SEMESTER 1

1. TBT 1001: Bioprocess Engineering	Unit 1

Module I

Principles of enzyme catalysis: Introduction to enzymes, mechanistic models for simple enzyme kinetics, rate parameters, models for more complex enzyme kinetics, effect of pH and temperature, methods of immobilization, diffusional limitations in immobilized enzyme systems, brief introduction to large scale enzyme production.

Module II

Microbial growth: Introduction to metabolism; Nutrient transport; Glycolysis; TCA cycle and other pathways; Control of metabolism; Factors affecting microbial growth; Stoichiometry: mass balances; Stoichiometry: energy balances; Growth kinetics; Measurement of growth.

Module III

Bioreactors: Introduction to bioreactors; Batch and Fed-batch bioreactors, Continuous bioreactors; Immobilized cells; Bioreactor operation; Sterilization; Aeration; Sensors; Instrumentation; Culture-specific design aspects: plant/mammalian cell culture reactors.

Module IV

Agitation and aeration: types of impellors and sparger, oxygen transfer rate, oxygen uptake rate, volumetric oxygen transfer rate (kLa), measurement of kLa, power requirement for agitation in gaseous and non gaseous systems.

Module V

Scale up, operation and control of bioreactors: Concepts of various bioreactor configurations, scale-up, various criteria for scale-up, scale-down, bioreactor instrumentation and control.

Module VI

Industrial Microbiology: Production of microbial polysaccharides, microbial transformation of steroids and sterols: Bioprocess technology, beer brewing, cheese manufacture, mold–modified foods, Wine, Vinegar, Microbial production of amino acids, antibiotics, microbial enzymes, organic acids; Strain improvement, culture preservation and inoculum development. probiotics. Production of antibiotics, biopolymers, vaccines.

Module VII

Industrial Processes and Process economics: Description of industrial processes; Process flow sheeting; Process economics

Books Recommended:

1. Lee, Biochemical Engineering
2. Shuler and Kargi, Bioprocess Engineering – Basic Concepts. Prentice Hall PTR
3. Aiba and Humphary. Biochemical Engineering

4. Doran, Bioprocess Engineering Principles
5. Bailey and Ollis, Biochemical Engineering Fundamentals

Texts/References

1. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002.
2. Pauline Doran, Bioprocess engineering principles, 1 Edition, Academic Press, 1995.
3. Colin Ratledge, Bjorn Kristiansen, Basic Biotechnology, 2nd Edition, Cambridge University Press, 2001.
4. Roger Harrison et al., Bioseparations Science and Engineering, Oxford University Press, 2003.

2. TBT 1003: Bioprocess Engineering	Unit 1

Module I

Basics Concepts: DNA Structure and properties; Restriction and DNA modifying enzymes; Cohesive and blunt end ligation; Linkers; Adaptors; Homopolymeric tailing; Labeling of DNA using different techniques; Hybridization techniques: Southern, Northern, Colony and Fluorescence and *in situ* hybridization; Chromatin Immunoprecipitation; DNA-Protein Interactions-Electromobility shift assay; DNaseI footprinting; Methyl interference assay.

Module II

Cloning Vectors: Plasmids; Bacteriophages; M13 mp vectors; Phagemids; Insertion and Replacement vectors; EMBL; Shuttle vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40; vaccinia/bacculo & retroviral vectors; Expression vectors (eukaryotic and prokaryotic); Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors; Inclusion bodies; Methodologies to reduce formation of inclusion bodies; Plant based vectors, Ti and Ri as vectors, Yeast vectors

Module III

Cloning Methodologies: Insertion of Foreign DNA into Host Cells; Transformation; Construction of libraries; Isolation of mRNA and total RNA; cDNA and genomic libraries; cDNA and genomic cloning; Metagenomics and its role in environment, Expression cloning; Jumping and hopping libraries; Southwestern and Farwestern cloning; Protein-protein interactive cloning and Yeast two hybrid system; Phage display; Principles in maximizing gene expression; Transgenics; cDNA and intragenic arrays; Differential gene expression and protein array, Introduction of DNA into mammalian cells; Transfection techniques

Module IV

PCR and Its Applications: Primer design; Fidelity of thermostable enzymes; DNA polymerases; Types of PCR – multiplex, nested, reverse transcriptase, real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T-vectors; PCR in gene recombination; Deletion; addition; Overlap extension; and SOEing; PCR in molecular diagnostics; Viral and bacterial load detection; PCR based mutagenesis, Mutation detection: SSCP, DGGE, RFLP, Oligo Ligation Assay (OLA), MCC (Mismatch Chemical Cleavage, ASA (Allele-Specific Amplification), PTT (Protein Truncation Test)

Module V

Sequencing methods: Enzymatic DNA sequencing; Chemical sequencing of DNA; Automated DNA sequencing; Next generation DNA sequencing techniques, RNA sequencing; Chemical Synthesis of oligonucleotides;

Module VI

Gene silencing techniques: Small double stranded RNAs; siRNA technology; Micro RNA; Construction of siRNA vectors; Principle and application of gene silencing;

Module VII

Gene knockouts and Gene Therapy: Creation of knock out *C. elegans*, *Arabidopsis* and mice; Disease model; Somatic and germ-line therapy- in vivo and ex-vivo; Suicide gene therapy; Gene replacement; Gene targeting;

Text/References:

1. S.B. Primrose, R.M. Twyman and R.W.Old; Principles of Gene Manipulation. 6th Edition, S.B.University Press, 2001.
2. J. Sambrook and D.W. Russel; Molecular Cloning: A Laboratory Manual, Vols 1-3, CSHL, 2001.
3. Brown TA, Genomes, 3rd ed. Garland Science 2006
4. Selected papers from scientific journals.
5. Technical Literature from Stratagene, Promega,

3. TBT 1005: Biophysics	**Unit 1**

Module I

Biophysical basics: Structure of Atom, Schrodinger's theory, Quantum numbers, Pauli's exclusion principle, Heisenberg uncertainty principle, Vander waals forces, Molecular orbital theories, Electro chemical cell, Brownian Motion.

Module II

Hydrodynamic and Bimolecular spectroscopy I: Centrifugation & Ultracentrifugation, Viscometry, Osmosis, Diffusion and Surface tension, Principle, Instrument Design, Methods & Applications of UV-Visible Spectra, IR Spectra, Raman Spectra, Fluorescence spectra, NMR and ESR Spectra., Linear and Circular Dichroism, Nuclear Magnetic Resonance Spectroscopy.

Module III

Diffraction Techniques and Bimolecular spectroscopy II: Crystals, Molecular crystal symmetry, Bragg's Law X ray diffraction by crystals. Principle, Instrument Design, Methods & Applications of Polarimetry, Refractometry, Flowcytometry, Cytophotometry, Raman spectroscopy, vibrational spectroscopy in biology, Mossbauer spectroscopy. Mass Spectrometry for Protein Identification.

Module IV
Microscopy: Compound, Phasecontrast, Fluorescence, Scanning & Transmission Electron Microscopy, CCD Camera, Introduction to Atomic Force Microscopy

Module V
Membrane Biophysics: Relation between membrane potential & cell characteristics, Zeta, Stern & total electrochemical potential, Helmholtz-Smoluchowski equation, Transmembranes potential & it's measurement by microelectrodes. Role of carriers in ion transport (ex: -Valinomycin & gramicidin), Transporting ATPase-Na-K ATPase.

Module VI
Neurobiophysics and Applications of Radioactivity: Synaptic transmission, Physicochemical basis of membrane potential, Resting and action potential, Propagation of action potential, Voltage clamp and patch-clamp techniques, Autoradiography, General principles, Types & constitutions of photographic emulsion.

Module VII
Electrophysiology and Nuclear Medicine: Principles of Electrocardiography, Heart- an electric potential sources, ECG waveforms, Standard lead systems, ECG preamplifiers, ECG readout devices, ECG machine, Measurements, Principles of Electroencephalography, Basic principles of Nuclear Medicine, Diagnostic use of Radioisotopes In-vivo & In-vitro procedures, (Single isotope, Double isotope methods).

Text Books

Reference Books

4. TBT NC 11: Data structure in C^{++} or **5. TBT NC 12: Biostatistics**	**Certificate course**

Syllabus should be provided later

6. TBT 1002: Lab I-Bioprocess Engineering Lab	**Unit 1**

Experiments based on the theory

7. TBT 1004: Lab II-rDNA Technology	**Unit 1**

Experiments based on the theory

Electives 1

8. TBT 1011: Animal Biotechnology	Unit 1

Module I

Techniques in animal tissue culture: Primary and secondary cell culture and maintenance; Embryonic fibroblast isolation and culture; stem cell isolation and cultures; measurement of cell viability/ toxicity, cell separation, development and, in vitro culture of oocytes/ embryo, cryopreservation and transport of germplasm; Embryonic and pluripotent stem cell culture and sorting;

Module II

Organ and histotypic cultures: cell synchronization, Bioreactors for tissue/ mass culture, design, characterization and recent development (scaling up animal cell culture; In Vitro fertilization and embryo transfer; Tissue engineering; Polyclonal and monoclonal antibody production; Organ Culture

Module III

Transgenesis: Gene propagation methods; Use of cloning and expression vectors, Adeno viral vectors and Baculoviruses; Genetically engineered proteins, vaccines, hormones etc. produced in the host; newly emerging transgenic tools.

Module IV

Medical Molecular Biology: Use of nucleic acid and antibodies as a specific probe in clinical diagnosis and tissue typing; custom made animals as different disease models comparable to human system; Gene therapy and its utilization; Protein and DNA vaccines; Production of Edible vaccines in plant system; synthetic DNAs; drug delivery. Cloning and xenotransplantation.; Gene mapping.

Module V

Animal and human genome projects: the human genome; goals of human genome projects; genetic linkage maps; polymorphic DNA markers; physical map; integrating genetic linkage and physical map; DNA sequencing; ethical, legal, and social implications. Use of molecular biology in forensic medicine RFLP and applications

Module VI

Ethical issues in animal biotechnology: Management aspects of biotechnology and genetic engineering. Discussion about current developments in animal biotechnology. Historical

perspectives, sterilization methods, organ culture - culture techniques, plasma clot, raft methods, agar gel, grid method, organ engineering. Cell culture substrates, cultural media, natural and artificial media, initiation and maintenance of cell cultures, cell culture products, cryopreservation techniques, in vitro fertilization and embryo transfer, Somatic cell hybridization, hybridoma technology.

Module VII

Animal genetic engineering: Chemical and electrochemical gene transfection methods - microinjection, viral and other methods of gene transfection; Production of transgenic animals with new traits using embryonic stem cell; Use conditional knockouts for the lethal genes; Use transgenic animals for producing important compounds required for pharmaceutical and therapeutic purposes; Bioethical issues related to animal biotechnology, Molecular markers.

Text & References:

***Text*:**

1. Animal Cell biotechnology: R.E. Spier and J.B. Griffiths (1988), Academic press.
2. Animal Biotechnology: Murray Moo-Young (1989), Pergamon Press, Oxford.

***References*:**

- Molecular Biotechnology: Primrose.
- Living resources for Biotechnology, Animal cells: A. Doyle, R. Hay and B.E. Kirsop (1990), Cambridge University Press, cambridge.
- Barnum's Biotechnology. D.C. Darling and S.J. Morgan,1994, Animal Cells Culture and media ,BIOS Scientific Publishers Limited.
- Jennie P. Mather and David Barnes, 1998, Methods in Cell Biology, Volume 57: Animal Cell Culture Methods Academic Press.

9. TBT 1013: Agricultural Biotechnology	Unit 1

Module I

Plant organ, tissue and cell culture: somaclonal variation and its use in crop improvement; embryo culture and its utility in hybridization programmes; anther culture, micro-propagation and its uses; artificial seeds; techniques of protoplast culture, regeneration and somatic cell hybridization, achievements and limitations, utility in improvement of crop plants; application in production of secondary metabolites and transformations, cryopreservation.

Module II

Plant Biotechnology: Elementary idea of theory and application of molecular techniques like centrifugation, spectrophotometry, HPLC/UPLC, MALDI-TOF, autoradiography, gel electrophoresis, Microarrays, PCR and its uses in genomics studies in plant

Module III

Development of various molecular markers: Restriction Fragment Length Polymorphism (RFLP); Random Amplification of DNA (RAPD); Simple Sequence Repeats (SSRs); Sequence Tagged Sites (STSs); Amplified Fragment Length Polymorphism (AFLP) and its variations (such as SAMPL, MFLP, etc.); Single Nucleotide Polymorphisms (SNP), DArT, RACE markers, etc.

Module IV

Application of molecular markers: Preparation of molecular maps (using F_2, DH, RILs); gene tagging using bulked segregation analysis (BSA) and near isogenic lines; QTL analysis; map-based cloning of genes; elementary idea of marker-assisted selection (MAS) in plant breeding Comparative genomics of crop plants, gene evolution

Module VI

Transgenic plants: Utility of transgenics in basic studies and in crop improvement (resistance for herbicides, viruses, insects and abiotic stresses; molecular farming for production of foreign proteins and edible vaccines; Use of antisense RNA and other technologies, biosafety issues including risks associated with transgenic crops; biosafety regulations.

Module VII

Stress Resistance Plant: Salt tolerance, freezing tolerances, chilling tolerance, and drought & food tolerance.

Text Books:

Transgenic Plant: Volume 1: Principles and Development by Kole, C.; Michler, C.; Abbott, A.G.; Hall, T.C. (Eds.) 1st Edition., 2010, XXII, ISBN: 978-3-642-04808-1

Transgenic Plants: Volume 2: Utilization and Biosafety by Kole, C.; Michler, C.; Abbott, A.G.; Hall, T.C. (Eds.) 1st Edition., 2010, XXII, ISBN: 978-3-642-04811-1

Plant Biotechnology and Transgenic Plants, K.M.O. Caldenty, W.H. Barz and H.L. Wills, Marcel Dekker

References:

Swaminathan, MS (1991). Biotechnology in Agriculture – A dialogue. MacMillan India, New Delhi.

Gupta, PK (2004). Biotechnology and Genomics. Rastogi Publications, Meerut

An Introduction to Plant Tissue Culture, M.K. Razdan, Oxford and IBH Publishing

Experiments in Plant Tissue Culture, J.H. Dodds and L.K. Roberts, Cambridge University Press
Plant Biotechnology, J. Hammond, P. McGarvy and V. Yusibov, Springer Verlag.

Plant Tissue Culture: Theory & Practice, S.S. Bhojwani and M.K. Razdan, Elsevier Health Sciences

10. TBT 1015: Pharmaceutical Biotechnology	**Unit 1**

Module I
Introduction and history of pharmaceutical Biotechnology: Scope of biotechnology in pharmacy and medical sectors, Enzymes and immobilized enzymes in therapy and diagnosis, fermentation and biological products in medical sector.

Module II
Genomics and its impact on medicine: Rational drug design processes-introduction to QSAR, 3-D QSAR; genetic counseling and gene testing; cancer- oncogenes, tumor suppressor genes and growth factors.

Module III
Pharmacogenomics: Hereditary disorders, Single nucleotide polymorphism (SNP) and its application in molecular medicine and personal medicine, Pharmacogenomics based approaches for cancer, diabetes, hypertension and Alzheimer's disease, etc.

Module IV
Gene therapy: Principles, methods and applications of gene therapy, viral, non-viral systems for gene therapy, gene therapy case studies – cancer, inborn errors and hematopoietic disorders.

Module V
Genetically engineered pharmaceuticals: Concept and method for production of r-therapeutics with reference to insulin, growth hormone, hematopoietic growth factors, hepatitis B vaccine and interferon.

Module VI
Diagnostic biotechnology: Principles of monoclonal antibodies production, design and development of ELISA kit, monoclonal antibodies in disease detection and treatment, role of PCR in microbial, plant and animal cell/virus detection.

Module VII

Pharmaceutical Industry: Layout, GMP (Good Manufacturing Practices), Introduction to various dosage forms, Stability of the prepared products, concept of expiry date, Pharmaceutical Products and Ethical Issues.

Text Books:

1. Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, Oliver Kayser, Rainer H. Miller, Wiley Interscience, March 2004
2. Pharmaceutical Biotechnology by S.P. Vyas, V.K.Dixit, 1st ed,CBS Publishers & Distributors, New Delhi, 1998
3. Pharmaceutical Biotechnology by Daan J.A. Crommilin & Robert D. Sindelar (edts.) Routledge, Taylor & Francis group, London 2002

***References Books*:**

1. Biotechnology and Biopharmaceuticals by Rodney J.Y. Ho and Milo Gibaldi, Wiley Liss Sons Inc. publications, New Jersey.Controlled Release Veterinary Drug Delivery M.J. Rathbone & R. Gurny**,** Elsevier JUL-2000
2. Controlled and Novel Drug Delivery Marcel Dekker, Robinson, J.R. & Lee, V.H.I.,: New York and Basel.
3. Pharmaceutical Management by Smith
4. Establishment of a pharmaceutical factory by Aganil
5. Dispensing for Pharmaceutical students by Cooper and Gunn's
6. The Science and Practice of Pharmacy by Remington
7. The Theory and Practice of Industrial Pharmacy by Lachman, Lieberman & Kanig

11. TBT 1017: Protein Engineering	**Unit 1**

Module 1

Protein: general introduction, forces that determine protein structure and physicochemical properties. Mechanisms of protein folding, molten globule structure, characterization of folding pathways.

Module II

Determination of protein structure: various spectroscopic techniques for protein structure determination. Background and basic principles, Absorption and Fluorescence, Circular Dichroism, FT-Raman, FT-IR, NMR, X-ray crystallography, MALLS.

Module III

Thermal properties of proteins: application of DSC. Protein denaturation, aggregation and gelation. Flow properties of proteins and sensory properties of proteinaceous foods.

Module IV

Protein functionality. Protein raw materials- cereals, legume, oil seeds and pseudo cereals. Muscle protein, Milk protein, Egg protein.

Module V
Protein modification as result of technological processes: thermal, enzymatic, physical, pressure, solvents, interactions.

Module VI
Nutritive role of food proteins.

Module VII
Design and construction of novel proteins and enzymes. Site directed mutagenesis for specific protein function, Basic concepts for design of a new protein/enzyme molecule, Specific examples of enzyme engineering.

Text & Reference Books:

1. Carl, Branden and Tooze, John. Introduction to Protein Structure, Garland Publishing (Taylor and Francis Group). New York.
2. Yada, R. Y.; Jackman, R. L.; Smith, J. L. Protein Structure-Function Relationships Blakie Academic and Professional: London
3. Clark, R. J. H and Hester, R. E. Spectroscopy of Biological Systems, John Wiley and Sons, New York
4. Nakai, S. and Modler, H. W. Food Proteins: Properties and Characterization, VCH Publishers, New York.

Elective 2

12. TBT 1021: Immunotechnology	Unit 1

Module I
Immune System: Immunodefficiency Conditions, Lymphocyte Traffic, Innate and adoptive immune response in protection

Module II
Autigen and antibody molecules: Antigen engineering for better immunogericty, Use for vaccine development, Antibody engineering, Antibody for diagnosis, Antibody for therapy

Module III
Theoretical basis of immunotechniques, antigen-antibody interaction, mathematical laws and deviation.

Module IV
Precipitation based techniques: immunodiffusion, immunoelectrophoresis, Rocket immunoelectrophoresis. Agglutination based techniques, dope testing, pregnancy testing and blood typing

Module V

General techniques: Western Blotting, ELISA, ELISPOT, FACS, Skin test, HLA typing, immunophenotyping, immunohistochemistry, immunoelectromicroscopy, immunofluorescence

Module VI
Molecular diagnostics: PCR based, microarray, FISH, comet assay, polymorphism studies

Module VII
Autoradiography, X-ray, PET, MRI

Books:

13. TBT 1023: Nanobiotechnology	**Unit 1**

Module I
Functional Principles of Nanobiotechnology: From Biotechnology to Nanobiotechnology. What is Nanobiotechnology? Information-Driven Nanoassembly, Energetics, Topdown and bottom up approach for building nanomaterials, Chemical Transformation
Biomaterials, Machine-Phase Nanobiotechnology

Module II
Structural Principles of Nanobiotechnology
Construction of Nanomachines, The Raw Materials: Biomolecular Structure and Stability, Protein Folding, Self-Assembly, Self-Organization, Molecular Recognition, Atomicity limits the tolerance of combining sites, Flexibility, Flexibility poses great challenges for the design of , nanobiomachines

Module III
Nanobiomachines in Action: The Unfamiliar World of Nanobiomachines, Modern nano biomachine using different molecular motors, Biomaterials created by nano particle, Biomaterial supplementing important human body part, Guided Tour of Natural Nanobiomachinery

Module IV
Biosensors as Precursors of Bioelectronics, Functionalization of Sensing Substrates, Biochip, Nanosensors-Miniaturization of Biosensors, Nanomaterial Based Biosensors. Electron Transfer of Biomolecules, Nanoparticle-Biomaterial Hybrid Systems for Sensing and Electronic Devices, Effect Biosensor in biological and physicochemical techniques

Module V
DNA Templated Electronics, Sequence –specific molecular lithography, Single Biomolecule Manipulation for Bioelectronics, DNA as a semiconductor.

Module VI
Applications of nanobiotechnology in early medical diagnostics, drug targeting, drug delivery, nanosurgery and other biomedical field.

Module VII

The Future of Nanobiotechnology: A Timetable for Nanobiotechnology, Lessons for Molecular Nanotechnology, Case Studies: Nanotube synthesis; A general nanoscale assembler, Nanosurveillance. Ethical Considerations. Respect for life, Potential dangers.

Books:

14. TBT 1025: Metabolic Engineering	Unit 1

Module I

Molecular Biology and Cellular Metabolism: Overview of molecular biology and cellular metabolism, Different models for cellular reactions, Metabolic regulation network at enzyme level and whole cell level.

Module II

Basic concepts of Metabolic Engineering: Identification of metabolic regulation is a key point in metabolic engineering. Overview of cellular metabolism, Different models for cellular reactions, induction – Jacob Monod model and its regulation, Differential regulation by isoenzymes, Feed back regulation.

Module III

Modeling of metabolic networks: Stoichiometry, kinetics, mass balances for the steady state, mass balances for the transient case

Module IV

Metabolic flux analysis: Linear programming, Cell Capability Analysis, Genome Scale, isotope labeling, Integration of anabolism and catabolism. Experimental determination method of flux distribution, Metabolic flux analysis and its applications, Thermodynamics of cellular processes

Module V

Metabolic control analysis: nonlinear programming, Synthesis and design of metabolic networks - integer programming, - mixed-integer nonlinear programming Case studies - ethanol production, amino acid biosynthesis, metabolism in bacteria and yeast.

Module VI

Metabolic engineering with Bioinformatics: Metabolic pathway modeling, Analysis of metabolic control and the structure, metabolic networks, Metabolic pathway synthesis algorithms.

Module VII

Applications of Metabolic Enginerring: Application in pharmaceuticals, chemical bioprocess, food technology, agriculture, environmental bioremediation and biomass conversion.

Text & References:

***Text*:**

1. Metabolic Engineering: Principles and Methodologies. Edited by G. Stephanopoulos, A.A. Aristidou, J. sNeilson. (1998) Academic Press, San Diego, CA.
2. Metabolic Engineering Edited by S. Y. Lee & E.T. Papoutsakis (1999) Marcel Dekker, New York, pp.423.

***References*:**

- Biochemistry by J. M. Berg, J. L. Tymoczko and Lubert Stryer (2002) Fifth Edition, W.H. Freeman, New York.
- Understanding the Control of Metabolism by David Fell (1997) Portland Press, London,.
- Metabolism at a Glance by J. G Salway (1994) Blackwell Scientific Publications, Oxford,.
- Systems Biology: Properties of Reconstructed Networks. B. O. Palsson, Cambridge University Press, 2006.
- Modeling Metabolism with Mathematica. P. J. Mulquiney and P. W. Kuchel, CRC Press, 2003.
- Pathway Analysis and Optimization in Metabolic Engineering. N. V. Torres and E. O. Voit, Cambridge University Press, 2002.
- The Regulation of Cellular Systems. R. Heinrich and S. Schuster, Chapman & Hall, 1996.
- Metabolic network reconstruction: Nature Reviews Genetics (2006) 7:130-141.
- Metabolic modelling approaches: Journal of Biotechnology (2002) 94: 37-63, Biotechnology and Bioengineering (2003) 84: 763-772
- Flux Balance Analysis: Current Opinion in Biotechnology (2003) 14: 491-496., Nature Reviews Microbiology (2004) 2: 886-897

15. TBT 1027: Reaction Engineering	**Unit 1**

Module 1

Kinetics of homogeneous reactions: classification of reactions, reaction rate, speed of reaction, rate equation, concentration-dependent term of rate equation, rate constant, order and molecularity, representation of elementary and nonelementary reactions, kinetic models for nonelementary reactions, temperature-dependent term of a rate equation, activation energy and temperature dependency.

Module II

Kinetic analysis of batch reactor data: Integral and differential methods for analyzing kinetic data, interpretation of constant volume batch reactor, data for zero, first, second and third order reactions, half life period, irreversible reaction in parallel and series, auto catalytic reaction.

Module III
Kinetic interpretation of batch reactor data for single reactions: interpretation of variable volume batch reaction data for zero, first and second order reactions, Ideal batch reactor, steady state CSTR and plug flow reactors and their use for kinetic interpretation.

Module IV
Design for single reaction: size comparison of single reactors, plug flow reaction in series and/or parallel, equal and different size of mixed reactor in series, finding the best system for given conversion, recycle reactor, Design of multiple reactions in batch, CSTR and PFR,

Module V
Energy balance equations: equations for batch, CSTR and PFR and their application to the design of reactors, concepts of non-ideality, residence time distribution of fluids in vessels, models for non-ideal flow.

Module VI
Reaction catalyzed by solids: introduction to heterogeneous reactions, rate equation for surface kinetics, pore diffusion resistance combined with surface kinetics, porous catalyst particles, performance equations for reactors containing porous catalyst particles, experimental methods for finding rates, advantages and disadvantages of packed bed and fluidized bed catalytic reactors.

Module VII
Biochemical reaction systems: enzyme fermentation, Michaelish-Menten kinetics, inhibition by foreign substances, kinetics of competitive and noncompetitive inhibitions, microbial fermentation, batch fermentor and mixed flow fermentor, kinetic expressions of fermentation.

Books Recommended:
1. Levenspiel, O. Chemical Reaction Engineering Ed.3, John Wiley & Sons (Asia)
2. Smith, Chemical Engineering Kinetics.
3. Foggler, Elements of Chemical Reaction Engineering

SEMESTER 2

16. TBT 2001: Bioprocess Plant Design	Unit 1

Module I
Introduction; general design information; Mass and energy balance;

Module II
General information of Piping and instrumentation for Bioprocessing; Materials of construction for bioprocess plants; Mechanical design of process equipment;

Module III

Vessels for biotechnology application; Design of fermenters; Design considerations for maintaining sterility of process streams processing equipment;

Module IV
Selection and specification of equipment for handling fluids and solids; Selection, specification, design of heat and mass transfer equipment used in bioprocess industries;

Module V
Design of facilities for cleaning of process equipment used in biochemical industries;

Module VI
Utilities of biotechnology production plants; Process economics; Bioprocess validation; Safety considerations;

Module VII
Case studies.

Text & References:

***Text*:**

- Plant Design and Economics for Chemical Engineers, M. Peters and K. Timmerhaus, McGraw-Hill.
- Applied Process Design for Chemical and Petrochemical Plants, E.E. Ludwig, Butterworth-Heinemann.

***References*:**

1. Chemical Engineering, R.K. Sinnott, J.M. Coulson and J.F. Richardsons, Butterworth-Heinemann
2. Chemical Engineers Handbook, R.H. Perry and D.W. Green, McGraw-Hill
3. Manufacturing Facilities Design and Material Handling, F.E. Meyers and M.P. Stephens, Prentice Hall
4. Process Plant Layout and Piping Design, E. Bausbacher and R. Hunt, Prentice Hall PTR.
5. Fundamentals of Chemical Engineering, Bezer Bencho
6. Fermentation and Biochemical Engineering Handbook: Principles, process design and equipment, H. C.
7. Vogel,C.L. Todaro, C.C. Todaro, Hoyes data corporation/ Hoyes publications.

17. TBT 2003: Downstream Processing	**Unit 1**

Module I
Characteristics of bioproducts; Coagulation, Flocculation and conditioning of broth.

Module II

Mechanical separation; Cell disruption techniques

Module III
Protein precipitation and separation

Module IV
Aqueous- two- phase extraction , Adsorption-desorption processes

Module V
Chromatographic methods of separation based on size, charge, hydrophobic interactions and biological affinity

Module VI
Membrane based separation; Dialysis, Electrodialysis; Micro filtration, Ultra filtration; Electrophoresis

Module VII
Crystallization; Drying

Texts/References:

1. E L V Harris and S. Angal, Protein Purification Methods, Ed. IRL Press at Oxford University Press, 1989.
2. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, Wiley-Interscience Publication, 1988.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, Mc-Graw Hill, Inc., 1986.
4. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.

18. TBT 205: IPR, Biosafety & Bioethics	**Unit 1**

Module I
Introduction to Intellectual Property: Types of IP: Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies

Module II
Agreements and Treaties: History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments

Module III
Basics of Patents and Concept of Prior Art: Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases;

Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)

Module IV

Patent filing procedures: National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting–disclosure/non-disclosure; Financial assistance for patenting-introduction to existing schemes, Patent licensing and agreement Patent infringement- meaning, scope, litigation, case studies

Module V

Biosafety: Introduction; Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals;

Module VI

Biosafety guidelines: Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including; Cartegana Protocol.

Module VII

Bioethics: Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

Texts/References:

1. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
2. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007

Important Links:

http://www.w3.org/IPR/
http://www.wipo.int/portal/index.html.en
http://www.ipr.co.uk/IP_conventions/patent_cooperation_treaty.html
www.patentoffice.nic.in
www.iprlawindia.org/ - 31k - Cached - Similar page
http://www.cbd.int/biosafety/background.shtml
http://www.cdc.gov/OD/ohs/symp5/jyrtext.htm
http://web.princeton.edu/sites/ehs/biosafety/biosafetypage/section3.html

19. TBT NC 21: Bioentrepreneurship	**Certificate course**

Module I

Fundamentals of Marketing

Module II
The marketing and selling of Biotechnology, Creating and marketing the image of the biotechnology company, Effective advertising and marketing..

Module III
Power and importance of Positioning of a company name and product.

Module V
The Art of Negotiation, Workable marketing and the strength of distribution.

Module VI
Opportunities in international marketing and lessons to be learned.

Module VII
Steps involved in commercialization of a biotechnological product. Case studies.

Text & References:

***Text*:**

1. Positioning by All Rise and Jack Trout (1986), Warner Books

***References*:**

- Six Sigma for Innovation and Growth Series, Prentice Hall
- Innovation, Product Development and Commercialization: Case Studies and Key Practices for Market
- Leadership By Dariush Rafinejad, JRoss Publishing: ISBN: 978-1-932159-70-7, June 2007
- Science Business: The Promise, the Reality, and the Future of Biotech by Gary P. Pisano Harva rd Business School Press: 2006.
- Design and Marketing of New Products by Urban and Hauser, ISBN 0-13-201567-6
- Mind to Market: A Global Analysis of University Biotechnology Transfer and Commercialization, sSeptember 2006 by the Milken Institute.
- Putting Biotechnology to Work: Bioprocess Engineering (1992) Commission on Life Sciences The national academy press

20. TBT 2002: Lab III- Bioprocess Plant Design	**Unit 1**

Experiments and exercise based on the theory

21. TBT 2004: Lab IV-Downstream Processing	**Unit 1**

Experiments based on the theory

Elective 3

22. TBT 2011: Computational Biology	Unit 1

Module 1

Unix environments: Overview of File System Hierarchy Standard (FHS), Unix basic commands, text-editor, setting up compiler environment, Linux Command line Installation of tools, Using libraries- GNU scientific library (GSL).

Module II

Basics in C: Types, Operators, Expressions, Control Flow, Functions, Pointers and Arrays, Structures, Input and Output, Headers and libraries, Tricks.

Module III

Algorithms: Introduction, Recursion, Sorting, Searching, Complexity of algorithms: worst case, average case and amortized complexity, Algorithm analysis, Algorithm Design Paradigms, Big-O and Theta notations.

Module IV

Data Structure: Arrays, Linked lists, Stacks (example: expression evaluation) and Queues. Binary search trees, Red-Black trees, Hash tables.

Module V:

Perl basics: text handling- regular expression, Application of perl to Bio-sequence analysis. Bioperl: Introduction, Objects and Classes and Applications: Sequences Alignments

Module VI

Biological sequence analysis: Sequence Alignment, Scoring matrices, PAM and BLOSUM, Local and Global alignment concepts, dynamic programming methodology: Needleman - Wunsch algorithm, Smith – Waterman algorithm, BLAST and FASTA, Statistical significance of BLAST hits., Multiple Sequence alignment, Progressive alignment, Heuristic methods for database searching, Methods for Phylogenetic estimation: Maximum parsimony, Distance Matrix Methods and Maximum Likelihood Methods.

Module VII

Structure prediction: Introduction to Protein Structure, Protein Secondary Structure prediction methods: Statistical methods of Chou and Fasman, Garnier-Osguthorpe-Robson, Fold Recognition and threading methods, Comparative modeling of proteins: Template Selection, Backbone modeling, loop building (search/generation), side chain generation and model evaluation and validation), Molecular Dynamics and Simulation: Energy minimization techniques, Molecular Dynamics simulations, Monte Carlo Simulations, Molecular visualization and graphics. Solvent accessible surfaces

Textbook:

1. Brian W. Kernighan and Rob Pike, The UNIX Programming Environment, Pearson Education (Indian reprint, 2003) ISBN: 81-297-0074-3.
2. Kernighan, Brian W. and Dennis M. Ritchie. 1988. The C Programming Language. 2nd ed. Prentice Hall PTR.
3. T.H. Cormen, C.E. Leiserson, and R.L. Rivest, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990
4. James Tisdall, Beginning Perl for Bioinformatics:An Introduction to Perl for Biologists, O'Reilly Media
5. James L. Antonakos and Kenneth C. Mansfield, Practical Data Structures Using C/C++, Prentice Hall (1999) ISBN: 01-302-6864-X.
6. David W. Mount (2001) Bioinformatics: Sequence and Genome Analysis. Cold Spring harbor Press
7. A.R.Leach: Molecular Modelling. Longman Singapore Publishers 1996

23. TBT 2013: Environmental Biotechnology	**Unit 1**

Module I:

Principles and Concepts of Environment: Ecosystem: types, characteristics, structure and function. Concept of biosphere. Food chains, food webs and trophic structures. Ecological pyramids, Biodiversity and its conservation strategies: global scenario, Natural resources, Current status of major resources. Population ecology.

Module II:

Environmental Pollution and Current Environmental Issues: Environmental Pollution and its impacts, Global warming and greenhouse effect, Global Ozone Problem, Acid rain, Land degradation, Biomagnification.

Module III:

Waste Water management: Need for water management, Conventional and advanced treatment technology, methanogenesis, methanogenic, acetogenic, and fermentative bacteria, emerging biotechnological processes in waste water treatment, Eutrophication, Effects of eutrophication on the quality of water environment, factors influencing eutrophication. Algae in eutrophication, algal blooms, Physico-chemical and biological measures to control.

Module IV

Solid waste management: Industrial solid waste; Domestic solid waste; Agricultural solid waste; Municipal solid waste; Effects of solid waste generation on quality of air, water and public health; Technical approach for solid waste management; Disposal of organic and medical waste; Recovery and recycling of metallic waste; Disposal of plastic waste and hazardous wastes: source management and safety.

Module V:
Environment protection through Biotechnology: Biodegradation and bioremediation of pollutants, Biomineralization, Biofertilizers, Biopesticides and Vermicomposting, degradative plasmids, release of genetically engineered microbes in environment.

Module VI
Biomass energy and biofuels: Production of Biodiesel: components and operation of a biodiesel processing system, production of Bioethanol, Bioelectricity: microbial fuel cells, factor affecting the current generation, Direct biomass combustion and co-firing technologies

Module VII:
Environmental Quality Assessment and Protection Acts: Environmental Protection standards in India, Environmental impact assessment, Environmental Legislations: National and international status, Environmental Planning for sustainable development, Kyoto protocol, Copenhagen summit 2010.

Text & References:
***Text*:**

- Fundamentals of ecology: M. C. Dash, TMH Publication
- Text Book of Environmental Biotechnology, Pradipta Kumar Mohapatra

***References*:**

- Ecology, Odum
- Environmental Chemistry, AK De
- Environmental Biotechnology, BD Singh
- Wastewater Engineering, Metcalf and Reddy
- Bioremediation Protocols, Sheham
- Biotechnology of Biofertilizers, Kannaiyan
- Manual of Environmental Microbiology, Hurstetc
- Environmental Microbiology: W.D. Grant & P.E. Long, Blakie, Glassgow and London.
- Biotreatment Systems, Vol. 22, D. L. Wise (Ed.), CRC Press, INC.
- Standard Methods for the Examination of Water and Waste Water (14 th Education),
- 1985. American Public health Association.

24. TBT 2015: Biosensor and Bioelectronics	**Unit 1**

Syllabus will be provided later

25. TBT 2017: Biospectroscopy and Image Analysis	**Unit 1**

Syllabus will be provided later

Elective 4
To be offer and decide by other department for this programme.