines and types.

Suggested Readings:

1. Kuby Immunology by Owen, Punt and Stranford.W.H. Freeman and Company.
2. Essential of Immunology by Roitt, I.M. ELBS, Blackwell Scientific Publication.
3. Cellular and Molecular Immunology by Abul K. Abbas, Andrew H.L, Shiv Pillai, Saunders Publications.
4. Janeway'sImmunobiology by Kenneth Murphy, Mark Walport, and Paul Travers. Garland Sciences.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-V)

CHM-CC-503 **Spectroscopy**
Time: 60 Hours **Credits: 04**

UNIT I: Introduction & Chemical Spectroscopy (15 Lectures)

Origin of spectra, Interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of. Born-oppenheimer approximation (statement only); Electromagnetic spectrum. Rotational Spectrum: Selection rules, Energy levels of rigid rotator (semi-classical principles), rotational spectra of diatomic molecules; relative population of rotational levels and spectral intensity, determination of bond length and isotopic effect. Vibrational spectrum: Simple harmonic oscillator (classical approach), Vibrational spectra of a diatomic molecule, determination of force constant and its relation with bond length and bond energy. Vibrational degree of freedom. Electronic spectroscopy: Selection rules and Franck-Condon principle.

UNIT II: UV-Visible Spectroscopy (15 Lectures)

Beer-Lambert's Law. Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument, molar absorptivity, presentation and analysis of electronic spectra. Types of electronic excitations. Effects of conjugation and solvents on absorption. Chromophores and auxochromes and their effect. Bathochromic and hypsochromic shifts. Ultraviolet spectra of enes and enones. Prediction of maxima of enes and enones using Woodward's rules. Applications of Ultraviolet and Visible Spectroscopy. Quantitative analysis by UV-Vis. method.

UNIT III: Infrared Spectroscopy (15 Lectures)

The infrared region. Molecular vibrations, significance of Hook's law and selection rules. The infrared spectrum. Fingerprint region and its significance. Factors affecting infrared absorption bands. Characteristic bands of Alkanes, alkenes, alkynes, alcohols, ethers, carbonyl compounds, amines and carboxylic acids and their derivatives. Interpretation of Infrared Spectra, Applications of Infrared Spectroscopy. Problem based exercise.

UNIT IV: Nuclear Magnetic Resonance (15 Lectures)

Basic principle of NMR, ^{1}HNMR: Shielding and deshielding of protons. The chemical shift. Equivalent and non-equivalent protons. Spin-spin splitting, coupling constants for vicinal, geminal and long range couplings. The ^{1}HNMR spectra of ethyl bromide, ethanol, acetaldehyde, ethyl acetate, methyl propionate, toluene and acetophenone.

^{13}C-NMR: Introduction, common modes of recording ^{13}C Spectra, decoupled and off-resonance decoupled spectra, Chemical Shift Equivalence, Factors affecting ^{13}C-Chemical Shifts. Interpretation of ^{13}C-NMR spectra of some common compounds.

Problem based exercises on UV, IR and NMR: Interpretation of spectral data for structural elucidation.

Suggested Readings:

1. Organic Spectroscopy, by L.D.S. Yadav
2. Organic Spectroscopy, by Kemp, W.H. Freeman & Co.
3. Spectroscopic Identification of Organic Compounds, R. M. Silverstein, G. C. Basler and T. C. Morrill, John Wiley & Sons.
4. Physical Methods in Chemistry, R.S. Drago, Saunders.
5. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill (1962).
6. Basic Principles of Spectroscopy, R. Chang, McGraw Hill, N.Y. (1970)
7. Fundamentals of Molecular Spectroscopy, Fourth Edition, C.N. Banwell and E.M. McCash, Tata McGraw-Hill Publishing Company Limited, New Delhi (1994).
8. Experiments and Techniques in Organic Chemistry, D. Pasto, C. Johnson and M. Miler, Prentice Hall.
9. Macroscale and Microscale Organic Experiments, K.L. Williamson, D.C. Heath
10. Vogel's Textbook of Practical Organic Chemistry, A.R. Tatchell, John Wiley
11. Chemistry of Natural Products: A laboratory Handbook by N.R. Krishnaswamy, University Press, 2003
12. Comprehensive Practical Organic Chemistry, V.K. Ahluwalia, RenuAgarwal (University Press India Ltd.-2000)
13. Organic Laboratory techniques, Donald C Pavia, Gary M Lampman.
14. Experimental Organic Chemistry John C Gilgert, Stephen F Martin(SCP) 8. Advanced Practical Organic Chemistry, Vol.II, Jagmohan (Himalaya Publishing House)

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-V)

BTCH-CC-504 **Lab Course Based on BTCH-CC-501**
Time: 30 Hours **Credits: 02**

1. Determination of human ABO blood groups.
2. Finding the coagulation time of blood.
3. Counting of mammalian RBCs.
4. Determination of TLC and DLC.
5. Determination of Haemoglobin concentration in blood.
6. To determine the effect of pH and temperature on the digestion of starch by salivary amylase.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.
8. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-V)

BTCH-CC-505 **Lab Course Based On BTCH-CC-502**
Time: 30 Hours **Credits: 02**

1. Different sterilization techniques.
2. Preparation of media.
3. Isolation of bacteria from soil, water and air.
4. Staining methods- Gram staining, spore staining and hanging drop.
5. Separation of Serum and plasma from blood.
6. Serological assays including the Immuno-diffusion (Radial and double immunodiffusion).
7. Separation of mononuclear cells by Ficoll-Hypaque method.
8. Electrophoretic separation of serum proteins.
9. Any other practical found feasible by the teacher and approved by HOD and Dean.
10. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-V)

CHM-CC-506 **Lab Course Based on BTCH-CC-503**
Time: 30 Hours **Credits: 02**

1. Establishing the validity of Beer-Lambert law.
2. Determination of composition of a binary mixture of $K_2Cr_2O_7$ and $KMnO_4$.
3. Determine the λmax. of some organic conjugated compounds by UV-Vis. Spectrophotometer.
4. Isolation of beta-carotene from carrots and determination of its λmax.
5. Estimation of sugar & amino acids (glucose and glycine).
6. IR of simple organic compounds for functional group identification.
7. Preparation of adipic acid from oxidation of cyclohexanol by chromic acid.
8. Saponification value of oils.
9. Any other practical found feasible by the teacher and approved by HOD and Dean.
10. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-V)

BTCH-GE-501 **Disease & Disease Models**
Time: 60 Hours **Credits: 04**

UNIT I: Cancer & Metabolic Diseases (15 Lectures)

Characteristics of tumor cells. Use of cell culture and animal models in cancer research and drug discovery. Carcinogenesis and agents promoting carcinogenesis. Oncogenes & tumor suppressor genes. Present cancer treatments & their limitations. New drug targets and challenges involving epigenetics. Overweight, Obesity, Diabetes & Metabolic diseases in metabolic syndrome. Correlations & present research in animal & humanized models.

UNIT II: Stem Cell Technology & Regenerative Medicine (15 Lectures)

Various systems for totipotent, pluripotent, multipotent and unipotent stem cells from embryonic development. Generation of pluripotent stem cells from somatic cells in model systems. Stem cell therapy, prenatal diagnosis & challenges. Modulators for stem cell fate determinations in regenerative medicine prospects in stem cell model systems with biological & ethical challenges.

UNIT III: Infectious & Neurodegenerative Diseases (15 Lectures)

Challenges in bacterial diseases, Tuberculosis, HIV & Malarial treatments. Drug resistance in Tuberculosis, causes and concerns. Differences between rodent and human tuberculosis. HIV treatment regimens with success and adverse effects. Present research in Malarial drug discovery. Alzheimer's and Parkinson's disease including stroke: incidence and pathologies. Limitations of model systems for their understandings. Genetic and epigenetic treatment strategies.

UNIT IV: Disease Models & Limitations (15 Lectures)

Application of *in vitro, in vivo* & *ex vivo* data with human physiology & disease correlation. Advantages of human biology versus physiology in disease diagnosis, prognosis and treatment studies. Usage of animals in various diseases and limitations. Present challenges of animal usage in disease models and possible future strategies.

Suggested Readings:

1. Harrison's Principles of Internal Medicine, (Harrison's Principles of Internal medicine) by Dan L. Longo, Anthony S. Fauci, Dennis L. Kasper , Stephen L. Hauser, J. LarryJameson and Joseph Loscalzo, McGrawhills publishers
2. The Biology of Cancer by R. Weinberg.
3. Cancer Biology by R. W. Ruddon.
4. The Biological Basis of Cancer by R. G. Mckinnell, R. E. Parchment, A. O. Perantoni and G. B. Pierrce, Cambridge University Press.
5. Infectiuos disease modelling: A hybrid approach by Peter Stechlinski and Xinzhi.
6. Modelling infectious diseases in humans and animals by Matt J. Keeling and PejmanRohani
7. Stem cell in regenerative medicine: Methods and protocols by Julie Audet and William L. Stanford.

Syllabus for 5 Year B.Sc.-M.Sc. Integrated Program in Biotechnology (Under CBCS)
(Semester-V)

BOT-GE-503 **Economic & Ethnobotany**
Time: 60 Hours **Credits: 04**

UNIT I: Economical Botany **(15 Lectures)**

Cultivation, propagation and economical importance of:
Fruits – Apple, Peach, Plum, Apricot, Cherry, Walnut, Almond.
Cereals and Millets –Rice, Wheat, Sorghum and Bajra.
Pulses – Kidney bean, Pigeon pea, Bengal Gram, Black Gram and Green Gram.
Spices – Cardamom, Mint, Clove, Cinnamon, Pepper, Coriander and Mustard.

UNIT II: Economical botany **(15 Lectures)**

Cultivation, propagation and economical importance of:
Narcotic plants – Cannabis sativa, Papaver sominiferum and Opium poppy.
Medicinal Plants – Rauwolfia, Withania, Vinca, Phyllanthus, Ocimum, Mentha, Aloe and Garlic.

UNIT III: Ethnobotany **(15 Lectures)**

Plant part used, active principal and medicinal properties of:
Glycyrrhiza glabra (Shanger), Arnebia bentham (Kahzaban), Artemisia absinthium (Thethwan), Crocus stavas (Kung), Coriandrum sativum (Danival), Morchella esculenta (Kanighitch), Malva sylvestris (Sotal), Taraxacum officinate (Handd), Papaver somniferous (Kashkhas).

UNIT IV: Plant Genetic Resource Management **(15 Lectures)**

Conservation of genetic resources of economic plants, In-Situ and Ex–Situ (National parks, Field gene banks, Seed banks, tissue culture and cryopreservation). Brief study of national and international organizations concerned with exploration, collection and conservation such as Botanical Survey of India (BSI), National Bureau of Plant Genetic Resources (NBPGR), Consultative Group for Indian Agricultural Research (CGAIR).

Suggested Readings:

1. Bendre and Kumar, Economic Botany, Rastogi Publication, Meerut.
2. Singh and Jain, Taxonomy of Angiosperm, Rastogi Publication, Meerut.
3. Saxena and Saxena, Plant Taxonomy, Pragathi Prakashan, Meerut.
4. Plant Taxonomy by O.P. Sharma Tata Mc Graw – Hill, Economic Botany BD Pandey S. Chand & Com Ltd New Delhi.
5. Kachroo and Dhar, Medicinal plants of Kashmir Himalaya.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-V)

BTCH-DSE-501 **Industrial Biotechnology**
Time: 30 Hours **Credits: 02**

UNIT I: Microbial Production Systems (8 Lectures)

Introduction to bioprocess technology. Range of bioprocess technology and its chronological development. Open and closed system, growth phases. Chemostat-its elaborations (Turbidostat & pH stat). Product formation in microbial cultures. Factors affecting product formation.

UNIT II: Culture types & Microorganisms (7 Lectures)

Batch, fedbatch, cyclic fed-batch culture and continuous culture. Application and examples of fed-batch culture. Industrially important microorganisms and improvement of strains. Isolation of mutants and use of recombinant DNA technology.

UNIT III: Introduction to Bioreactors (7 Lectures)

Design of bioreactors/fermenter vessels. Basic functions of a fermenter. Significance and designs of impeller, baffles and sparger. Sterilisation techniques (heating, radiation, chemical and filtration)

UNIT IV: Down-stream processing (8 Lectures)

Microbial production of ethanol, amylases, lactic acid. Microbial production of antibiotics. Single Cell Proteins (SCPs), uses and applications. SCP production from methanol, wood, sewage etc.

Suggested Readings:

1. Principles of Fermentation Technology by Stanbury PF, Whitaker A and Hall SJ.
2. A textbook of Industrial Microbiology by Crueger W and Crueger A. Biotechnology.
3. Bioprocess Engineering by Michael L. Shuler/Fikret Kargi.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-CC-601 **Recombinant DNA Technology & Applications**
Time: 60 Hours **Credits: 04**

UNIT I: Principles & Tools (15 Lectures)

Enzymes for DNA manipulation, Restriction modification systems, Types and Nomenclature, restriction maps. DNA modifying enzymes and their applications like Klenow fragments, T4 DNA polymerase, polynucleotide kinase, phospahatases, reverse transcriptases, exonucleases, endonucleases and ligases. Cohesive and blunt end ligation. Linkers and adaptors. Vectors: Definition and properties, simplest cloning vectors based on *E. coli* plasmids, bacteriophage vectors, vectors for longer pieces of DNA, insertion and replacement vectors.

UNIT II: Techniques & Procedures (15 Lectures)

Polymerase chain reaction: Principle, types and applications. primer designing, reverse transcriptase and real time PCR. DNA sequencing: Maxum-Gilbert, Sanger and Next-gen sequencing. Site directed mutagenesis. Genomic and cDNA libraries, southern hybridization. Chromatin immunoprecipitation. Reporter gene assay.

UNIT III: Gene Transfer & Transgenic Organisms (15 Lectures)

Gene transfer technology, Methods of DNA transfer into cells: Bacterial, animal and plant cells. Embryo transfer techniques, introduction to transgenic animals: Mice, Cow etc. Use of protoplasts and tissue culture, Agrobacterium tumefaciens and A. rhizogenes, Ti plasmids. Transgenic plants and examples.

UNIT IV: Applications of Genetic Engineering (15 Lectures)

Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each). Important therapeutic products from plants. Genetic modification in medicine, gene therapy, success stories and ethical issues. Hybridoma technology and application. Recent developments in stem cell technology. Human genetic engineering, problems & ethics.

Suggested Readings:

1. Gene Cloning and DNA Analysis, An Introduction by Brown TA Wiley-Blackwell
2. Gene Cloning and Manipulation by Christopher Howe, Cambridge University Press
3. Principles of Gene Manipulation by Primrose SB, Twymann R and Old B Wiley-Blackwell.
4. Analysis of Genes and Genomes, by Reece J Richard, Wiley-Blackwell

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-CC-602 **Protein & Enzyme Technology**
Time: 60 Hours **Credits: 04**

UNIT I: Protein Structure (15 Lectures)

Basis of Protein structure. Primary, Secondary, tertiary and quaternary structure of proteins. Dihydryl angles and Ramachandran plot. Oligomeric proteins, protein domains and motifs. Structure and function of oxygen binding proteins (Hemoglobin and Myoglobin). Protein denaturation and renaturation. Factors affecting protein folding, models of protein folding. Misfolding& Diseases.

UNIT II: Enzyme Kinetics & Activation (15 Lectures)

Nomenclature & classification of enzymes, Uni-substrate enzyme kinetics and factors affecting the rate of enzyme catalyzed reactions. Michealis-Menten equation. Transformation of Michealis–Menten plot to linear forms. Lineweaver-Burk plot, Briggs-Haldane modification, Eadie-Hofstee plots. Advantages and disadvantages of alternate plotting. Enzyme inhibition: Reversible inhibition: Uncompetitive, Non-competitive, Competitive & Mixed inhibition. Irreversible inhibition. Feedback inhibition and feed forward stimulation. Reversible and irreversible covalent modifications of enzymes. Enzyme activators-examples.

UNIT III: Multisubstrate Enzyme Kinetics (15 Lectures)

Determination of rate constant for enzyme catalyzed reactions, Protein–Ligand binding including measurement, analysis of binding isotherm. Hill and Scatchard plots, Allosteric enzymes, Symmetric and sequential modes for action of allosteric enzymes and their significance, Kinetics of multi substrate reactions. Primary and secondary plots for determination of kinetic constants for multisubstrate reactions. Investigation of reaction mechanism using steady state methods. Use of initial velocity, inhibition and exchange studies to differentiate between multi substrate reaction mechanisms.

UNIT IV: Enzyme Technology (15 Lectures)

Enzyme localization, Enzyme assay, Direct and coupled assays. Strategies for bulk enzyme production. Enzyme isolation, Enzyme purification, criteria and aim for purification, techniques/& steps involved. Salting out, Chromatography, Ion exchange, Adsorption, Hydrophobic and Gel filtration & their significance. Ascertaining purity level of enzyme, specific activity; criteria of enzyme purity, characterization of an enzyme, determination of the molecular weight. Industrial applications of enzymes-in diagnosis, therapy, brewery, dairy, food processing, detergent, textile. Enzyme immobilization technology and its industrial applications. Enzyme inhibitors and drug design.

Suggested Readings:

1. Fundamentals of Enzymology: Cell and Molecular Biology of Catalytic Proteins. Nicholas C. Price and Lewis Stevens. Oxford University Press.
2. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry, Trevor Palmer.
3. Enzyme Kinetics and Mechanisms. Kenneth B. Taylor. Kluwer Academic Publishers.
4. Fundamentals of Enzyme kinetics. Athel Cornish-Bowden, Portland press.
5. Fundamentals of Biochemistry: Life at the Molecular Level. Donald Voet, Judith G. Voet and Charlotte W. Pratt. Publisher: Wiley.
6. Lehninger, Principles of Biochemistry. David L. Nelson and Michael M. Cox, WH Freeman and Company.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

CHM-CC-603 **Advanced Chemistry**
Time: 60 Hours **Credits: 04**

UNIT I: Analytical Chemistry (15 Lectures)

Adsorption techniques, kinds of adsorption interactions, adsorption characteristics, Introduction and classification of chromatography. Thin layer chromatography, column chromatography, Ion exchange, size exclusion and Gas-liquid chromatography (Instrumentation, Principle and applications). High Performance Liquid Chromatography, Reverse HPLC and their applications. Centrifugation and electrophoresis techniques.

UNIT II: Chemistry of Natural Products (15 Lectures)

Alkaloids: Introduction, occurrence and isolation. Structure elucidation and synthesis of Atropine.

Steroids: Introduction and importance, structure features of cholesterol, its relationship with bile acids, transformation of cholesterol to steroidal hormones and vit-D and its biogenesis.

***Terpenoids*:** Introduction, Isoprene rule, classification, structure and synthesis of beta-carotene and Zingiberene. Biogenesis. Major constituents of essential oils.

Fats and oils: Saponification, soaps/detergents and their mode of action.

UNIT III: Chemistry in Biology (15 Lectures)

Distribution and biological role of elements (Na^+, K^+, Ca^{2+}, Mg^{2+}, Fe^{2+} and halogens) in life. Structure and Biological role of Haemoglobin, myoglobin & Chlorophyll. Biological Nitrogen Fixation. Metal complexes (Platinum, Rhodium and Gold complexes) as anticancer drugs, Phosphorylation of sugars. Synthesis and application of unnatural amino acids, Chemical synthesis of DNA. Role of HCN & HCHO in biosynthesis. Formation of purines and pyrimidines from HCN under prebiotic conditions. Biological redox reactions (oxidation by NAD^+ and reduction by NADPH).

UNIT IV: Drug Design & Medicinal Chemistry (15 Lectures)

Procedures followed in drug design, concept of lead compound and lead modification, concepts of prodrugs and soft drugs, structure-activity relationship (SAR). Theories of drug activity (occupancy, rate and induced fit theory). History and development of QSAR. Concepts of drug receptors. Physicochemical parameters: lipophilicity, partition coefficient, electronic ionization constants, steric, Shelton and surface activity parameters and redox potentials.

Antibiotics: Cell wall biosynthesis, inhibitors, β-lactam rings, antibiotics inhibiting protein synthesis. Synthesis of Penicillin G, Penicillin V, Ampicillin, Amoxicillin, Chloramphenicol, Cephalosporin, Tetracycline and Streptomycin.

Suggested Readings:

1. Fundamentals of Analytical chemistry, D. A. Skoog; D. M. West; F. J.Holler, Harcourt college publications.
2. Principles and practice of analytical chemistry, F. W. Fifield; D. Kealey, Blackwell publication.
3. Analytical chemistry, G.D. Christian, Wiley and son's publication.
4. Analytical chemistry- Instrumental Techniques (Vol. II); M. Singh, Dominant publishers.
5. Organic chemistry, I. L. Finar, Vol. II, ELBS Publications, UK.
6. Medicinal chemistry; new age international publishers by Ashutosh Kar.
7. Textbook of Practical Organic Chemistry, Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Prentice-Hall, 5th edition, 1996.
8. Practical Organic Chemistry, Mann, F.G. & Saunders, B.C., Orient-Longman, 1960.
9. Senior Practical Physical Chemistry, Khosla, B. D.; Garg, V. C. & Gulati, A., R. Chand & Co.: New Delhi (2011).
10. Comprehensive Practical Organic Chemistry by Ahluwalia, V.K. & Aggarwal, R., Universities Press

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-CC-604 **Lab Course Based on BTCH-CC-601**
Time: 30 Hours **Credits: 02**

1. Plasmid DNA isolation.
2. Restriction digestion of Plasmid.
3. Preparation of competent cells.
4. Transformation of competent cells by heat shock.
5. Transformation of competent cells by electroporation method.
6. Polymerase chain reaction.
7. Agarose gel electrophoresis.
8. Any other practical found feasible by the teacher and approved by HOD and Dean.
9. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-CC-605 **Lab Course Based on BTCH-CC-602**
Time: 30 Hours **Credits: 02**

1. Native-PAGE and SDS-PAGE of proteins.
2. Extraction & assay of Alkaline phosphatase.
3. Assay of enzyme activity.
4. Determination of optimum pH and temperature for enzyme activity.
5. Subcellular fractionation of tissue(s).
6. Measurement of specific activity for marker enzyme of each fraction.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.
8. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester–VI)

CHM-CC-606 **Lab Course Based on CHM-CC-603**
Time: 30 Hours **Credits: 02**

1. Isolation of caffeine from tea leaves.
2. Isolation of lycopene from tomato
3. Preparation of sulphanilamide, paracetamol.
4. Determination of fat content of cheese and estimation of salt content in butter.
5. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
6. Separation of a mixture of two sugars by ascending paper chromatography.
7. Separation of a mixture of o- and p-nitrophenol or o- and p-aminophenol by thin layer chromatography (TLC).
8. Any other practical found feasible by the teacher and approved by HOD and Dean.
9. Educational tour to different labs.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-GE-601 **Microbial & Fermentation Technology**
Time: 60 Hours **Credits: 04**

UNIT I: Growth Kinetics & Growth Parameters (15 Lectures)
Microbial culture and its growth kinetics. Growth rate parameters: specific growth rate, doubling time, validity of exponential growth, validity of exponential growth law; growth yield, metabolic quotient. Mathematical model of simple batch culture. Growth associated kinetics.

UNIT II: Fermentation Operations (15 Lectures)
Bioreactor operations, configuration and their main components. Types of culture/production vessels–Airlift, Cyclone column, Packed Tower and their application in production processes. Media formulation, media sterilization and techniques. Inoculum development, criteria for transfer of inoculums.

UNIT III: Bioprospection & Applications (15 Lectures)
Immobilized cell systems, active immobilization and passive immobilization. Bioprocess considerations in animal cell culture; methods, bioreactor considerations and products, Bioprocess considerations in plant cell culture. Utilizing genetically engineered organisms. Guidelines for choosing Host-vector systems, product constraints, genetic instability.

UNIT IV: Down-Streaming Processing (15 Lectures)
Pre-treatment strategies, downstream processing, criteria and different techniques. Removal of microbial cells and solid matter: precipitation, filtration and centrifugation. Cell disruption techniques, mechanical and non-mechanical. Membrane Processes: Ultra filtration, reverse osmosis, liquid membranes. Crystallization and drying. Effluent treatment and disposal of effluents.

Suggested Readings:

1. Principles of Fermentation Technology, by Stanbury PF, Whitaker A and Hall SJ.
2. Biotechnology: A textbook of Industrial Microbiology, by Crueger W and Crueger A.
3. Bioprocess Engineering and Technology, by Michael L. Shuler / FikretKargi.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BOT-GE-603 **Plant Taxonomy**
Time: 60 Hours **Credits: 04**

UNIT I: Introduction & Features (15 Lectures)

Fundamental components of taxonomy (identification, nomenclature, classification). Taxonomic resources - Herbarium- functions & important herbaria, botanical gardens. Flora, Keys- single access and multi-access. Botanical Nomenclature-Principles and rules of ICBN (ranks and names; principle of priority, binomial system; type method, author citation, valid-publication.

UNIT II: Classification (15 Lectures)

Types of classification- Artificial, natural and phylogenetic. Bentham & Hooker's system of classification- merits and demerits. Engler & prantle's system of classification- merits and demerits. Phylogeny – origin and evolution of Angiosperms

UNIT III: Systematic Taxonomy-I (15 Lectures)

Systematic study and economic importance of the following families: Annonaceae, Brassicaceae, Rutaceae, Curcurbitaceae, and Apiaceae.

UNIT IV: Systematic Taxonomy-II (15 Lectures)

Systematic study and economic importance of plants belonging to the following families: Asteraceae, Asclepiadaceae, Lamiaceae, Ephorbiaceae, Arecaceae, and Poaceae.

Suggested Readings:

1. Porter, C.L. Taxonomy of flowering Plants, Eurasia Publishing House, New Delhi.
2. Lawrence, G.H.M., Taxonomy of Vascular Plants, Oxford & IBH Publishers, New Delhi, Calcutta.
3. Jefferey, C., An Introduction to Plant Taxonomy J.A. Churchill, London.
4. Mathur, R.C., Systematic Botany (Angiosperms) Agra Book Stores, Lucknow, Ajmer, Allahabad, Delhi.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VI)

BTCH-DSE-601 **Drug Metabolism & Toxicology**
Time: 30 Hours **Credits: 02**

UNIT I: Drug Absorption & Disposition (8 Lectures)
Mechanism of drug absorption, physico-chemical, biological and pharmaceutical factors affecting drug absorption through GIT. Techniques for the GIT absorption assessment. Drug clearance, mechanism of clearance and factors affecting drug clearance, volume of distribution and its significance.

UNIT II: Pharmacokinetic Characterization of Drugs (7 Lectures)
Approaches to pharmacological testing, drug half-life, Pharmacokinetics, pharmacodynamics and pharmacogenetics of drugs. Clinical applications of pharmacogenetic testing, urinary excretion data and its application in pharmacokinetic characterization of drugs. Kinetics of maternal-fetal drug transfer.

UNIT III: Biotransformation of Drugs (8 Lectures)
Drug entry and fate in living system, absorption, distribution, excretion and detoxification, phase I and phase II reactions and their inter-relationships, components of mixed function oxidases, substrate-cytochrome P450 interactions, isoenzymes of cytochrome P450. Extra microsomal enzymes and their role in detoxification.

UNIT IV: Fundamentals of Toxicology (7 Lectures)
History of toxicology, toxicants, therapeutic dose, dose-response curve, Determination of ED_{50} and $LD_{50,}$ multiple toxicants response, serum enzymes behavior. Drug abuse. Mechanism of action of toxicants. Drug receptor interactions.

Suggested Readings:

1. Casarett and Doull's Toxicology by Klaassen C D, Amdur M O &Doull J. Macmillan publishing company, New York.
2. Industrial Toxicology by Williams P L &Burson J L. Van- Nostrand Reinhold, New York.
3. Principles and methods of toxicology by Hayes A W. Raven press New York.
4. Lippincott's illustrated reviews: Pharmacology by Richard a Harvey, Pamela C Champe, Richard Finkel, Luigi X Cubeddu. Wolters Kluwer.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-VI)

BTCH-DSE-602 **Molecular Medicine**
Time: 30 Hours **Credits: 02**

UNIT I: Overview (7 Lectures)

Introduction to Molecular Medicine. Human genome: implication and applications. Single Nucleotide Polymorphism. Gene therapy as a potential tool to cure human diseases. Recombinant molecules in medicine.

UNIT II: Molecular Basis of Infectious Diseases (8 Lectures)

Understanding the mechanisms available for genetic variability in different pathogens to defy host immune system. Host signaling in response to infections. Bacterial two component signaling systems. Bacterial adhesins, virulence factors. Protein and DNA secreting systems and Pathogenicity Island. Molecular basis of antimicrobial resistance and its detection.

UNIT III: Molecular Basis of Metabolic Disorders (8 Lectures)

Introduction to metabolic disorders: Insulin dependent and independent diabetes; Obesity and Fatty Liver Disease, Cardiovascular diseases, Neurodegenerative diseases like Parkinson. Ageing, Inherited metabolic disorders. Physiological, oxidative and nitrosative stress in metabolic disorders. Inflammation and immunity in metabolic diseases.

UNIT IV: Molecular Therapies (7 Lectures)

Ligand based drug design and structure based drug design. Telomerase targeting in cancer therapy, Antisense-oligo deoxynucleotides, Peptide nucleic acids, Hammerhead ribozymes etc.

Suggested Readings:

1. Principles of Molecular Medicine by Marschall S. Runge Cam Patterson.
2. Molecular Medicine: An Introduction by Jens Kurreck, Cy Aaron Stein.
3. Principles of Molecular Medicine, 2nd ed, MS Runge, C Patterson, VA McKusick.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-CC-701 **Advanced Cell Biology**
Time: 60 Hours **Credits: 04**

UNIT I: Cell: Structural Organization & Techniques (15 Lectures)

Cell theory and modern cell biology. Cell organelles: Structure of the Endoplasmic Reticulum, Golgi body, Lysosome, Peroxisome, Plant vacuole, Ribosome, Mitochondria, Chloroplast, Nucleus, Cytoskeleton, Plant cell wall. Subcellular fractionation by differential centrifugation. Protoplasm, cytoplasm and cytosol.

UNIT II: Membrane Biology & Transport (15 Lectures)

Biological membranes–Chemical composition and structural plan. Models of membrane structure; Membrane as a two dimensional fluid. Factors affecting the fluidity and permeability of the membrane. Phase transition, Membrane proteins: types and isolation. Movements of small molecules and ions across the membrane. Movements of macromolecules across membrane, Osmosis, Diffusion, Active and Passive transport. Types of ATPases. Endocytosis, Receptor mediated endocytosis, Phagocytosis. Membrane fusion; Artificial membranes.

UNIT III: Cellular Physiology (15 Lectures)

Cytoplasmic membrane/endomembrane system. Synthesis and transport of proteins to membrane and various organelles. Secretory proteins-transport mechanism. Protein targeting to the peroxisome. Major functions of various cell organelles. Packaging of eukaryotic DNA into chromosome. Nucleosome and higher levels of structural organization of eukaryotic chromosome. Nuclear pore complex and its function. Trafficking across the nucleus. Nucleolus and the synthesis of ribosome. Electric properties of membrane; Patch clamp and voltage clamp techniques.

UNIT IV: Cell Signaling & Signal Transduction (15 Lectures)

Signal hypothesis, Signal transduction & regulation. Receptors and ligands, Proteins and other molecules involved in the transduction of signal into the cell and eliciting a response. G proteins and G protein coupled receptors. Growth factors and receptor tyrosine kinase. Second messengers; Cell cycle and its regulation. Cell signaling in the development and differentiation. Cell death mechanisms-Apoptosis, necrosis and autophagy.

Suggested Readings:

1. Molecular Biology of the Cell by Alberts, B Taylor and Francis, New York. USA.
2. Molecular Cell Biology by Lodish et al: W.W Freeman and Company, New York, USA.
3. The Cell: Organization, Functions and Regulatory Mechanisms by Shakir Ali, Pearson Education.
4. The Cell: A Molecular Approach by Cooper, G.M. and Hausman, R.E. ASM Press

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-CC-702 **Molecular Biology**
Time: 60 Hours **Credits: 04**

UNIT I: DNA Structure & Properties (15 Lectures)

Overview of DNA structure. General biophysical properties of DNA. Forces & factors that stabilizes the DNA structure. DNA topology. Denaturation & renaturation of DNA, melting curves and assessment of GC% and Tm; Hyper and hypochromic effects of DNA. C-value paradox and significance. General features of DNA replication: Semi-conservative & other common types. Directionality of DNA replication with examples from prokaryotic and eukaryotic systems. Structural and functional order of various enzymes/proteins involved in DNA replication. DNA polymerases: Molecular mechanism of DNA polymerization & role of magnesium during the polymerization of nucleotides. Organelle DNA including Mitochondria and Chloroplast. Role of inhibitors and analogs in pathway elucidations.

UNIT II: DNA Replication Mechanisms (15 Lectures)

Structure and function of various prokaryotic (DNA Pol I, DNA Pol III holoenzyme) and eukaryotic DNA polymerases. Origin of replication in prokaryotic *(E. coli)* and eukaryotic *(S. cerevisae)* model systems. Replication of core genome and replication of extra-chromosomal DNA. Priming of DNA replication, formation of primosome and origin recognition complex. Replication elongation: Processivity of DNA polymerases with structural and functional features in typical model systems for leading and lagging strand synthesis. Elements and factors required for replication of core genome in prokaryotes & eukaryotes. Replication Termination: Termination in prokaryotes and the molecular components involved. Decatenation of newly replicated circular genomes. End replication of linear genomes & role of telomerase in the formation of telomers with mechanism. Important features of M13 and λ phage genome replications. Copy number & replication efficiency. Proofreading activity of DNA polymerases and its mechanism.

UNIT III: DNA Damage & Repair Mechanisms (15 Lectures)

DNA damage and mutation (causes, differences & types) with examples from prokaryotes and eukaryotes). Physical and chemical DNA damaging agents including spontaneous hydrolysis and deamination of DNA bases, alkylating agents, radiations, base analogues and intercalating agents. Generation of Single & double-stranded breaks. DNA repair systems: Direct reversal repair system. Excision Repair system: Base excision (Uracil misincorporation) and nucleotide excision repair mechanisms. Mismatch repair system, error-prone repair and translesion synthesis. Double-strand DNA break repair system: Homologous recombination repair and non-homologous end-joining (NHEJ) repair systems and Strand invasion & heteroduplex formation. Molecular mechanisms of meiotic recombination and its significance. Important mutation mechanisms with examples from human disease origins like chromosomal abnormalities & cancer.

UNIT IV: Transcription & its Mechanisms (15 Lectures)

Types of RNA with their physical and chemical structures & functions. Secondary structures of RNA. Prokaryotic transcription: Promoters & their structure and function. RNA polymerases: Composition, structure and function of each subunit. Role of sigma factor/alternative sigma factors in promoter recognition and open promoter formation. Structural and functional events of transcription initiation, elongation & termination complexes with their proofreading.

Eukaryotic RNA polymerases: RNA Pol I, RNA Pol II and RNA pol III. Promoters: Class II promoters & transcription factors: Structure and function (core promoter elements, upstream elements, downstream elements, initiator elements). Mechanism of transcription initiation at class II promoters. Promoter clearance and RNA Pol II C-Terminal Domain phosphorylation. Class I & III promoters & transcription factors: Structure and function (core elements, upstream elements). Transcription elongation & termination signals & proofreading. Inhibitors of transcription with their significance.

Suggested Readings:

1. Molecular Biology of the gene by Watson G.D.Cold spring Habor Ltd Press.
2. Molecular Biology: gene to protein by Burton E. Jones & Bartlett.
3. Biotechnology: applying the genetic revolution by Clark & Pazdernik. Academic Press.
4. Genetics from genes to genomes by Hartwell. McGrawhill.
5. Genetic: molecular Approaches by Russell. Pearson Press.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-CC-703 **Cellular Energetics & Metabolism**
Time: 60 Hours **Credits: 04**

UNIT I: Bioenergetics & Carbohydrate Metabolism (15 Lectures)

Concept and significance of free energy, standard free energy change of a chemical reaction. Thermodynamics of high-energy phosphate compounds-ATP and other high energy phosphate compounds. Glycolysis, Krebs cycle, Pentose phosphate pathway, Gluconeogenesis, Glycogenesis, Glycogenolysis, Regulation of carbohydrate metabolism. Electron transport chain and oxidative phosphorylation. Inborn errors of carbohydrate metabolism, Galactosemia and Glycogen storage diseases.

UNIT II: Lipid Metabolism (15 Lectures)

β-oxidations of saturated & unsaturated fatty acids, α, ω, oxidation and energetics. Biosynthesis of fatty acids–Fatty acid synthase complex, biosynthesis of palmitate, energetics, Regulation of fatty acid biosynthesis. Desaturase and elongase. Biosynthesis of triacylglycerols, Phosphoglycerides and sphingolipids. Biosynthetic pathways for Cholesterol and regulation. Ketone bodies- production and utilization during starving and diabetes. Lipid storage disease.

UNIT III: Amino Acid Metabolism (15 Lectures)

Biodegradation of amino acids–deamination, transamination, decarboxylation, Glycogenic and ketogenic amino acids. Pathways of amino acid catabolism. Aromatic amino acid biosynthesis. Urea cycle including its regulation. Derivatives of Amino acids Inherited disorders of amino acid metabolism- phenylketonuria, alkaptonuria, maple syrup urine disease.

UNIT IV: Nucleic Acid Metabolism (15 Lectures)

De-novo nucleotide biosynthesis. Recycling of Purine and Pyrimidine nucleotides by salvage pathways. Degradation of purines and pyrimidines. Structure and regulation of ribonucleotide reductase. Biosynthesis of ribonucleotides, deoxy ribonucleotides and polynucleotides. Inhibitors of nucleic acid biosynthesis. Disorders of purine metabolism (Gout, Lesh-Nyhan syndrome, Severe Combined Immunodeficiency Disease).

Suggested Readings:

1. Lehninger Principles of Biochemistry 4th Ed by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill College.
3. Biochemistry ByLubertStryer. WH Freeman and Co.
4. Biochemistry: The Molecular Basis of Life by Trudy McKee and James R McKee. Publisher: McGraw-Hill Higher education.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-CC-704 **Lab Course Based on (CC-701,702 & 703)**
Time: 60 Hours **Credits: 04**

1. Extraction and purification of nucleic acids.
2. Electrophoretic separation of isolated DNA, RNA and proteins.
3. Protein purification & characterization.
4. Suspension culture and production of secondary metabolites.
5. Protein estimation by different methods.
6. Quantitative estimation of cholesterol.
7. Separation of amino acids & sugars by TLC/Paper Chromatography.
8. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-DSE-701 **Medical Technology & Clinical Diagnostics**
Time: 30 Hours **Credits: 02**

UNIT I: Advanced Diagnostic Tools (7 Lectures)
Principles and importance in disease diagnosis: X-ray, Magnetic Resonance Imaging (MRI), Positron Emission Tomography (PET) scan, ECG, EEG and Blood gas apparatus. Pre-natal diagnostic techniques.

UNIT II: Blood Marker Evaluations (8 Lectures)
Regulation of water, electrolyte and acid-base balance: Role of kidneys and hormones. Clinical features, analysis with modern tools and management of water balance, electrolyte and acid-base disorders. Serum & plasma marker based biochemical & immune reaction tests for body parameter measurements.

UNIT III: Enzyme Analysis & Significance (8 Lectures)
Principle, assay and clinical significance of serum enzymes (transaminases, creatine kinase, lactate dehydrogenase, phosphatases, isocitrate dehydrogenase etc. Cardiac, inflammatory, tumor markers based on aberrant DNA, RNA & protein profiles. Quality assurance and quality control.

UNIT IV: Organs and Organ Function Tests (7 Lectures)
Kidney, liver and cardiovascular: Disorders, clinical investigation (Liver function tests, Kidney function tests, cardiac function tests) and interpretation. Prevalent metabolic disorders and their clinical evaluation.

Suggested Readings:

1. Teitz Text book of clinical biochemistry. Burtiset al., William Heinmann medical books, Ltd., Pearson Professional Ltd.
2. Harrison's Principles of Internal Medicine by Dan L. Longo, Anthony S. Fauci, Dennis L. Kasper, Stephen L. Hauser, J. Larry Jameson and Joseph Loscalzo, McGrawhills publishers.
3. Fundamentals of Clinical Chemistry–Teitz, W.B.Saunders company.
4. Clinical Biochemistry – Metabolic and clinical aspects, Pearson Professional Ltd.
5. Clinical Chemistry: Principles, Techniques, and Correlations. Michael L. Bishop, Edward P. Fody, Larry E. Schoeff.
6. Practical Clinical Biochemistry, volume I and II Varley*et.al.,* CBS Publishers.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-DSE-702 **Lab Course Based on DSE-701**
Time: 30 Hours **Credits:02**

1. Estimation of serum bilirubin.
2. Estimation of glucose by various methods.
3. Estimation of diagnostic enzymes like acid phosphatase, alkaline phosphatase, ALT and AST.
4. Estimation of serum urea and creatinine.
5. Estimation of serum triglycerides, total cholesterol, HDL cholesterol, LDL cholesterol
6. Estimation of Na^+, K^+ and Cl^-.
7. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year B.Sc.-M.Sc. Integrated Program in Biotechnology (Under CBCS)

(Semester-VII)

BTCH-GE-703 **Functional Foods and Nutrigenomics**
Time: 30 Hours **Credits: 02**

UNIT 1: Balanced Foods & Absorption (7 Lectures)

Composition of food, Balanced diet. Recommended daily allowances (RDA). Basal metabolic rate (BMR) and specific dynamic action (SDA) and factors affecting them. Nutrition in childhood, pregnancy, lactating women and old age. Composition of human milk. Breast feeding versus formula milk feeding. Physiological importance of dietary fibers on biochemical & molecular mechanisms of nutrient absorptions.

UNIT II: Nutrient-Gene Interaction (7 Lectures)

Genome-food interface & mechanisms. Functions, dietary sources and clinical manifestations of deficiency/excess of vitamins: A, D, E, K, Vitamin B-complex including folate and Vitamin C at gene level. Minerals–calcium, iron and iodine. Essential fatty acids and their physiological functions. Lipoproteins: HDL, LDL, Chylomicrons.

UNIT III: Nutrient-Epigenetic Implications (8 Lectures)

Major diseases in relevance to nutrient-epigenetic imbalance. Clinical features and management of the Protein Energy Malnutrition (PEM), Vitamin A Deficiency, Iron Deficiency Anaemia, Iodine Deficiency Disorders, Zinc Deficiency, Flurosis. Vitamin D deficiency and Over-nutrition in Obesity, Coronary heart disease & Diabetes etc. Folate, Vitamin B-12 & methyl donors in genomic stability.

UNIT IV: Food Preparation & Preservation (8 Lectures)

Food preparation methods. Food preservation techniques and Food processing techniques-canning, dehydration, ultra-filtration, sterilization, irradiation etc. Food Spoilage. Microbiology of food, water, meat, poultry, milk, vegetables. Major food borne infections & their action at the molecular level.

Books Recommended:

1. Lehninger Principles of Biochemistry by David L. Nelson and Michael M. Cox, WH Freeman and Company.
2. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill College.
3. Biochemistry ByLubertStryer. WH Freeman and Co.
4. Nutrition and health by Gerald Wiseman. CRC Press.
5. Nutrition by Marian L. Farrell, Jo Ann L. Nicoteri. Jones & Bartlett Learning.
6. Human nutrition by Bernard A. Marcus, JohnWiley& Sons, Incorporated.
7. Microbiology: Concepts and Applications by MJ Pelczar, ECS Chan and NR Krieg, McGraw-Hill.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-DSE-704 **Lab Course Based on DSE-703**
Time: 30 Hours **Credits: 02**

1. Measurements of minerals in different clinical settings.
2. Estimation of Vitamins in health and diseased conditions.
3. Detection of various types of Anemic conditions.
4. Media preparation in animal and plant cell cultures.
5. Handling of rodent model(s), di-sectioning and dosage via different routes.
6. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VII)

BTCH-SEC-701 **Biotechnology & Skill Development**
Time: 60 Hours **Credits: 04**

UNIT I: Biotechnology: Introduction & Applications (15 Lectures)
Definition, introduction & scope. Basic skills, tools & their utilities. Importance of Biotechnology in everyday life. Significance in health & disease.

UNIT II: Biotechnology: Crop Yield & Quality (15 Lectures)
Skills for increasing crop yield in vegetables & fruits. Skill development in generation of hybrid quality seeds. Production of disease resistant strains in various domestic crops. Quality maintenance by seed bank technology.

UNIT III: Biotechnology: Nutrient Rich Animal Products (15 Lectures)
Intervention of technology for nutrient enrichment of animal based foods. Definition of gene & stem cell technology. Basic skills in domestic animals for upscaling milk, meat and hides etc. Biotechnological understanding of production of high productivity & disease resistant breeds & strains.

UNIT IV: Biotechnology & Economy (15 Lectures)
Understanding correlation between Biotechnology & Economy. Role of Biotechnology in human resource and other resource developments. Applications of Biotechnological intervention in agriculture, health & veterinary fields for the economic development.

Suggested Readings:

1. Building Biotechnology by Yali Friedman, published in United States of America.
2. Career Development in Bioengineering and Biotechnology by Guru Prasad Madhavan.
3. Barbara Oakley, Luis Kun. Springer Publishers.
4. Biotechnology by B. D. Singh. Kalyan Publishers.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-CC-801 **Mechanisms of Gene Regulation**
Time: 60 Hours **Credits: 04**

UNIT I: Post-transcriptional Processing & Surveillance (15 Lectures)
Post-transcriptional RNA processing of Heteronuclear RNA (hnRNA): Splicesome, exon-intron junctions, splicing signals & mechanism. Alternative splicing, Regulation of splicing and mRNA surveillance. Group-I & group-II introns in Self-splicing RNAs. Nucleo-cytoplasmic mRNA transport, mRNA stability and half-life period. Eukaryotic and prokaryotic rRNA & t-RNA processing. Trans-splicing. RNA editing and molecular mechanism. Post-transcriptional modifications of mRNA: Capping structure & function of 5` end capping. Polyadenylation mechanism & importance.

UNIT II: Gene Expression & Regulation (15 Lectures)
Regulation of bacterial transcription: Inducible and repressible operons in prokaryotes. Lac operon & mechanism of negative control & role of CAP. Trp operon: Structure and regulation. Eukaryotic Gene Regulation: Mechanism of Regulation. Regulatory Elements, Enhancers, Silencer Elements. Transcription Factors, Methods of Studying Transcription Factors. Domain Structure of Transcription factors, DNA binding domains (Zinc Finger Domains, Leucine Zipper Domains, Homeodomains, Basic Domains). Transcription activation domains, Transcriptional coactivators, Repressors and their roles in Transcription.

UNIT III: Chromatin Remodeling & Epigenetic Regulation (15 Lectures)
Chromatin structure, chromatin remodeling and transcriptional gene regulation. CpG islands & DNA methylation & posttranslational modifications. Histones & histone code functions. Nucleosomes as transcription barriers. Important histone modifications like acetylation, methylation, phosphorylation and their roles in transcription. Structure & epigenetics of euchromatin versus heterochromatin gene silencing. Regulation of eukaryotic gene expression by small RNAs and micro RNAs. Epigenetics in stem cell biology, cancer & other diseases. Epigenetic enzymes: biomarkers & drug targets. Significance of epigenetics in stem cell fate & cancer stem cell fate determination.

UNIT IV: Genetic Code & Translation (15 Lectures)
Genetic code, General characteristic features. Universality & exceptions, degeneracy & Wobble hypothesis in base pairing. Structural features of prokaryotic and eukaryotic mRNA & Ribosomes. t-RNA: Secondary and tertiary structure. Amino-acyl tRNA synthetases. Translational Initiation in prokaryotes with formation of initiation complex with Shine-Dalgarno sequence. Prokaryotic regulation: Role of secondary structures, small RNAs and riboswitches. Translation initiation in eukaryotes, Kozak sequence and its significance. Cap-dependent and Cap-independent translation & role of Internal Ribosome Entry Sites (IRES). Eukaryotic regulation: RNA Secondary structures & microRNAs in translation regulation. Translation elongation: Three-site ribosome model of tRNA binding. Translation termination:

termination codons & release factors for Ribosome dissociation. Non-ribosomal peptide synthesis. Inhibitors of translation & their significance in antibiotic/drug discovery.

Suggested Readings:

1. Molecular Biology by Robert F Weaver: McGraw-Hill Higher Education.
2. Cell and Molecular Biology: Concepts and Experiments. Karp. John Wiley& Sons. Inc.
3. The Cell: A Molecular Approach. Cooper, G.M. and Hausman, R.E.ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Molecular Biology of the Gene. Watson, J. D., Baker T.A., Bell, S. P., Gann, A., Levine, M., and Losick, R. Cold Spring Harbour Lab. Press, Pearson Pub.
5. Genes Goldstein, Kilpatrick, Krebs. Lewin's Jones & Bartlett Publishers.
6. Molecular Cell Biology. Harvey Lodish, Arnold Berk, Chris A. Kaiser Monty Krieger, Anthony Bretscher W H Freeman & Co.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-CC-802 **Plant Biotechnology**
Time: 60 Hours **Credits: 04**

UNIT I: Plant Tissue Culture **(15 Lectures)**

Introduction to tissue culture. Design of tissue culture laboratory. Sterilization procedures, types and composition of media. Initiation and maintenance of callus and suspension culture. Shoot tip culture-Virus elimination by shoot tip culture. Embryo culture and embryo rescue wide hybridization. Protoplast isolation and fusion. Selection and regeneration of hybrid plants. Germplasm conservation. Anther culture & its applications.

UNIT II: Transgenic Plants **(15 Lectures)**

Plasmids & gene transfer mechanism. Virulence gene, vectors (Ti, Ri and binary) involving agrobacterium tumefacian. Different promoters, genetic markers, reporter genes, viral vectors and multi gene transfer. Direct DNA transfer, transformation of monocots, transgene stability and gene silencing. Transgenic plants: herbicide resistance, disease resistance, virus resistance, nematode resistance (with examples). Metabolic engineering for enhancing the secondary metabolites.

UNIT III: Agriculture Biotechnology **(15 Lectures)**

Increasing crop productivity: enhancing photosynthetic, nutrition use and nitrogen fixing efficiencies of plants. Manipulation of plant architecture and flowering behaviour. Quality improvement: seed storage proteins, essential amino acids, vitamins and minerals. Molecular assisted selection (MAS): RFLP, RAPD, AFLP and microsatellite markers, QTL analysis.

UNIT IV: Applications of Plant Biotechnology **(15 Lectures)**

Genetically modified foods, transgenic crop (Golden rice, edible vaccines etc) and heat shock proteins. Plant derived recombinant therapeutic proteins. Plant derived recombinant antibody. Immobilization of plant cells. Chloroplast transformation: advantages, vectors, success. Plant secondary metabolites: alkaloids, terpenoids, steroids and industrial enzymes. Biodegradable plastics, polyhydroxybutyrate, therapeutic proteins.

Suggested Readings:

1. Plant Biotechnology: The Genetic Manipulation of Plants Adrian Slater Nigel W. Scott Fowler: Oxford University Press.
2. Plant propagation by Tissue Culture : Edwin F. George,Michael A Hall: Springer-verlag
3. Agrobacterium: From Biology to Biotechnology: Tzfira,Tzvi,Citovsky,Vitaly: Springer.

Syllabus for 5 Year Integrated B.Sc-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-VIII)

BTCH-CC-803 **Developmental & Systems Biology**
Time: 60 Hours **Credits: 04**

UNIT I: Human Embryonic Development (15 Lectures)

Human Embryogenesis background and stages: Formation of a zygote, zygotic cleavage. Blastulation, Cell Differentiation, Gastrulation, Neurulation, Implantation, Gestation, Germ layer derivatives and Organ systems. Recent understandings and technologies.

UNIT II: Stem Cell & Regenerative Biology (15 Lectures)

Introduction to Stem cells: Historical perspectives, Properties and features. Stem cells and their characteristics in plant and animal systems. Types of stem cells and their functions. Stem cell Markers. Stem cell differentiation as a developmental model system. Stem Cell Technology: Procedures, applications and limitations. Regeneration: Role of stem cell technology in Regenerative Medicine. Mechanism and signaling pathways. Ethical issues for the use of stem cells in humans.

UNIT III: Systems Biology Models (15 Lectures)

Introduction to Systems biology: Significance and scope. Understanding developmental biology with systems biology approach. Use of C. elegans, Drosophilla and Zebrafish as model organisms, for evaluating the function(s) of genes important during development and in diseased state.

UNIT IV: Human Developmental Disorders (15 Lectures)

General understanding of the common developmental disorders in humans including the developmental disability, intellectual disability, metabolic disorders, spine, spinal cord and neurotransmitter disorders etc. Recent developments and corrective strategies with emphasis on use of stem cells.

Suggested Readings:

1. Langman's Medical Embryology, 8th Edition, by T.W. Sadler,
2. Developmental Biology, 11th Edition.S.F., by Gilbert, M.J.F Barresi,
3. Life: The science of Biology, 9th Edition.Sadava, by Hillis,Heller,Berenbaum,
4. Essentials of stem cell biology, 2nd Edition, by Patricia A Howlin, Tony Charman and Mohammad Ghaziuddin, Robert Lanza.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-VIII)

BTCH-CC-804 **Lab Course Based on (BTCH-CC-801, 802 & 803)**
Time: 60 Hours **Credits: 04**

1. Sterilization of plant material.
2. Preparation of plant tissue culture media.
3. Preparation of protoplasts.
4. Aseptic culture techniques for establishment and maintenance of cultures.
5. Preparation of stock solutions of MS basal medium and plant growth regulator stocks.
6. Molecular weight determination of protein by gel filtration chromatography.
7. Western Blotting
8. Polymerase chain reaction.
9. Demonstration of cell regeneration.
10. Study of Cell Division using microscope–identification of various stages.
11. Autoclaving, media preparation and sterilization techniques.
12. Cell Culturing, sub-culturing, preservation and storage methods.
13. Media preparation in animal and plant cell cultures.
14. Handling of rodent model(s), di-sectioning and dosage via different routes.
15. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-DSE-801 **Molecular Genetics & Epigenetics**
Time: 30 Hours **Credits: 02**

UNIT I: Genetic Inheritance (7 Lectures)

Mendelian genetics, crosses & laws of inheritance. Test and back crosses, incomplete dominance, co-dominance, pleitropy, multiple allelism, polygenic inheritance, epistasis, penetrance and expressivity etc with examples. Extrachromosomal inheritance & importance.

UNIT II: Genetic Abnormalities (8 Lectures)

Mutations & chromosomal abnormalities: causes and types with examples. Sex linked & sex influenced expression with examples from human diseases. Prediction of allelic and genotype frequencies by Hardy Weinberg principle. Genetic counseling.

UNIT II: Chromatin, Nucleosome & Diseases (8 Lectures)

Chromatin, Histones, Nucleosome structure and higher order chromatin organization. ATP dependent chromatin remodeling and transcriptional gene regulation. Histone variants and complexes involved in their exchange. Histones & histone code functions. Important covalent histone modifications & enzymes like acetylation, methylation, phosphorylation and their roles in transcription. Posttranslational modifications & epigenetic control. Histone modifications in cancer.

UNIT III: DNA Methylation & Diseases (7 Lectures)

One carbon donors & Methylation cycle. DNA methylation at CpG islands. DNA methylation at intergenic regions and repetitive elements. Significance of hypomethylation & hypermethylation. Epigenetic enzymes: biomarkers & drug targets. Significance of epigenetics in stem cell & cancer stem cell fate determination. Regulation of eukaryotic gene expression by long non-coding RNAs, small RNAs and micro RNAs. Aberrant DNA methylation modifications in cancer, metabolic & neurodegenerative diseases.

Suggested Readings:

1. Principles of Genetics by Gardner, E.J., Simmons, M.J., Snustad, D.P. Wiley India.
2. Principles of Genetics by Snustad, D.P., Simmons, M.J. V Edition. John Wiley and Sons Inc.
3. Concepts of Genetics by Klug, W.S., Cummings, M.R., Spencer, C.A. Benjamin Cummings.
4. Genetics- A Molecular Approach by Russell, P. J. Benjamin Cummings.
5. Epigenetics by Allis, Jenuwein, and Reinberg. Cold Spring Harbor Press.
6. Epigenetics by Lyle Armstrong. Garland Science.
7. The Epigenetics Revolution: How Modern Biology Is Rewriting Our Understanding of Genetics, Disease, and Inheritance by Nessa Carey. Columbia University Press.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-DSE-802 **Lab Course Based on DSE-801**
Time: 30 Hours **Credits: 02**

1. Karyotyping with the help of photographs/teaching kits.
2. Pedigree charts of some common characters like Blood grouping & Color Blindness.
3. Photographs/permanent slides showing Translocation ring, Barr body.
4. Study of polyploidy in onion root tip by colchicine treatment.
5. Design & criteria of unmethylated & methylated primers.
6. Methylation specific-PCR to differentiate and detect unmethylated versus methylated cytosines.
7. Detection and quantification of histone modification(s) by ELISA method.
8. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-DSE-803 **DNA Fingerprinting Technology**
Time: 30 Hours **Credits: 02**

UNIT I. Concept & Background (8 Lectures)
Basic principles of DNA as biological blueprint of life. Historical perspective, extraction of DNA for analysis and its quantization. Sample & preservative requirements, procedure & considerations for evaluating DNA evidence.

UNIT II: **Techniques & Use (8 Lectures)**
Repetitive DNA. DNA fingerprinting & Polymerase chain reaction, sequence polymorphisms, Short tandem repeats (STR) and role of fluorescent dyes, nature of STR loci. Restriction fragment length polymorphism (RFLP) & genetic markers used in RFLP. Typing procedure, interpretation of results & individualization of evidence.

UNIT III: Applications & Developments (7 Lectures)
Applications of DNA fingerprinting. Latent fingerprinting Vs. DNA fingerprinting. Y-chromosome analysis, Mitochondrial DNA sequence analysis.

UNIT: IV: DNA Fingerprinting in Forensics (7 Lectures)
Forensic DNA typing & collection of specimens. Principle of application. Touch DNA & parentage testing. Principles of heredity & genetics of paternity. Narco analysis and Brain fingerprinting techniques. Use of fibers & hairs in forensic identification. Limitations & challenges.

Suggested Readings:

1. Forensic DNA Typing by J.M. Butler, , Elsevier, Burlington.
2. DNA in the Courtroom: A Trial Watcher's Guide by H. Coleman and E. Swenson, GeneLex Corporation, Washington.
3. Forensic Science; an Introduction to Scientific and Investigative Techniques by James, S.H. and Nordby, J.J.CRC Press, USA.
4. DNA Profiling and DNA Fingerprinting byJorg T. Epplen Thomas Lubjumhin, BirkhauserVerlag, Basel.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-DSE-804 **Lab Course Based on DSE-803**
Time: 30 Hours **Credits: 02**

1. Extraction of DNA from body fluids.
2. Agarose gel electrophoresis and the visualization of DNA.
3. Single & double Restriction Digestion of DNA.
4. To perform the assay of RFLP.
5. To perform the assay of RAPD.
6. Permanent and temporary mount of Mitosis.
7. Permanent and temporary mount of Meiosis.
8. Any other practical found feasible by the teacher and approved by HOD and Dean.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-VIII)

BTCH-AEC-801 **Human Health Awareness**
Time: 60 Hours **Credits: 04**

UNIT I: **Common Diseases & Treatments** **(15 Lectures)**

Malnutrition of important vitamins and amino acids. Significance of Mid-day meal program in combating malnutrition. Gastroenteritis, celiac disease, and gastroesophageal reflux disease. Treatments for communicable diseases including Polio, Hepatitis & AIDS. Management of life style diseases including hypertension, coronary heart disease, stroke, diabetes and obesity.

UNIT II: **Health & Medical Requirements** **(15 Lectures)**

Routine checkups and diagnosis. Importance of Liver, Kidney, Pancreas and Heart function tests. Sugar & Hormonal levels. Vaccine discovery & types. Routine vaccination Programs in India. National Immunization schedule of India & its impact. Need of new vaccines. Antibiotic & Drug resistance.

UNIT III: Mental Health Disorders **(15 Lectures)**

Characteristics of mentally healthy person; Warning signals of poor mental health; Types and causes of mental illness. Depression: causes & and its treatments. Issues with pain management and self-medication. Substance abuse (Drugs, Cigarette, Alcohol). De-addiction and rehabilitation.

UNIT IV: **Blood Groups & Compatibility** **(15 Lectures)**

Blood composition and groups. Blood coagulation and disorders. Blood transfusion. Social benefits of blood donation. Genetic counseling & Blood group compatibility. *In vitro* Fertilization (IVF).

Suggested Readings:

1. Harrison Principles of Internal Medicine, 18 th by Dan L. Longo , Anthony S. Fauci, Dennis L. Kasper , StephenL. Hauser , J. Larry Jameson and Joseph Loscalzo , McGrawhills publishers.
2. Lehninger Principles of Biochemistry 4th Ed by David L. Nelson and Michael M. Cox, WH Freeman and Company.
3. Immunology: International Edition by Janis Kuby, Thomas J. Kindt, Barbara A. Osborne and Richard A. Goldsby. WH Freeman and Co. Ltd.
4. Clinical Chemistry – principles, procedures and correlations, Bishop, Lipppincott.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IX)

BTCH-CC-901 **Advanced Immunology**
Time: 60 Hours **Credits: 04**

UNIT I: Immune System: Cells & Organs (15 Lectures)
Innate and Adaptive Immunity, Cell and Humoral immunity. Cells of Immune System -B cell, T cell, APC, NK Cells. Lymphoid organs – Primary (Thymus, Bone marrow, Bursa of Fabricus) and Secondary Lymphoid Organs (Lymph node, Spleen, Payer's patches, Tonsils). MHC molecules, antigen processing and presentation.

UNIT II: Immune System Signaling (15 Lectures)
Antigen receptors and accessory molecules of T and B lymphocytes. Basis of self & non-self discrimination. Memory T-cell maturation, activation and differentiation. Antigen receptor signaling. Functional T cell Subsets. Cell mediated immune responses: T-Cell mediated cytotoxicity, Macrophage activation, ADCC. B cell maturation, activation and differentiation. Cytokines and other effector components. Cytokine receptor families and signaling pathways. Defense systems in plants & invertebrates.

UNIT III: Antibody & T-Cell Diversity (15 Lectures)
Overview of structure and types of immunoglobulins. Organization of immunoglobulin genes and mechanism of immunoglobulin gene rearrangements. Generation of antibody diversity, gene arrangement and expression of antibody gene. Class switching, clonal deletion, Allelic exclusion. T-cell receptor gene rearrangements. Complement system & its functioning. Hypersensitivity reactions & types.

UNIT IV: Immunopathology & Diseases (15 Lectures)
Primary and secondary immunodeficiencies. Immunity to bacteria (TB), viruses (HIV) and parasites (Malaria). Organ specific autoimmune diseases. Systemic autoimmune diseases: Proposed induction mechanisms, genetic and environmental basis and their treatments. Transplantation: Types of grafts. Graft rejection, Graft versus host disease, Clinical Transplantation, Immunosuppressant therapies. Tumor immunity: Malignant transformation of cells and immune responses. Tumor antigens, Tumor evasion of the immune system. Production of recombinant antibodies by recombinant technology & Hybridoma technology. Recombinant antibodies, chimeric and humanized antibodies in immunotherapy of cancer and other diseases.

Suggested Readings:

1. Kuby Immunology by Owen, Punt and Stranford.W.H. Freeman and Company.
2. Essential of Immunology 12th edition .Roitt, I.M. ELBS, Blackwell Scientific Publication.
3. Cellular and Molecular Immunology Abul K. Abbas, Andrew H.L, Shiv Pillai,Saunders Publications.
4. Janeway'sImmunobiology, by Kenneth Murphy, Mark Walport, and Paul Travers. Garland Sciences.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)
(Semester-IX)

BTCH-CC-902 **Animal Biotechnology**
Time: 60 Hours **Credits: 04**

UNIT I: Recombinant DNA Technology (15 Lectures)
Definition, procedure & role of different enzymes in recombinant DNA technology. Modification of cut ends. Cloning and Expression vectors. cDNA and use of reverse transcriptase. Sequential steps in gene cloning, integration of DNA insert into vector, Nick translation, introduction of vector into suitable host, detection of recombinant clones. Complementation, colony or plaque screening and colony hybridization.

UNIT II: Applications of Recombinant DNA Technology (15 Lectures)
Genetic engineering with special reference to production of growth hormone, insulin, blood proteins (clotting factors), antibodies, vaccine technology, recombinant vaccines and immunomodulators. Various methods for transgenics, Antisense RNA technology with examples from RNA interference in animal models. Microarray analysis for gene expression, expression of proteins with fusion tags (GFP, FLAG) and their significance. *In-vitro* transcription and translation.

UNIT III: Animal Technology Assays and Methods (15 Lectures)
Assays in animal technology including probes with radioactive and non-radioactive labeling. In situ hybridization, Hybridization arrested translation & Studying protein-protein and protein-nucleic acid interactions. The principle of construction of cDNA and genomic library. Site directed mutagenesis, Production of proteins from cloned genes, Reporter gene assays & Tagging and their application in co-localization studies.

UNIT IV: Advanced Reproductive Technology (15 Lectures)
Biotechnological approaches to reproductive biotechnology in animals. Introduction to embryo biotechnology. Methodology of super ovulation & *in vitro* fertilization. Nuclear transfer technology and its application for animal cloning. Characterization of embryonic stem cells & applications.

Suggested Readings:

1. Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman:Blackwell Publishing Professional.
2. Analysis of Genes and Genomes by Richard J. Reece: Wiley.
3. Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick,Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press.1.
4. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, by, R. Ian Freshney, published by Wiley-Blackwell, UK.
5. Animal Cell Culture: A Practical Approach by JRW Masters, published by Oxford University Press, UK.

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(Semester-IX)

BTCH-CC-903 **Tools & Techniques in Biotechnology**
Time: 60 Hours **Credits: 04**

UNIT I: Analytical & Separation Techniques (15 Lectures)

Analytical spectroscopy including UV/IR/Visible absorbance, luminescence & fluorescence based assays for estimations (Principles & Instrumentation). Applications of radiotracers/fluorescent dyes as probes in biochemical estimations. Protein isolation, purification & characterization including chromatographic techniques like Gel filtration, Affinity, Ion-exchange, Gas & HPLC & FPLC (Principle & Applications). Principles & Applications of Proteomic techniques like SDS-PAGE, Isoelectric focusing, 2-D Gel electrophoresis, Mass spectrometry (MALDI-TOF & LC-MS), Protein Sequencing, Arrays & Western blotting. Genomic techniques involving DNA/RNA isolation & separation techniques from blood & tissues. Electrophoresis, Primer design, PCR & types.

UNIT II: Advanced Molecular Biology Techniques (15 Lectures)

Dot blotting, Southern & Northern blotting hybridization techniques (Steps involved). DNA/RNA microarray, Differential gene expression by quantitative real time PCR (Principle & Applications). Principle of DNA footprinting, Gel retardation assays, DNA finger printing etc. Principles of FISH, RFLP, RAPD techniques.

RNAi and antisence technology (Principle & Method). Principle & sequential steps of generating Gene knock out/knock in & Transgenics (homozygous & heterozygous). Procedure for generation of stem cells. Principle & steps of gene editing & CRISPR-Cas9 for selective gene deletion. Genomic and cDNA library. Genome Sequencing & Mapping applications. Sequencing of DNA, RNA for pathway elucidations (Principle & Requirements).

UNIT III: Immunological & Cell Biology Techniques (15 Lectures)

Principles & Methods of ELISA and its types. Procedure for generation of antibodies in animal systems. Hybridoma technology & monoclonal antibody generation (Principle & method). Complement hemolytic activity assay & Complement fixation tests (Procedure). Principle and applications of Immuno-diffusion, Agglutination reactions, Radioimmuno assay, Immunofluorescence. Immunological studies including flow cytometry (Principle). Cell culture involving media preparation, Thawing, Freezing, Counting, Plating, Maintenance, growth & use of antibiotics (Overview). Principles & applications of Imaging and microscopy including Fluorescence, Confocal & Electron Microscopy.

UNIT IV: Genetic & Epigenetic Techniques (15 Lectures)

Principle, steps & applications of Gene cloning & constructs, Transfection & its agents (transient & stable), Gene silencing by siRNA/ShRNA, Over-expression & Reporter gene assays, Site directed mutagenesis, Metabolic assays. Principle & method for Gene ablation

studies & Ames test, Bi-sulphite conversion, sequencing for promoter methylation and Chromatin Immunoprecipitation.

Suggested Readings:

1. Principles and Techniques Biochemistry; Molecular Biology. Wilson & Walker.Cambridge University Press.
2. Biochemistry Laboratory: Modern Theory and Techniques. Rodney F. Boyer.Pearson.
3. Chromatography: Basic Principles, Sample Preparations and Related Methods by Elsa Lundanes, Leon Reubsaet, Tyge Greibrokk WILEY.
4. Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman: Blackwell Publishing Professional.
5. Analysis of Genes and Genomes by Richard J. Reece: Wiley.
6. Molecular Biotechnology - Principles and Applications of Recombinant DNA by Glick, Bernard R.; Pasternak, Jack J.; Patten, Cheryl L: ASM Press.
7. DNA recombinant Technology and molecular techniques by M U Hussain: Black Prints India INC.
8. Immunology by Richard A. Goldsby, Thomas J. Kindt, Barbara A. Osborne and Janis Kuby. WH Freeman and Co. Ltd.

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(Semester-IX)

BTCH-CC-904 **Lab Course Based on (BTCH-CC-901, 902 & 903)**
Time: 60 Hours **Credits: 04**

1. Separation of Serum and plasma.
2. Serological assays including the Immuno-diffusion and blood typing.
3. Antibody titer by ELISA method.
4. Complement fixation test.
5. Blood smear identification of leucocytes by Giemsa stain
6. Separation of mononuclear cells by Ficoll-Hypaque.
7. Electrophoretic separation of serum proteins.
8. Isolation of industrially important microorganisms for microbial processes.
9. Ethanol production using various organic wastes.
10. Cell disruption by sonication.
11. Media preparation and sterilization for animal tissue culture.
12. Culture of different cell lines at different serum concentrations.
13. Cryopreservation of cells.
14. Transfection of cell lines with plasmids.
15. Cell viability assay in cell lines.
16. Any other practical found feasible by the teacher and approved by HOD and Dean.
17. Educational tour to different labs during winter session.

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(Semester-IX)

BTCH-DSE-901 **Cancer Biology & Therapies**
Time: 30 Hours **Credits: 02**

UNIT I: Introduction to Cancer (7 Lectures)
Introduction and hallmarks of cancer, Inflammation and cancer, Cancer cell metabolic alterations and Tumor microenvironment. Chemical carcinogenesis, endogenous & exogenous mutagens.

UNIT II: Mechanisms of Tumorigenesis (8 Lectures)
Tumor viruses and the discovery of oncogenes, Mechanisms of oncogene activation. Role of growth factors and receptors in carcinogenesis. Aberrant signalling in cancer, RAS signalling in cancer. Familial cancer syndromes and the discovery of tumor suppressors. Mechanism of tumor suppressor genes with special reference to p53 and Rb gene.

UNIT III: Cancer Diagnosis (7 Lectures)
Determining a cancer's stage, TNM staging system, Cancer stage grouping. Biochemical, histological and radiological methods for cancer diagnosis.

UNIT IV: Cancer Therapies (8 Lectures)
Emerging therapies, chemotherapy and radiotherapy strategies for cancer treatment. Cancer chemotherapeutic drugs. Biological rationale for both traditional chemotherapies and novel targeted therapeutic approaches. Immunotherapy in cancer, Immunoevasive and other strategies used by cancer cells.

Suggested Readings:

1. The Biology of Cancer by R.A. Weinberg.
2. Molecular Biology of Cancer: Mechanisms, target and Therapeutics by L. Pecorino.
3. Basic Immunology: Abul K. Abbas, Andrew H. Lichtman.

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(Semester IX)

BTCH-DSE-902 **Tissue Culture & Animal Handling**
Time: 30 Hours **Credits: 02**

UNIT-I: Cell Culture & Tissue Engineering (8 Lectures)
Three dimensional cultures: Introduction. Multicellular tumour spheroids (MCTS). Spheroid culturing techniques. Tissue engineering: Introduction. Tissue Engineering of Skin, Nerve implants. Design criterion for tissue engineering. Cell substrates and support material.

UNIT-II: Organ & Histotypic Cultures (7 Lectures)
Organ and Histotypic cultures: Introduction. Advantages and limitations. Differences between Organotypic and Histotypic cultures. Factors affecting the growth of organotypic and histotypic cultures.

UNIT-III: Laboratory Rat & Mouse Handling (7 Lectures)
Rat and mouse handling/transfer–Restraint, oral gavage, one-handed injection technique, intraperitoneal (IP) injection, subcutaneous (SQ) injection, maxillary bleed, tail vein injection, retro-orbital bleed and injection, ear notching and ear tagging.

UNIT-IV: Laboratory Rabbit Handling (8 Lectures)
Restraint–Manual restraint methods, mechanical restraint devices. Compound administration techniques. Sampling techniques–blood sampling, tissue chunk sampling, urine sampling. Anesthetizing the rabbit. Aseptic surgery. Euthanasia.

Suggested Readings:

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, by, R. Ian Freshney, published by Wiley-Blackwell, UK.
2. Animal Cell Culture: A Practical Approach by JRW Masters, published by Oxford University Press, UK.
3. Basic Cell Culture: A Practical Approach by John M. Davis, published by Oxford University Press, UK.
4. Laboratory Rat Procedural Techniques Manual by John J. Bogdanske, Scott Hubbard-Van Stelle, Margaret Rankin Riley, Beth M. Schiffman, published by CRC press.
5. Laboratory Mouse Procedural Techniques Manual by John J. Bogdanske, Scott Hubbard-Van Stelle, Margaret Rankin Riley, Beth M. Schiffman, published by CRC press.
6. The Laboratory Rabbit Reference by Mark A. Suckow, and Valerie Schroeder.

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(Semester-IX)

BTCH-DSE-903 **MOOCs**
Time: 30 Hours **Credits: 02**

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(Semester-IX)

BTCH-OGE-901 **Clinical Nutrition**
TIME: 60 HOURS **Credits: 04**

UNIT I: Basics of Energy & Water Metabolism (15 Lectures)

Energy and its Unit. Calorific value of food. Basal Metabolic Rate (BMR), Measurement of BMR & factors affecting BMR. Specific dynamic action (SDA) of food. Energy requirements of man and woman and factors affecting energy requirements. Distribution of fluids in the body, water metabolism and Regulation of water balance. Disorder of water metabolism.

UNIT II. Carbohydrate Nutrition (15 Lectures)

Dietary requirement and sources of carbohydrates. Protein sparing action. Metabolic effects of fiber and the microbiota. Metabolic Disorders: Glycogen storage diseases, diabetes mellitus: its diagnosis and acute metabolic complication. Health risks of obesity with an emphasis on type II diabetes, cardiovascular disease, and cancer risks.

UNIT III. Protein & Lipid Nutrition (15 Lectures)

Essential amino acids for man and concept of protein quality Cereal protein and their limiting amino acids. Protein energy malnutrition (PEM). Protein metabolic disorders.
Major classes of dietary lipids. Essential fatty acids and their physiological functions. Dietary sources, biochemical functions and deficiency diseases of Water soluble. Fat soluble vitamins

UNIT IV. Diet & Nutrition (15 Lectures)

Balanced diet and Components of diet. Diet requirement for young, old, men and women. Diet as medicine. Diseases due to diet deficiency and over eating. Functions of nutrients in the human body; sources and properties of nutrients. Digestion, absorption, metabolism, storage, and excretion of nutrients and other markers of nutritional adequacy or excess with emphasis on micronutrients.

Suggested Readings:

1. Principles of Biochemistry by Geoffrey Zubay. Publisher: McGraw Hill College.
2. Nutrition and health by Gerald Wiseman. CRC Press.
3. Nutrition by Marian L. Farrell, Jo Ann L. Nicoteri. Jones & Bartlett Learning.
4. Human nutrition by Bernard A. Marcus, JohnWiley& Sons, Incorporated.
5. Microbiology: Concepts and Applications by MJ Pelczar, ECS Chan and NR Krieg, McGraw-Hill.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-X)

BTCH-CC-1001 **Research Project Work/Training*#**
Credits: 14

*Research Project Work/Training (External/Internal).
#Departmental Evaluation by Faculty, HOD and Dean, School of Life Sciences.

- Educational tour to different labs during winter session.

Syllabus for 5 Year Integrated B.Sc.-M.Sc. Program in Biotechnology (Under CBCS)

(Semester-X)

BTCH-CC-1002 **Journal Club*[#] & Seminar*[#]**
Credits: 02

*Each student under the supervision of a faculty/advisor will present a manuscript from a reputed Journal on a topic related to his/her project work, to the department.

*Recent Review article(s) based Seminar.

[#]Departmental Evaluation by Faculty, HOD and Dean, School of Life Sciences.

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(Semester-X)

BTCH-CC-1003 **Biostatistics & Bioinformatics/MOOCs**
Time: 60 Hours **Credits: 04**

UNIT I: Overview & Applications (15 Lectures)

Definition & applications of Statistics. Arithmetic mean, median, mode: theory and simple numerical problem. Measures of variation: standard deviation, standard error, variance, coefficient of variation.

Sample size requirements & its significance for relevance in designing the biological parameters. Correlation, types and methods: simple, multiple, linear and nonlinear correlation. Spearman's correlation, rank correlation. Regression: linear and curvilinear regression (for two variable X and Y only). Regression lines by least square method. Regression equations of X on Y and Y on X only.

UNIT II: Significance Tests & Biostatistical Tools (15 Lectures)

Null hypothesis. Standard error. Level of significance. Degrees of freedom. Significance of mean for large samples. Significance in means for small samples (students t-test). Significance in ratio of two samples, F-test (for difference between variance of two samples)

Calculation & significance of Chi square test, Analysis of variance test (ANOVA) for one and two-way classification, Signed rank test, Dunnet's test. Use of Power analysis and Odds ratio.

Unit III: Biological Databases (15 Lectures)

Definition of Bioinformatics & application of its tools. Databases and its types, Biological database. Data Acquisition: Retrieval methods for DNA sequence, protein sequence and protein structure information.

Unit IV: Software's Sequence Alignment & *in silico* tools (15 Lectures)

Dynamic programming algorithms. Heuristic Methods of sequence alignment, FASTA, BLAST and PSI BLAST. Multiple Sequence Alignment and software tools for pairwise and multiple sequence alignment.

Methods of phylogenetic analysis: UPGMA, WPGMA, neighbor joining method, Fitch/Margoliash method. Advantages & Disadvantages of *in silico* tools in biological research with examples.

Suggested Readings:

1. Fundamentals of Biostatistics, Rosner. Brooks Cole, Boston, MA.
2. Introduction to the Practice of Statistics, Moore and McCabe. Freeman and Co., New York.
3. Bioinformatics: Databases and Systems, by Stanley I. Letovsky.
4. Bioinformatics Databases: Design, Implementation, and Usage (Chapman & Hall/ CRC Mathematical Biology & Medicine), by Sorin Draghici.

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(Semester-X)

BTCH-CC-1004 **Professional Development & Career Progression [#] (National & International)**

Time: 60 Hours **Credits: 04**

[#]Departmental Evaluation by Faculty, HOD and Dean, School of Life Sciences.