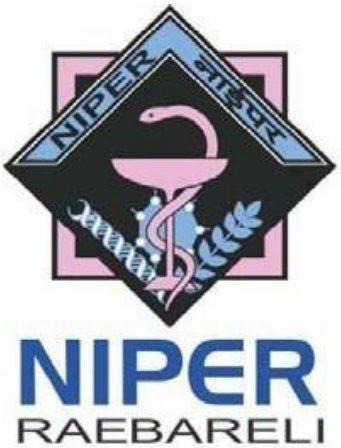

SYLLABUS
M.S. (Pharm.) Biotechnology

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Course No.	Course Name	Credits
Semester -I		
PT-530	Biochemical Engineering Fundamentals	**2**
BT-520	Cell Biology	**2**
BT-550	Biochemistry	**2**
BT-530	Microbiology and Microbial Genetics	**2**
***MC-511**	Spectral Analysis	**2**
***MC-530**	Separation Techniques	**1**
***GE-510**	Biostatistics	**2**
GE-511	Seminar	**1**
LG-510	General Laboratory Experience	**3**
	Total Credits	**17**
Semester-II		
BT-610	Molecular Biology	**2**
BT-620	Recombinant DNA Technology	**2**
BT-630	Immunology and Immunotechnology	**2**
BT-650	Analysis, Diagnostics and Cell Based Screening	**2**
BT-660	Sequence Analysis	**2**
GE-611	Seminar	**1**
LS-610	General Lab Experience in the Area of Specialization	**2**
	Total Credit	**13**
Semester-III		
TH-598	Synopsis	**5**
TH-599	Presentation	**3**
	Total Credits	**8**
Semester-IV		
TH-698	Thesis	**9**
TH-699	Defence of Thesis	**3**
	Total Credits	**12**
	Grand Total (I-IV semesters)	**50**
	*Common with other disciplines	

M.S. (Pharm.) Biotechnology-Semester I

PT- 530 Biochemical Engineering Fundamentals (2 Credits)

1. **Homogeneous reactions and Microbial growth:** Zero-order kinetics; First-order kinetics; Michaelis- Menten kinetics; Determining enzyme kinetic constants from batch data**:** Kinetics of microbial growth; substrate utilization and product formation; Structured and unstructured model of growth; Equations for substrate utilization and product formation and related numericals.
2. **Sterilization of air and medium:** Different methods of sterilization; Kinetics of sterilization; batch and continuous sterilization; advantages and disadvantages thereof; Calculation of del factor and solving of numerical.
3. **Reactor design and operation:** Bioreactor configurations; Monitoring and control of bioreactors; Ideal reactor operation; Batch operation of a mixed reactor; Total time for batch reaction cycle; Fed-batch operation of a mixed reactor; Continuous operation of a mixed reactor; Chemostat cascade; Continuous operation of a plug flow reactor; Detailed studies on the batch, continuous and fed-batch bioreactors.
4. **Reactor types and Applications**: Types of reactors: Immobilized plant cell reactors, Stirred tank; Airlift reactor; Packed bed. Novel design concepts and comparison of reactor performance.
5. **Agitation:** Need of agitation in aerobic fermentation; Effect of agitation; How agitation helps aeration; Different types of agitational methods; impeller design and relationship with the characteristics of the fluid; flow behaviour etc.
6. **Aeration:** Need of aeration in aerobic fermentation; effect of aeration; how aeration helps agitation; different types of aeration methods; aeration in high density fermentation; aeration in qualescence and non-qualescence medium; flow behaviour etc.
7. **Mass transfer:** Mass and energy balance in microbial processes; Resistance encountered in fermentation medium by the oxygen molecule; Role of Dissolved oxygen concentration in the mass transfer; Determination of mass transfer co-efficient (KLa), Factors affecting KLa and their relationship.
8. **Heat transfer in bioreactors:** Mechanisms of heat transfer; heat transfer between fluids, Calculation of heat transfer coefficients; Heat transfer equipment; Steady state conduction; LMTD calculation; Relationship between heat transfers; Cell concentration and stirring conditions.
9. **Dimensional analysis:** Various types of dimensionless analysis in terms of mass transfer; Heat transfer and momentum transfer; Importance of dimensionless number in designing the bioreactors, heat exchangers etc.
10. **Scale-up:** Principles and criteria; Different methods of scale up and the detailed analysis with case studies; Instrumentation and control of bioprocesses.

Recommended books:

1. Bioprocess Engineering: Basic Concepts by Michael L. Shuler, Fikret Karg
2. Bioprocess Engineering Principles by Pauline M. Doran

3. Biochemical Engineering Fundamentals by James Edwin Bailey, David F. Ollis
4. Principles of Fermentation Technology by Peter F. Stanbury, Allan Whitaker, Stephen J.Hall
5. Biochemical Engineering Fundamentals by James Edwin Bailey, David F. Ollis

BT-520 Cell Biology (2 Credits)

1. **Cell structure and organization:** Cells as a unit of life, prokaryotic and eukaryotic cells, biomembranes, structure and basic functions of various cell organelles i.e nucleus, ribosomes, ER, golgi, lysosomes, peroxisomes, exosomes, cytoskeleton.

2. **Tools and Techniques of Cell Biology:** Histology, staining, fluorescence, confocal microscopy, TEM and SEM. Fluorescent dyes and GFP tagged proteins in visualization, FACS, cell fractionation, cell culture.

3. **Organization of tissues:** Cell-cell and cell-matrix interactions, cell adhesion molecules, components of the extracellular matrix, cellular junctions and role.

4. **Cell cycle:** G1, G2, S and M phase of the cell cycle. Cell cycle analysis and its applications, programmed cell death apoptosis versus necrosis. Role of telomeres in the cell cycle.

5. **Cell Signaling:** Receptor concept, receptor signaling and expression, orphan receptors, extra-cellular signals and cell functions, hormones, second messengers and hormone actions, growth factors.

6. **Transport across membranes:** Osmosis, active and passive transport. Protein transporters ion channels, antiporters, symporters, Applications in the field of medicine.

7. **Cellular movement & Molecular motors:** Types of movement, extravasation, role of Cytoskeletal proteins in movement, molecular motors, the movement of cilia and flagella, Muscle contraction, myosin and kinesins in the movement of vesicles.

8. **Protein Synthesis and Targeting:** Ribosome and endoplasmic reticulum, Secretory pathway, targeting and sorting of proteins, nuclear localization signal, organelle specific signal sequence, ATP driven translocation, glycosylation, transport of protein, endocytosis, exocytosis, micropinocytosis.

9. **Relevance of Cell Biology:** Stem cells, Tissue engineering, infectious disease.

10. **Cancer and Diagnostics:** Tumor cells, cell lines and models, proto-oncogenes and oncogenes, oncogenic mutations, loss of cell cycle control, carcinogens. *Ca*ncer diagnostics, human retroviral diseases specially AIDS. Role of enzymes in diagnostics.

Recommended books:

1. Molecular Cell Biology by Harvey Lodish
2. Molecular Biology of the Cell by Bruce Alberts
3. Principles of Biochemistry : Lehninger
4. Biochemistry by L. Stryer

BT-530 Microbiology and Microbial Genetics (2 Credits)

1. **Classical genetics:** 'Transforming factor', Hershey and Chase's experiment, Replica plating, Types and selection of mutants.

2. **Mechanisms of genetic exchange:** Transformation, Transduction (generalized, specialized), Genetic Mapping using transduction, Triple cross experiments, Cis-trans complementation. Conjugation (Hfr strains, Interrupted mating, time-of- Entry mapping), Lederberg-Tatum experiment, Resistance plasmids. Genetic mapping

3. **Transposition:** Mechanism and models. Insertion sequences. Composite transposons. Transposon-generated *in-vitro* mutagenesis.

4. **Gene regulation in prokaryotes:** Principles, Differences between prokaryotes and eukaryotes. Regulation of transcription (lac operon, tryptophan operon, etc.), Structures of repressors. Mechanism of *lac* repressor. Translational control, feedback inhibition. Blue-white screening.

5. **Viruses and other infectious agents:** Structure, classification, Life cycle of viruses: Koch's postulates. Viroids, satellites, prions.

6. **Distinguishing feature of various groups of microorganisms and their characteristics:** Actinomycetes, bacteria, moulds, yeasts and algae and their broad classification. Archaebacteria and microorganisms of extreme environment: pure culture concept and culture characteristics.

7. **Microbial growth principles, nutrition and Recycling of energy sources:** Growth measurement techniques: assimilation of carbon, nitrogen and sulphur. Various growth media for the cultivation oforganisms. Cultivation of anaerobes, rare actinomycetes etc.**:** Bioassays, recycling of carbon, nitrogen and sulphur.

8. **Isolation and preservation:** Isolation, development and preservation of industrial microorganisms; Isolation of microorganisms from various sources and long term preservation and improvement of cultures.

9. **Biochemical pathways:** Energy transduction in microbial systems, phosphoketolase, Enter-doudorff and glyoxalate pathways: Anaerobic respiration: Microbial pathogenicity.

10. **Control of microorganisms:** Rate of death of bacteria; Conditions influencing antimicrobial action; Mode of action of antimicrobial agents; Control of microorganisms by physical agents; Control of microorganisms by chemical agents; Antibiotics and other chemotherapeutic agents.

***Recommended books**:*

1. Microbiology (4/e) by Lansing Prescott, John Harley and Donald Klein, McGraw Hill
2. Lewin's Genes X by Jocelyn E. Krebs, Elliott S. Goldstein and Stephen T. Kilpatrick.Jones & Bartlett
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA (4/e) by Bernard R. Glick, Jack J. Pasternak and Cheryl L. Patten, ASM Press
4. Microbiology, 5th Edition by Michael J. Pelzer, Jr. E.C.S. Chan, Noel R. Krieg
5. Biotechnology: Atextbook of Industrial Microbiology by Wulf Crueger, Anneliese Crueger,
6. Prescott's Microbiology by Joanne M. Willey, Linda Sherwood, Christopher J. Woolverton, Lansing M. Prescott
7. Brock's Biology of Microorganisms by Michael T. Madigan, John M. Martinko, Jack Parker
8. Principles of Fermentation Technology by Peter F. Stanbury, Allan Whitaker, Stephen J. Hall
9. Principles of Microbe and Cell Cultivation by S.J.Pirt
10. Instant notes in Microbiology by S. Baker, Jane Nicklin.
11. Biotol series (This series has many books pertaining to all fields of Biotechnology, students have to select the books as per the topics of interest)

BT-550 Biochemistry (2 Credits)

1. **Biomolecules**: Carbohydrates, Lipids, chemistry and classification, structures of biomolecules, biochemical properties, pharmaceutical importance.

2. **Protein and Nucleic acids:** Structure (primary, secondary, tertiary and quaternary), properties, pharmaceutical importance.

3. **Enzymes:** Classification, mode of action (activation, specificity), enzyme kinetics, enzyme inhibitors and regulators, allosteric enzymes, isoenzymes, multienzyme system, pharmaceutical importance.

4. **Coenzymes and cofactors:** Coenzymes, classification of vitamins, role and mechanism of action of some important coenzyme (NAD /NADP, FAD, lipoic acid, tetrahydrofolate, B12- coenzyme), role of cofactors with specific examples.

5. **Biochemical energetics Part I**: free energy, concept of standard free energy, laws of thermodynamics, exergonic and endergonic reactions.

6. **Biochemical energetics Part II:** energy rich compounds, coupling of reaction, biological oxidation-reduction.

7. **Carbohydrate metabolism:** Glycolysis, gluconeogenesis, pentose phosphate pathways (PPP), glycolysis, TCA cycle, glyoxylic acid cycle, regulation of carbohydrate metabolism, electron transport chain and oxidative phosphorylation, disorders of carbohydrate metabolisms.

8. **Lipid metabolism:** Hydrolysis, absorption and transport of lipids, catabolism of lipids, α-, β- and ω- oxidation of fatty acids, ketone bodies formation, biosynthesis of fatty

acids, disorders of lipid metabolisms.

9. **Protein metabolism:** Hydrolysis of proteins, pathways of amino acid degradation, urea cycle and formation of uric acid, assimilation of ammonia, biosynthesis of amino acids, inborn error of protein metabolism.

10. **Nucleic Acid Metabolism:** Purine and pyrimidine biosynthesis, salvage pathway, degradation of nucleotides, role of ribonucleotide reductase, pharmaceutical importance, disorders of purine and pyrimidine metabolisms.

Recommended books:

1. Principles of Biochemistry by Lehninger
2. Biochemistry by L. Stryer

MC-511 Spectral Analysis (2 Credits)

1. Ultra Violet (UV) and visible spectroscopy:

a) Energy levels and selection rules: Definitions, molecular orbital approach for energy absorption, various modes of transitions.
b) Correlation of structural variation with UV absorption: Factors influencing the position and intensity of absorptions, Inductive and resonance effects, effect of ring size, influence of stereochemical factors.
c) Predicting UV absorption: Woodward- Fieser, Fieser-Kuhn and Nelson rules;
d) Other factors: Non-conjugative effect, solvent effect, S-cis band.

2. Infrared (IR) spectroscopy:

a) Characteristic regions of the spectrum: Various modes of vibrations, Energy levels
b) Correlation of structure with IR spectra: Influence of substituents, ring size, hydrogen bonding, vibrational coupling and field effect on frequency
c) Applications: Determination of stereochemistry. Spectral interpretation with examples.

3. Nuclear Magnetic Resonance (NMR) spectroscopy:

a) Fundamentals: Physical basis, magnetic nuclei, resonance, relaxation processes, signal-sensitivity.
Instrumentation: Continuous-Wave (CW) instrument, Pulsed Fourier Transform (FT) instrument, Functions, Relation with sensitivity, Sampling.
c) 1H NMR, correlation of structure with spectra: Chemical environment and shielding, chemical shift and origin of its concept, reference compound, local diamagnetic shielding and magnetic anisotropy, relation with chemical shift, chemical and magnetic non-equivalence, spin-spin splitting and its origin, Pascal's triangle, coupling constant, mechanism of coupling, integral, NMR solvents and their residual peaks, protons on heteroatoms, quadrupole broadening and decoupling, effect of conformations and stereochemistry on the spectrum, Karplus relationship, diastereomeric protons, Heteronuclear coupling to 19F and 31P, virtual coupling, long range coupling-epi, peri, bay effects. Shift reagents-mechanism of action, spin decoupling and double resonance. Explanation of spectra of some compounds and drugs.
d) 13C NMR, correlation of structure with spectra: Chemical environment, shielding and carbon-13 chemical shift, calculation, proton-coupled 13C Spectra, Proton-decoupled

13C spectra, Nuclear Overhauser Enhancement (NOE), Problem with integration, Distortionless Enhancement by Polarization Transfer (DEFT), Heteronuclear coupling for carbon to deuterium, carbon to 19F, carbon to 31P.Explanation of spectra of some compounds and drugs.

4. **Mass spectrometry (MS):** Molecular ion and metastable peak, fragmentation patterns, nitrogen and ring rules, McLafferty rearrangement, electron and chemical ionization modes, applications.

Recommended books:

1. Spectroscopy by Donald L Pavia, Gary M Lampman, George S Kriz, James A Vyvyan

2. Organic spectroscopy by William Kemp

3. Spectroscopic Methods in Organic Chemistry by Dudley H. Williams & Ian Fleming

4. Spectrometric Identification of Organic Compounds by Robert M. Silverstein, Francis X. Webster & David J. Kiemie

5. Applications of Absorption Spectroscopy of Organic Compounds by Dyer

6. Fundamentals of Molecular Spectroscopy by Colin N. Banwell & Elaine M. McCash

b) Spectroscopy by Pavia, Donald L. Lampman, Gary M. Kriz, George S

MC-530 Separation Techniques (1 Credit)

1. **Separation Techniques:** Need for learning separation techniques, separation techniques in natural product research and drug discovery, extraction techniques.

2. **Chromatography:** General principles, classification of chromatographic techniques, normal and reverse phase, bonded phase chromatography, stationary phases, activity of stationary phases, elutropic series, and separation mechanisms.

3. **Column Chromatography and Short Column Chromatography**: Column packing, sample loading, column development, detection.

4. **Flash Chromatography and Vacuum Liquid Chromatography:** Objectives, optimization studies, selecting column and stationary phases, selecting suitable mobile phases, automated flash chromatography, and reverse phase flash chromatography.

5. **High Performance Liquid Chromatography:** Principles, instrumentation, peak shapes, capacity factor, selectivity, plate number, plate height, resolution, band broadening, pumps, injector, detectors, columns, column problems, gradient HPLC, HPLC solvents, trouble shooting, sample preparation, method development.

6. **Planar Chromatography - TLC/HPTLC/OPLC:** Basic principles, sample application, development of plates, visualization of plates, 2D TLC, densitometry, Over pressure layer chromatography.

7. **Counter Current Chromatography:** Basic principles, droplet counter current chromatography, centrifugal partition chromatography, choice of solvents for SP and MP.

8. **Gas Chromatography:** Principles, instrumentation, split-splitless injector, head space sampling, columns for GC, detectors, quantification.

9. **Biochromatography:** Size exclusion chromatography, ion exchange chromatography, ion pair chromatography, affinity chromatography general principles, stationary phases and mobile phases.

10. **Hyphenated Techniques:** Introduction to GC-MS and LC-MS techniques and their applications in natural products.

***Recommended books*:**

1. Methods in Biotechnology, Natural Product Isolation by Sarker, Latif, Gray

2. Methods in Biotechnology, Natural Product Isolation by Richard Canell

3. Various Reviews and Research Paper

GE-510 Biostatistics (2 credits)

1. **Statistics:** Introduction, its role and uses. Collection; Organization; Graphics and pictorial representation of data; Measures of central tendencies and dispersion. Coefficient of variation.

2. **Probability:** Basic concepts; Common probability distributions and probability distributions related to normal distribution.

3. **Sampling:** Simple random and other sampling procedures. Distribution of sample mean and proportion.

4. **Estimation and Hypothesis testing:** Point and interval estimation including fiducial limits. Concepts of hypothesis testing and types of errors. Student- t and Chi square tests. Sample size and power.

5. **Experimental design and analysis of variance:** Completely randomized, randomized blocks. Latin square and factorial designs. Post- hoc procedures

6. **Correlation and regression:** Graphical presentation of two continuous variables; Pearson's product moment correlation coefficient, its statistical significance. Multiple and partial correlations. Linear regression; Regression line, coefficient of determination, interval estimation and hypothesis testing for population slope. Introduction to multiple linear regression models. Probit and logit transformations.

7. **Non-parametric tests:** Sign; Mann-Whitney U; Wilcoxon matched pair; Kruskal wallis and Friedman two-way anova tests. Spearman rank correlation

8. **Statistical techniques in pharmaceutics:** Experimental design in clinical trials; Parallel and crossover designs. Statistical test for bioequivalence. Dose response studies; Statistical qualitycontrol

Recommended books:

1. Fundamentals of Biostatistics by *Bernard Rosner*

2. Pharmaceutical Statistics: Practical and Clinical Applications by *Bolton and Bon*

3. Statistical Misconceptions by *Huck*

GE-511 Seminar (1 credit)

1. Introduction, Information retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material, thesis, dissertation and references.
4. Reading research papers
5. Skills in oral presentation.

Each student has to present a seminar before end of the semester.

LG-510 General Laboratory Experience-15 hours/week (3 credits)

1. **Analytical techniques (75 hours):**
   a) Spectral analysis workshop (45 hours):
   b) Separation techniques (30 hours):

2. **Computer and application in pharmaceutical sciences (100 hours):** Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems.

3. **Biotechnology for pharmaceutical sciences (20 hours)**
   Day-1: Preparation for plasmid miniprep.
   Day-2: Plasmid miniprep and restriction digestion.
   Day-3: Gel electrophoresis and molecular weight calculation.
   Day-4: Discussion of result and viva.

4. **Biotechnology specialization (75 hours):**
   Cell biology (25 hours):
   Day-1: Sterilization by autoclaving and filtration.
   Day-2 : Media preparation and cell counting.
   Day-3 : Sub cellular fractionation by homogenization, solubilization, sonication and protein estimation.
   Day-4 : Running SDS-PAGE and Viva.

   Enzyme kinetics (25 hours):
   Day-1 : Assay of trypsin.
   Day-2 : Thermal stability of trypsin.
   Day-3 : Lineaweaver-Burk plot for trypsin.
   Day-4 : Plotting of graphs and discussion of result

   Enzyme biochemistry (25 hours):
   Day-1: Enzyme kinetics, time course.
   Day-2: Effect of pH and temperature.
   Day-3: Inhibition studies and characterization.
   Day-4: Ionic strength effect and viva.

   Bacterial Culture & Growth Kinetics:
   Day-1: Direct and indirect methods to measure bacterial growth, Media preparation,setting up of primary cultures.
   Day-2: Monitoring growth kinetics, effect of different parameters on growth, plottingof growth curves.
   Day-3: Calculation of mean generation time and growth rate constant, analysis ofresults, discussion of results & viva.

M.S. (Pharm.) Biotechnology-Semester II

BT-610 Molecular Biology (2 credits)

1. **Genome Organization:** Organization of bacterial genome, structure of eukaryotic chromosomes, role of nuclear matrix in chromosome organization and function, matrix binding proteins, heterochromatin and euchromatin, DNA re-association kinetics (Cot curve analysis), repetitive and unique sequences, satellite DNA, DNA melting and buoyant density, nucleosome phasing, DNase I hypersensitive regions, DNA methylation & imprinting.

2. **DNA Structure:** Structure of DNA- A-, B-, Z-, P- and triplex DNA, measurement of properties-spectrophotometric, CD, AFM and electron microscope analysis of DNA structure.

3. **Replication:** replication initiation, elongation and termination in prokaryotes and eukaryotes, enzymes and accessory proteins, fidelity, replication of single stranded circular DNA, gene stability.

4. **Repair & Recombination:** DNA repair-enzymes, photoreactivation, nucleotide excision repair, mismatch correction; SOS repair, recombination, homologous and non-homologous, site-specific recombination, chi sequences in prokaryotes.

5. **Prokaryotic & Eukaryotic Transcription:** Prokaryotic transcription, transcription unit, Promoters- constitutive and inducible, operators, regulatory elements, initiation attenuation, termination-Rho-dependent and independent, anti-termination, transcriptional regulation-positive and negative, Regulation of gene expression, negative and positive, trans acting products and cis acting sequences, control of structural gene clusters, induction and repression of genes, role of antisense RNA in gene inactivation, regulator RNA's and micro RNA's as regulators in eukaryotes.

6. **Eukaryotic transcription and regulation:** RNA polymerase structure and assembly, RNA polymerase I,II, III, eukaryotic promoters and enhancers, general transcription factors, TATA binding proteins (TBP) and TBP associated factor (TAF), activators and repressors, transcriptional and post transcriptional gene silencing.

7. **Post Transcriptional Modifications:** Processing of hnRNA, tRNA, rRNA, 5'-cap formation; 3'-end processing and polyadenylation, Splicing, RNA editing, mRNA stability, catalytic RNA.

8. **Translation & Transport:** Translation machinery; Ribosomes, composition and assembly, universal genetic code, degeneracy of codons, termination codons, Iso-accepting tRNA, Wobble hypothesis, Mechanism of initiation, elongation and termination, Co-and post translational modifications, genetic code in mitochondria, protein stability, protein turnover and degradation**.**

9. **Mutations, Oncogenes and Tumor suppressor genes:** Nonsense, missense and point mutations, Intragenic and Intergenic suppression, Frame shift mutations, Physical, chemical and biological mutagens. Viral and cellular oncogenes, Tumor suppressor genes from humans, structure, function and mechanism of action of PRB and p53 tumor suppressor proteins, activation of oncogenes and dominant negative effect, suppression of tumor suppressor genes, oncogenes as transcriptional activators.

10. **Transposable elements:** Transposition Transposable genetic elements in prokaryotes and eukaryotes, mechanisms of transposition, role of transposons in mutation.

Recommended books :

1. Genes VIII by Benjamin Lewin
2. Principles of Genetics by Gardner, Simmons and Snustard

BT-620 Recombinant DNA Technology (2 credits)

1. **Basic techniques in Gene analysis:** Purification and analysis of nucleic acids: Isolation of DNA and RNA, plasmid purification, agarose, polyacrylamide and pulse field gel electrophoresis, southern, northern and western blotting.

2. **Vectors:** Cloning, and expression vectors, Plasmids, selectable markers, blue-white selection, phage, yeast vectors and YACs. Tags for purification and visualization, bacterial transformation, manual and automated sequencing.

3. **Plant Biotechnology:** *Agrobacterium tumefaciens*, vectors, nuclear, chloroplast transformation, pest resistance, delay of fruit ripening, antibody generation in plants, edible vaccines. Ethics of rDNA products.

4. **Animal biotechnology:** Transformation of animal cells, stable and transient transfection, selection markers.

5. **Viral vectors:** Adenovirus, adeno-associated virus, baculovirus, herpes virus, retrovirus-based expression systems.

6. **Gene targeting:** Random and specific, *Cre/lox P* system, knock-out mice.

7. **Transgenic animals:** Principle, nuclear transfer from somatic cells, stem cells, tests for pluripotency, mouse, frog, Drosophila.

8. **Protein 'pharm'ing:** Design of second generation therapeutic molecules, examples of engineered proteins of therapeutic potential, tools for protein engineering, library-based selection methods.

9. **Gene therapy:** Somatic cell gene transfer, autologous and non-autologous *ex* vivo gene therapy, prospects and limitations.

10. **Nucleic acid therapeutics:** Antisense technology, siRNA, trans-splicing, ribozymes, aptamers, case studies, advantages and challenges.

Recommended books:

1. Principles of Gene Manipulation and Genomics (7/e) by Sandy Primrose and Richard Twyman, Wiley-Blackwell
2. Analysis of Genes and Genomes by Richard J Reece, John Willey & Sons.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA (4/e) by Bernard R. Glick, Jack J. Pasternak and Cheryl L. Patten. ASM Press
4. Relevant review & research papers

BT-630 Immunology and Immunotechnology (2 credits)

1. **Immunity:** Innate and adaptive, immune response memory, specificity and recognition of self and non-self, immunogenicity, antigenicity, physiology of immune response, epitope analysis, synthetic peptides and immune response, immunity to virus, bacteria, fungi.

2. **Cells and organs of the immune system:** Lymphoid cells, T-cells, B-cells, monocytes, phagocytes, mast cells and basophils, primary and secondary lymphoid organs, interplay between cells.

3. **Humoral immunity:** Antigen-antibody interactions, affinity, avidity, immunoglobulins, molecular mechanism of generation of antibody diversity, molecular biology of IgG.

4. **Cell mediated immunity:** T cell subsets and surface markers, T cell-dependent and-independent markers, structure and function of MHC, association of MHC with disease susceptibility, structure of T cell antigen receptor.

5. **Natural immunity:** Inflammation, stimuli, chemotaxis, arachidonic acid metabolite and cytokines, vascular modifications, healing and fibrosis.

6. **Natural killer cells:** Functional definition, mechanism of lysis, recognition structures, phosphorylation.

7. **Immune memory:** B-cell memory, significance, mutations and switches in memory cells, T-cell memory, lack of mutations and switches in T-cell memory, activation, super activation, loss of memory.

8. **Immune tolerance:** B-cell tolerance, reversible and irreversible tolerance, antigen induced tolerance, induction, T-cell tolerance, partial engagement of signal transducer, self-antigens, molecular consequence of tolerance.

9. **Disorders:** Hypersensitivity reaction, immunosuppression, autoimmune disorders, its molecular mechanism, immunodeficiency disorders (AIDS), tumor immunology.

10. **Immuno-biotechnology:** Hybridoma, phage display technology, vaccines, Antibody engineering, second generation antibodies a brief outline.

Recommended books:

1. Cellular and Molecular Immunology by Abdul K. Abbas, Andrew H. Lichtman and ShivPillai
2. Kuby Immunology by Thomas J. Kindt, Barbara A. Osborne, and Richard A. Goldsby
3. Refer to relevant research and review articles.

BT-650 Analysis, Diagnostics and Cell Based Screening (2 credits)

1. **Total protein assay:** Quantitative amino acids analysis, Folin-Lowry protein assay, BCA assay, UV spectrophotometry, *etc*.
2. **Purity:** Protein impurities, contaminants, electrophoretic analysis, HPLC based analysis, DNA content analysis, immunological assays for impurities, combined immunological and electrophoretic methods, host-cell impurities, etc. ICH guidelines.
3. **Potency assays:** In-vitro biochemical methods MTYT assay, assay for apoptosis, cell-line derived assays, whole animal assays, etc.
4. **PCR & Mutagenesis**: PCR enzymes, primer design, RT-PCR, Real time PCR, cDNA synthesis, applications of PCR, random and site directed mutagenesis, primer extension mutagenesis, strand selection mutagenesis, cassette mutagenesis, PCR based mutagenesis, Quik Change mutagenesis.
5. **Principles, methods and applications of immuno-diagnostics:** Principles and methods of some clinically used diagnostic immunoassays, e.g., homogeneous immunoassays,

fluorescence, chemiluminescence and bioluminescence enzyme immunoassays, immunoblot, immunoaffinity, immunoprecipitation, biotinylation, immunosensors.

6. **Principles, methods and applications of DNA-based diagnostics:** DNA probe based diagnostics, sample preparation, hybridization, separation, detection, PCR-RFLP in paternity and forensic cases SNP detection MALDI and DHPLC.

7. **High-throughput screening:** Requirements and parameters, Advantages and disadvantages of biochemical and cellular assays; miniaturization and automation.

8. **Cell-based screening assays:** Advantages over in vitro assays. Different formats: radioactive, luminescence, fluorescence, etc. Assays compatible with cell membranes: GTPγS, cAMP accumulation.

9. **Yeast two-hybrid system:** Different Y2H systems, their advantages and disadvantages, examples.

10. **GPCRs as targets:** Identification of drug molecules; Important parameters: intracellular calcium, cAMP, β-arrestin, receptor internalization, reporter gene assays; orphan GPCRs; desensitization and internalization.

Recommended books:

1. The Immnoassay Handbook by David Wild
2. High Throughput Screening: The Discovery of Bioactive Substances by John P. Devlin.
3. Refer to relevant research and review articles.

BT-660 Sequence Analysis (2 credits)

1. **Basics of Computational Biology:** Database concept; Protein and nucleic acid databases, structural databases.

2. **The NCBI:** publicly available tools, Resources at NCBI and EBI, DNA and protein information resources on the web.

3. **DNA Sequence Analysis Part I:** Analysis of sequencing chromatogram editing and contig building. Sequence-function relationship; Detection of protein-coding regions, promoters, transcription factor binding sites, restriction enzyme cleavage sites and intron-exon boundaries.

4. **DNA Sequence Analysis Part II:** Databases and search tools; Biological background for sequence analysis. Retrieval of DNA sequences and searching of databases for similar sequence. Submitting DNA sequence to databases, where and how to submit.

5. **Protein sequence analysis:** Comparison of protein sequences and database searching. Predictive methods for protein sequences. Methods for discovering conserved patterns in protein sequences and structures and protein motifs.

6. **BLAST, various methods of DNA and protein BLAST and interpretation of output:** Sequence alignment, Pairwise alignment, Techniques, Multiple Sequence Alignment.

7. **Predicting secondary structure from protein sequences:** Protein structure prediction, homology modelling. Comparison of protein three-dimensional structures. Protein family- based methods for homology detection and analysis.

8. **Phylogentic analysis sequence-based taxonomy:** Overview and assumptions from Multiple Alignment to phylogeny. Neighbour joining, maximum likelihood vs. parsimony. Computational tools for phylogentic analysis.

9. **Next generation sequencing, Platforms and Applications:** Concept theory, library preparation and applications in sequence detection and analysis, platforms; Illumina (Miseq, Hiseq, Novaseq), Oxford nanopore, Pacbio.

10. ***In-silico*** **analysis of nextgen sequences:** Basespace, Bowtie, Staraligner, Epi2me.

Recommended books*:*

1. Essential Bioinformatics, by Jin Xiong
2. Bioinformatics: Sequence and Genome Analysis, by David W. Mount
3. Systems Biology by Bernhard Palsson
4. Systems Biology in Practice, Concepts, Implementation and Application by E. Klipp, R. Herwig, A. Kowald, C. Wierling, H. Lehrach.
5. Relevant Research and Review Papers.

GE-611 Seminar (1 credits)

Students are required to submit written record and present details of the project to be pursued in semester-III and IV. This should include the purpose and basis of the project, stating aims, objectives and probable outcomes, be able to supplement these with necessary information, literature review towards it, and process for the project itself.

LS-610 General Laboratory Experience-10 hours/week (2 credits)

1. **Cell Biology**
   Expt-1: Cell proliferation/cytotoxicity assay (MTT). Expt-2: Western transfer and immunoblotting.
2. **Recombinant DNA technology:**
   Expt-1: Sequence retrieval and analysis Expt-2: PCR primer generation
   Expt-3: PCR and gel electrophoresis
   Last day: Discussion of results and viva
3. **Enzyme isolation:**
   Day-1-9: Extraction of α-amylase from wheat germ and its partial purification
4. **Enzyme biochemistry:**
   Day-1-9: Expression, partial purification and characterization of a recombinant enzyme.
5. **Bacterial Transformation:**
   Day-1-7: Commonly used methods for bacterial transformation, preparation of competent cells, comparison of transformation by electroporation and heat shock,estimation of transformation efficiency.