Savitribai Phule Pune University
(Formerly University of Pune)

Department of Technology
Board of Studies, Chemical & Biotechnology (CB)
Curriculum Structure for M.Tech Program

Sr. No.	Subject Code	Subject Name	Credits	Teaching Scheme (Theory)	Teaching Scheme (Lab)
Semester (I)					
1	MMaths	Mathematics for Technology	3	√	
2	CBC2	Reaction Engineering	3	√	
3	CBC3	Applied Biology	3	√	
4	CBE4	Advanced Separation Process	3	√	
5	CBE*	Elective-1 (Cancer Genomics)	3	√	
6	CBLP1	Lab Practice - 1	3		√
7	CBSM1	Seminar - 1	1		√
Semester (II)					
8	CBC5	Bioprocess Technology	3	√	
9	CBC6	Advanced Modeling Techniques	3	√	
10	CBC7	Advanced Analytical Techniques	3	√	
11	CBE8	Advanced Genetic Engineering	3	√	
12	CBE*	Elective-2	3	√	
13	CBLP2	Lab Practice - 2	3		√
14	CBSM2	Seminar - 2	1		√
Semester (III)					
15	TSD	Technical Skill Development	3	√	
16	CBE*	Elective-3	3	√	
17	CBIntProj	Interim Project	10		√
Semester (IV)					
18	CBFinProj	Final Project (Dissertation Submission)	16		√
		TOTAL CREDITS	70		

AUDIT COURSES				
Sr. No.	**Subject Code**	**Subject Name**	**Credits**	**Semester**
1	CYSA	Cyber Security	2	I
2	HRE101	Human Rights & Duties	1	I
3	HRE102/HRE103	Human Rights & Vulnerable Groups/Law Policy , Society & Enforcement mechanism	1	II

Notes:

1) Electives can also be Open Electives in spirit of CBCS.

2) Maximum 25% Open Electives are allowed.

3) Candidates are expected to perform minimum three (3) assignments for every Lab Practice, and submit report as a bona fide document to supervisor/course instructor. The assignment may be in the form of modeling/ simulation/ programming/ experimental investigation/ fieldwork

4) The candidates are expected to select three electives from the list provided in Table(s) in this document

LIST OF ELECTIVES FOR BOARD OF CHEMICAL AND BIOTECHNOLOGY

Sr. No.	Subject Code	Subject Name
1	CBE1	Fermentation Technology
2	CBE2	Advanced Biomaterials
3	CBE3	Genomics and Proteomics
4	CBE4	Advanced Downstream Processing
5	CBE5	Biofuel and Bioenergy
6	CBE6	Advanced Genetic Engineering
7	CBE7	Nutrition and Food Processing
8	CBE8	Herbal Drug Technology
9	CBE9	Enzyme Technology
10	CBE10	Alcohol and Brewery Technology
11	CBE11	Stem cell and Cancer Biology
12	CBE12	Advanced Bioinformatics
13	CBE13	Metabolic Engineering
14	CBE14	Structural Biology
15	CBE15	Nanotechnology
16	CBE16	Intellectual Property Rights and Bioethics
17	CBE17	Advanced Analytical Techniques
18	CBE18	Instrumentation and Process Control
19	CBE19	Thermodynamics
20	CBE20	Strain Development
21	CBE21	Advanced Bioseparations
22	CBE22	Advanced immunology

23	CBE23	Agricultural Biotechnology
24	CBE24	Biocatalysis and Green Technology
25	CBE25	Environmental Biotechnology
26	CBE26	Process Modeling and Simulation
27	CBE27	Virology
28	CBE28	Biopharmaceutical Technology
29	CBE29	Chemoinformatics
30	CBE30	Advanced Transport phenomena
31	CBE 31	Plant Tissue Culture Technology
32	CBE32	Advanced Thermofluids I
33	CBE33	Advanced Thermofluids II
34	CBDS50	Proteomics Technology
35	CBDS53	Dental Materials and Its Applications
36	CBDS52	Polymer Blends and Composites
37	CBE34	Bioadsorption
38	CBDS51	Application of Intelligent Systems in Metabolic Process Modelling
39	CBE35	Phytochemicals Extraction and Purification
40	CBE36	Vaccine Development and Manufacturing
41	CBE37	Alcohol and Brewery Technology
42	CBE38	Microbial Growth Kinetics and Reactor Models
43	CBE39	Thick Film Technology
44	CBE40	Advanced Statistics
45	CBE41	Advance Coating Technology
46	CBE42	Cancer Genomics

47	CBE43	Advanced Separation Process
48	CBE44	Introduction to Enzymes and Fermentation Technology
49	CBE45	One Carbon Metabolism and Epigenetics
50	CBE46	Optimization Techniques
51	CBOE1	Integrative Health and Complementary Medicines
52	CBOE42	Cancer Genomics
53	CBDS1	Biosensors
54	CBDS2	Fermentation and Bioprocess
55	CBDS3	Biotechnology for Ethanol Production

Programme Outcomes

Programme issues are narrower checks that describe what the scholars are hoped to undergo and be qualified to do upon the scale. They relate the knowledge, chops and geste the scholars develop through the Programme. The Programme issues(PO) are specific to the Programme and are harmonious with the Graduate Attributes and grease the attainment of PEOs.

At the end of the Programme the Students shall be suitable to

Program Learning Outcomes:

1. Apply Technological knowledge
2. Identify and Analyse knowledge to solve branch specific problems
3. Carryout independent study of design and development work to break practical problems.
4. Ability to conduct experiments, Demonstrate a degree of mastery in Materials, design and thermal at a position advanced than the Bachelor's Programme.
5. Develop algorithms using commercial and open source tools and breakthrough the ways in mechanical with optimal results.
6. Societal needs, environment concerns and sustainable developments
7. Individual task and Team work
8. Engage in lifelong literacy clinging to professional, ethical, legal, safety, environmental and societal aspects for career excellence.

S.P.Pune University

Department of Technology

SYLLABUS FOR MTech- Integrated MTech-PhD (Chemical and Biotechnology)

MATHEMATICS FOR TECHNOLOGY (COMPUTATIONAL METHODS)

Unit 1: Numerical Differentiation I:

Partial differential equation Laplace and Poisson's equation-solution, method of characteristics for solution of initial boundary value problems, relaxation method

Unit 2: Numerical Differentiation II:

Finite Difference, Gaussian elimination and Gauss, Jordan methods, matrix inversion, Gauss Seidel method –Newton- Raphson method

Unit 3: Statistics and Probability:

Moments, Skewness and Kurtosis, Probability, conditional probability, various theoretical distributions like binomial, normal, log-normal, Poisson, gamma distribution, Pearson type I, II & II distribution test of significance, Gumbel distribution, testing of hypotheses – Large sample tests for mean and proportion, Chi-square test, errors, types of errors.

Unit 4: Regression and Correlation:

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design

Unit 5: Transforms:

Laplace Transformer: LT of standard function, inversions and their application in civil engg. Fourier Transformer: Fourier integral, Fourier transform and their application in civil engg.

Unit 6: Matrix method and Finite element:

Matrix method analysis (Stiffness) co ordinate calculation for different types of structure.Finite element method basics (1D and 2D) co ordinate calculations.

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of system of linear equations

- Identify the special properties of a matrix such as the eigen value, eigen vector, employ orthogonal transformations to express the matrix into diagonal form, quadratic form and canonical form

- Equip themselves familiar with the functions of several variables and mean value theorems

- Familiarize with special functions to evaluate some proper and improper integrals using beta and gamma functions

Reference Books

1. Higher Engineering Mathematics by B. S. Grewal (Khanna Publication, Delhi).

2. Venkatraman, M.K., Numerical Methods in Science and Engineering, National Publisher Company.

3. Shanthakumar M.S., Numerical Methods & Analysis

5. Gupta, S.C. and Kapur, V.K., "Fundamentals of Mathematical Statistics ", Sultan Chand & Sons, New Delhi, 1999.

Reaction Engineering

Multiple Reactions: Parallel series, series, parallel reactions, calculation of yield and selectivity. Series Parallel Reaction Networks, Design principles, non isothermal reactions and temperature pressure effects.
Concepts of non ideal reactors, Concepts of residence time distribution, micro mixing and macro mixing. Problems on RTD.
Metabolic flux analysis, Concepts of structured model and introduction to cybernetic models.
Kinetics of Heterogeneous Reactions: Catalytic Reactions, Rate controlling steps**,** Langmuir-Hinshelwood model, Rideal-Eiley Mechanism, Steady State approximation.
Catalysis, Important characteristics of industrial catalysts, Catalyst Synthesis and Characterization.
Evaluation of kinetic parameters, Monods equation, death rate of cell, Sterilization Mechanisms and Kinetics of Enzyme Action: Mechanisms of Enzyme Action; Concept of active site and energetics of enzyme
Kinetics, substrate complex formation Specificity of enzyme action; estimation of Michaelis-Menten parameters, Importance of KM, Multi-substrate reaction mechanisms and kinetics.
Types of Inhibition kinetic models; Substrate and Product Inhibition Analysis of Film and Pore Diffusion Effects on kinetics of Immobilized Enzyme, Mass Transfer Effects in Immobilized Enzyme Systems, Immobilized System, different types of reactors used in biological transformations, key differences from conventional reactors.
Mass Transfer effects In Heterogeneous Reactions: Mass and heat Transfer coefficients in packed beds, Quantitative treatment of external transport effects, modeling diffusion with and

without reaction. Intra-pellet mass and heat transfer, Evaluation of effectiveness factor, mass and heat transfer with reaction.
Heterogeneous Catalytic Reactors. Introduction to multiphase reactor design, Two phase fluidized bed model, slurry reactor model, Trickle bed reactor model

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply reaction engineering principles for Chemical Industries and Biotech processes.
- Understand inherent metabolic pathways and their complex interaction for bio-systems
- Empower with the operational aspects of various reactors for better performance to achieve desired product distribution in most optimal manner.
- Familiarize with the conventional design aspects of the reactors
- Familiarize with the non-ideality aspects of the reactors and various Residence Distribution Functions
- Ability to scale up the process and translate lab-data to bigger scale.

References:

1. Rajiv Dutta, ***Fundamentals of Biochemical Engineering***, Springer, Berlin, 2008.
2. Pauline M. Doran, ***Bioprocess Engineering Principles***, Elsevier Science and Technology Books, New York, 1995.
3. Gilbert F. Froment and Kenneth B. Bischoff, ***Chemical Reactor Analysis and Design***, 2nd Edition, Jojn Wiley & Sons, New York, 1990.
4. Octave Levenspiel, ***Chemical Reaction Engineering***, 3rd Edition, John Wiley & Sons, New York, 1999
5. Diazo Kunii, and Octave Levenspiel, ***Fluidization Engineering***, 2nd Edition, Butterworth, Boston, MA, 1991.
6. James Smith, Chemical Kinetics, 3rd Edition, McGraw Hill, New York, 1981.
7. Charles N. Satterfield, ***Heterogeneous Catalysis in Industrial Practice***, McGraw-Hill, New York, 1991.
8. H. Scott Fogler, ***Elements of Chemical Reaction Engineering***, 4th Edition, Pearson, Prentice Hall of India, New Delhi, 2012.

Advanced Modeling Techniques

Introduction to modeling simulation, different types of models - Unstructured and structured models, Deterministic and stochastic models, Segregated and un segregated models, compartmental models. Continuity equation, Energy equation, equation of motion.

Phase and chemical equilibrium, chemical kinetics, Model building, application of mathematical modeling, scope of leverage.

Model adaption and checking, preparing the data, parameter determination, simplification, validation, calibration, optimization of models, analytical methods, and numerical methods.

Immobilized Enzymes: Effect of mass transfer resistances (external: Damkohler Number, Effectiveness Factor and internal :: Thiele Modulus etc.) Effective Diffusivities in gels

Genetic Engineering:Fermentation Kinetics of recombinant cultures, rates of growths of plasmid-carrying, plasmid-free cells, Stability of recombinant cells in CSTF, Enzyme Kinetics: Simple Enzyme Kinetics, Substrate Enzyme Kinetics, MichaelisMenten approach, Briggs-heldane (pseudo steady state) approach, Evaluation of MichaelisMenten parameters, Langmuir's plot, Linewear-Burk plot, Eadie-Hofstee Plot, Kinetics of Enzymatic hydrolysis of Cellulose, Batch, Plug Flow reactor, CSTR kinetics, Inhibition Of Enzyme Reactions : Noncompetitive Inhibitions, Effects of pH, Temperature, Shear; Introduction to metabolic pathway modeling.

Metabolic pathway modeling and signaling pathway to system biology, genetically structured models. Fermentation Kinetics of recombinant cultures, rates of growths of plasmid-carrying, plasmid-free cells, Stability of recombinant cells in CSTF. Immobilized Enzymes: Effect of mass transfer resistances. Kinetics of Enzymatic hydrolysis of Cellulose, Batch, Plug Flow reactor, CSTR kinetics. Inhibition Of Enzyme Reactions : Noncompetitive Inhibitions, Effects of pH, Temperature, Shear. Batch, CSTR, PFR, CSTF and PFF in series, Cell recycling in all above fermenters, Other Fermenters.

Agitation Equipment: Basic mass transfer modeling, mass transfer coefficients, Interfacial area measurement, Correlations for a, Da, Gas hold up, Power consumption, Oxygen absorption rate, correlation for kla, Scale up, Shear sensitive mixtures. Scope of modeling: All types of fermentations, Activated sludge process, Anaerobic digesters, All types of Enzymatic reactions, Cell Kinetics, Aerobic digesters.

Data driven models: Regression Analysis, Neural Networks, Sensitivity Analysis, Idea of Genetic Programming

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Understanding of various modelling strategies

- Development of mathematical expression for complex chemical and biological systems
- Equip graduates with simulation strategies and iterative process
- Familiarize with hands-on exposure to some of the commercial software
- Basic understanding of empirical modelling, various regression and artificial neural networks

References:

1. Katalin Hangos, Ian Cameron, ***Process Modeling and Model Analysis***, Academic Press, London, 2001.
2. Binay K. Dutta, ***Mathematical Methods in Chemical and Biological Engineering***, CRC Press, 2016.
3. Pauline M. Doran, ***Bioprocess Engineering Principles***, Elsevier Science and Technology Books, New York, 1995.
4. Rajiv Dutta, ***Fundamentals of Biochemical Engineering***, Springer, Berlin, 2008.
5. R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, ***Transport Phenomena***, 2nd Edition, John Wiley and Sons, 2002.
6. H. Scott Fogler, ***Elements of Chemical Reaction Engineering***, 4th Edition, Pearson, Prentice Hall of India, New Delhi, 2006.
7. Said Elnashaie and Frank Uhlig, ***Numerical Techniques for Chemical and Biological Engineers using MATLAB***, Springer, New York, 2007.

Advanced Separation Techniques

Introduction: Review of conventional processes, Recent advances in separation techniques based on size, surface properties, ionic properties and other special characteristics of substances, Process concept, Theory and equipment used in cross flow filtration, cross flow electro filtration, dual functional filter, Surface based solid - liquid separations involving a second liquid

Membrane Separation: Types and choice of membranes, Plate and frame, tubular, spiral wound and hollow fiber membrane reactors and their relative merits, Commercial, pilot plant and laboratory membranes permeators involving dialysis, reverse osmosis, Nanofiltration, ultrafiltration, Microfiltration and Donnan dialysis, Economics of membrane operations, Ceramic membranes.

Separation By Adsorption Techniques: Mechanism, Types and choice of adsorbents, Normal adsorption techniques, Affinity chromatography and immuno chromatography. Types of equipment and commercial processes, Recent advances and process economics.

Ionic Separations: Controlling factors, Applications, Types of equipment employed for electrophoresis, Di-electrophoresis, Ion exchange chromatography and electro dialysis, Commercial Processes.

Other Techniques: Separations involving Iyophilisation, Prevaporation and permeation techniques for solids, liquids and gases. Industrial viability and examples, Zone melting, Addluctive crystallization, Other separation process, Supercritical fluid extraction, Oil spill Management, Industrial effluent treatment by modern techniques.

Knowledge of mass transfer operations and mechanical operations. Objectives: i) Learn new techniques of separation ii) Learn possible cases of industrial application iii) Learn estimation of separation coefficient

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Understanding of various mass transfer operations
- Detailed understanding of membrane separation process
- Understanding of adsorption techniques
- Familiarize with various ionic separations
- Basic understanding of some of the advanced separation processes

References:

1. Lacey, R.E. and S.Loaeb " Industrial Processing with Membranes ", Wiley -Inter Science, New York, 1972.

2. King, C.J. " Separation Processes ", Tata McGraw - Hill Publishing Co., Ltd., 1982.

3. Schoew, H.M. - " New Chemical Engineering Separation Techniques ", Interscience Publishers, 1972.

4. Ronald W.Roussel - " Handbook of Separation Process Technology ", John Wiley, New York, 1987.

5. Kestory, R.E. - " Synthetic polymeric membrances ", Wiley, New York, 1987.

Advanced Analytical Techniques

Classification of instrumental analytical methods.

Lambert-Beer law and its analytical application.

Application of the atomic absorption (AAS) and atomic emission(EAS-ICP) spectroscopy for trace and ultra trace elements analysis.

UV-VIS molecular spectroscopy: analytical application of spectrophotometry and fluorescence spectroscopy.

FTIR and Raman spectroscopy, their application in biological system analysis.

Mass spectrometry – determination and structural analysis of organic compounds.

Potentiometry, ion selective electrodes.

Voltammetric methods.

Conductometry and conductometric titration.

Coulometric methods applied to industrial analysis and air pollution observation.

Separation and mixtures analysis by gas and liquid chromatography and capillary electophoresis.

Instrumental analytical methods: atomic absorption spectroscopy (AAS), atomic emissionspectroscopy (AES-ICP), flame emission spectroscopy, spectrophotometry, spectrofluorometry, IR spectroscopy, potentiometry, coulometry, voltammetric methods, conductometry, gas and liquid chromatography

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Understand the fundamentals and applications of various physicochemical methods of analysis Detailed understanding of membrane separation process
- Familiarize methods of samples preparation for analysis by help of various physicochemical methods
- Able to select suitable/appropriate methods of analysis taking into account specimen features and type/kind of analysis

- Able to perform quantitative and qualitative analysis and to analyze the results of these analysis

Reference Book:

1. D. A. Skoog, D. M. West, F. J. Holler, S.R. Crouch, Fundamentals of Analytical Chemistry, Thomson Brooks/Cole, 2004.

2. F. Rouessac, A. Rouessac, Chemical Analysis, Modern Instrumentation Methods and Techniques, John Wiley & SonsLtd, 2007.

3. K. Danser, Analytical Chemistry, Theoretical and Metrological Fundamentals, Springer, 2007.

4. R.M. Silverstein, F.X. Webster, D.J. Kiemle, Spectroscopic identification of organic compounds, John Wiley&Sons Ltd, 2005

Bioprocess Technology

Cell disruption methods: Chemical method (detergent, alkali), physical (Osmotic shock, grinding with abrasive, solid shear, liquid shear) and enzymatic lysis, the release of intracellular products Removal of insoluble and recovery of intracellular components: Flocculation and sedimentation, decanting, centrifugation and filtration methods Principles, operation, design and scale-up, Material balance and numerical examples of these processes; Extraction and Leaching Selection of solvent, Single stage extraction, multistage crosscurrent, countercurrent and co current extraction, Types of extractors – stage type and differential type Solid – Liquid Extraction (Leaching): Definition, Preparation of the solid, Factors affecting leaching operations, Methods of operation, Single stage leaching, Continuous counter current leaching, Constant and variable underflow, Leaching equipments, Calculation of single stage and multistage leaching processes

Adsorption and Ion Exchange: Types, Adsorption Isotherms - Langmuir, Freundlich, BET, Heat of adsorption, Pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA), Equipments for adsorption, Principles of Ion Exchange, Techniques and applications, Equilibria and rate of ion exchange; Chromatography –Separation Technique, Classification of chromatographic techniques, General description of column chromatography, chromatography column dynamics, Chromatographic terms and parameters, Practice of chromatography, HPLC; scale up of chromatography, planar chromatographic techniques, process consideration in preparative chromatography. Introduction to types of chromatography

Crystallization and drying: Crystallization, Principle rate of crystal growth, Population balance and size distribution, Calculations of yield, Enthalpy balances, Equipment Drying, Definition, Principles, Equilibrium in drying, Drying hysteresis, Types of moisture binding, Drying operations, Batch drying, Rate of batch drying, Rate of drying curve, Mechanism of batch drying, Mechanism of moisture movement in solid continuous drying, Time required for drying, Classification of drying equipments, Numerical relating drying

operations; Importance of separation techniques in biotechnology, its scope from research to industry, Synthesis of Bioseparations Processes, Process analysis, Process Economics, Illustrative Examples, Industrial applications with examples, Separation of bioconversion products/ secondary metabolites e.g. Steroids and antibiotics

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of system of linear equations
- Identify the special properties of a matrix such as the eigen value, eigen vector, employ orthogonal transformations to express the matrix into diagonal form, quadratic form and canonical form
- Equip themselves familiar with the functions of several variables and mean value theorems

Familiarize with special functions to evaluate some proper and improper integrals using beta and gamma functions

References

1. *Treybal R.E., Mass Transfer Operations –McGraw Hill*
2. *McCabe W.L. and Smith J.C., Unit Operations of Chemical Engineering, McGraw Hill*
3. *Belter, P.A. Cussler, E.L., and Hu, W.S. Bioseparation: Downstream processing for Biotechnology, Wiley, New York.*
4. *Coulson J.M. and |Richardson J.F., Chemical Engineering, Vol I & II –McGraw Hill*
5. *Foust A.S., Principles of Unit Operations in Chemical Engineering,*
6. *Smith B.D., Design of Equilibrium Stage Processes*

Applied Biology

History and scope of Microbiology, Introduction to microbial diversity, Unculturable and culturable bacteria. Classification of microorganisms, Haeckel's three kingdom concept, Whittaker's five kingdom concept, three domain concept of Carl Woese. Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Morphology, ultrastructure, components, appendages, shapes and arrangement of bacterial cell. Cell wall and cell membrane in archaebacteria, Gram positive and Gram negative eubacteria and eukaryotes. Morphology, physiology and diversity of bacterial spores. Cell division. Reserve food material. General

features and importance of algae, fungi and protozoa. Morphological diversity of cells, cell structures and thallus. Types of life cycle, Structure of cells and growth. Dormancy (spore diversity) and reproduction. Parasexuality, Microbial genetics

Diversity in microbial metabolism, Aerobic and anaerobic metabolism, Chemolithotrphy, chemoorganotrophy, photolithotrophs, etc. Sulfur, iron, hydrogen, nitrogen oxidations, Methanogenesis, Acetogens, Metabolism and fueling reactions. Brief account of photosynthetic and accessory pigments in prokaryotes-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, Xanthophylls, phycobilli proteins. Catabolic principles and breakdown of carbohydrates. lipids, Oxidative and substrate level phosphorylation. Fermentation of carbohydrates. Homo- and heterolactic fermentations. Respiratory metabolism, Embden Mayer Hoff pathway, Entner Doudoroff pathway, Glyoxylate pathway, Kreb's cycle. Reverse TCA cycle. Gluconeogenesis, Pasteur effect, ETC Electron carriers, Artificial electron donors, Inhibitors, Uncouplers

Nitrogen fixation, Genes involved in nitrogen fixation and their regulation, Assimilation of nitrogen, dinitrogen, nitrate nitrogen, ammonia, synthesis of major amino acids, Polyamines, Synthesis of polysaccharides, Biofertilizers: Production technology and storage methods for Rhizobium, Azotobacter, Azospirillum, Cyanobacteria , Azolla, PSM, Cellulolytes, VAM and PGPR. Biopesticides: Organisms, their targets, ideal candidates, biology of commercialized biopesticides. Chemistry of biocidal component, effect on target pests, Production technology and storage methods for Bacillus thuringiensis and Baculovirus

Microbial growth, continuous and batch cultures, Industrial production of lactic acid, citric acid, enzymes viz. Proteases, amylases, cellulases, Acetic acid, Production and diversification of antibodies, Steroid conversions and their industrial applications. Biogums, Bioplastics, Biochips, Biosensors, Nanotechnology, DNA structure: Watson- Crick model, A,B, Z structures, physicochemical properties, DNA supercoiling and packaging in eukaryotes, Euchromatin, heterochromatin, UV absorption, thermal denaturation, Tm, hyperchromicity, nucleic acids in mitochondria, chloroplasts, viruses and bacteria,DNA replication, semiconservative replication model, rolling circle model, enzymes in replication , gyrases etc. repair enzymes, DNA unwinding, recombination, telomeres, telomerases, RNA types, RNA types, tRNA, mRNA, rRNA structural features, introns and exons, RNA splicing, ribozyme, post-transcriptional modifications, inhibitors of transcription, reverse transcriptase, Transcription, structure of gene, regulation of gene expression, operon concept (lac, trp, his operon), repression, promoters, enhancers, silencers Genetic code, Protein biosynthesis, translation, factors required for translation, inhibitors, regulation, post-translational modifications, protein synthesis in prokaryots and eukaryotes. Introduction to recombinant DNA technology, Restriction enzymes, Vectors used-plasmids, phagemids, phage vectors, cDNA, Genomic libraries, cloning, PCR cloning, selection of clones. Applications of rDNA technology in health and disease, recombinant proteins, Factor VIII, erythropoietin, vaccines, genetherapy, genetically modified crops

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Develop knowledge and skills in basic and the particular areas of applied biology.
- Engage in further studies in a relevant biological discipline leading to academic or research careers.
- Excel in production or service based careers.
- Develop other generic skills, thus adaptable to even a non-discipline based career.

References

1. *Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.*
2. *Stanier RY, Ingraham JL and Wheelis, ML and Painter PR 1986. General CBS Pub (AVI Pub. Comp.)*
3. *Freifelder D. Molecular Biology, Jones and Barrtlett Publishers 1987*
4. *Moat AG & Foster JW 1999. Microbial Physiology. Wiley*
5. *Microbiology. Mac Millan Education Ltd., London*
6. *Brun Y V, and Shimkets LJ 2000. Prokaryotic development. ASM Press.*
7. *BIOTOL. Biotechnological innovations in chemical synthesis*
8. *Butterworth-Heinemann. Reed G (ED). Industrial Microbiology.*
9. *Hershnergev CL, Queener SW and Hegeman Q. 1998. Genetics and biotechnology of industrial microorganisms. American Soc. Microbiology*
10. *Demain A.L. Biology of industrial microorganisms.*
11. *Ewesis et al. 1998. Bioremediation principles. McGraw Hill.*
12. *Harvey Lodish et al 'Molecular Cell Biology' 1999*
13. *Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, Peter Walter. Molecular Biology of the Cell, 4th edition, Garland Publishing, New York, London, 2002*
14. *Sambrook and Russell. Molecular Cloning-A Laboratory Manual Vol 1, 2, 3. Third Edition, ColdSpringHarbor Laboratory Press, Cold Spring Harbor, New York 2001*
15. *T.A. Brown, 'Genomes' John Wiley and Sons PTE Ltd.*
16. *Ansumbel F.M, Brent R, Kingston R.E, Moore D.D., 'Current protocols in Molecular Biology' Green Publishing Associates, NY 1988*
17. *Berger S.L., Kimmer A.R, 'Methods in Enzymology' vol 152, Academic Press. 1987*
18. *I Edward Alcamo, HAR court Academic Press'DNA Technology'*

Advanced Transport Phenomena

Review of Mathematics: Scalar, Vectors, Tensors, divergence, relation between rectangular coordinates and cylindrical coordinates, relation between rectangular coordinates and spherical coordinates, partial derivative, substantial derivative, total derivative, line integral, surface integral, integral theorems, frame of reference (Eularian and Lagrangian),Review of Basic Concepts: Newton's law of viscosity, Classification of fluids, Newtonian & non-Newtonian fluids, flow curves for non-Newtonian fluids with examples, basic equation of fluid flow-Continuity equation, Momentum balance equation, Hagen-Poiseullie equation

Thermal conductivity, Fourier's law, Temperature distributions in solids and laminar flow, one dimensional steady state heat conduction, Natural and forced convection, concept of heat transfer coefficient and overall heat transfer coefficient, dimensionless numbers in heat transfer, Thermal boundary layer Diffusivity and the mechanisms of mass transport, Ficks law of diffusion, Concentration distributions in solids and laminar flow, review of classical flow problems using shell balances, Momentum, Heat and mass transfer analogies, Flow Systems and Heat Transfer: Viscosity, momentum transport, laminar and creeping flow,

The equations of change for isothermal flow: Equations of continuity, equation of motion, the equation of mechanical energy, application of Navier-Stokes equation to solve problems, the equations of change for incompressible non-Newtonian fluids The equations of change for non-isothermal flow: Equations of energy, the energy equation in curvilinear coordinates, and use of equations of change to set up steady state heat transfer for problems, mass transfer in multicomponent Systems:The equations of change for multi component systems: The equations of continuity for a binary mixture, the equation of continuity of A in curvilinear coordinates, the multicomponent equations of change in terms of the flows, the multi component fluxes in terms of the transport properties, use of equations of change to set up diffusion problems, Interphase transport, Microscopic and macroscopic balances

Simultaneous Transfer Processes: Velocity, temperature and concentration distributions with more than one independent variables, unsteady flow, stream function, potential flow, boundary layer theory, steady state two dimensional flow for momentum, heat and mass transfer, Turbulence: Turbulent flow: Introduction, Theories of turbulence-Phenomenological and statistical, Turbulent transfer processes in single and multiphase systems, Temperature distribution in turbulent flow, fluctuations and time smoothened equations for velocity, temperature and concentration, time smoothing of equation of change , equation of energy, equation of continuity of A, Reynolds stresses.

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply mathematical expression for various transport processes
- Understanding and utilization of various Numerical Techniques

- Utilization of Analogy for better insights into various transport processes
- Develop heat transfer equations for various complex operations
- Familiarize students with mass transfer operations for diversified transfer operations

References

1. *R.M. Felder and R.W. Rousseau, Elementary Principles of Chemical Processes, 3rd Edition, J. Wiley, New York, 2000*
2. *Unit Operations of Chemical Engineering: McCabe, Smith &Harriot, TMH, 5th edition*
3. *R. B. Bird et al., Transport Phenomena, 2nd Edition, Wiley, 2006*
4. *Wiety, J. R., Wilson, R. E. and Wicks C. E., Fundamental of Momentum heat and Mass Transfer, John Wiley & Sons*
5. *Beeks W. J. and Muttzall, Transport Phenomenon, John Wiley & Sons*
6. *Benett, C.O. and Myers, J. E, Momentum, Heat and Mass Transfer*
7. *Robsenow, W.M. and Choi, H.Y, Heat, Mass Transfer and Momentum, PHI*
8. *Geankopolis, Transport Processes & Unit operations: 3rd edition, PHI*
9. *Coulson & Richardson, Chemical Engineering, Vol-I & II:, Butterworth Heinemann*
10. *Foust, A.S., Wenzel, L.A, et.al. Principles of Unit Operations, 2nd edition, JWS*
11. *D. M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, 6th Edition, Prentice Hall of India, New Delhi, 1996*
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14. *James R. Welty, Charles E. Wicks and Robert E. Wilson, Fundamentals of momentum, heat and mass transfer, , John Wiley & sons, IncNew York*

Fermentation Technology

The isolation, preservation and improvement of industrial microorganisms: The isolation of industrially important microorganisms, Isolation methods not utilizing selection of the desired characteristic, The preservation of industrially important microorganisms, The selection of induced mutants synthesizing improved levels of enzymes of industrial, Significance. The use of recombination systems for the improvement of industrial microorganisms, The economics and scale of microbial product fermentations. Different products need different fermentation processes. Fed-batch culture as the paradigm for many efficient microbial processes

Media for industrial fermentations, sterilization &Inocula Development: Introduction Typical media Energy sources Carbon sources Nitrogen sources Buffer Oxygen requirements Antifoams Medium sterilization The design of batch sterilization processes, design of continuous sterilization processes, Sterilization of the fermenter, feeds and air Filter design Development of inocula for bacterial processes, Development of inocula for fungal processes, Development of inocula for streptomycete processes, aseptic inoculation of plant fermenter

Production of Beverages & Organic Products: Production of alcohol, glycerol and beer. Mechanism of alcohol and glycerol fermentation.Production of wine and other alcoholic beverages.Microbial production of organic acids viz. Citric, gluconic, fumericitaconic, gibberellic and kojic acids, Activities of lactic acid bacteria and industrial production of lactic acid. Activities of acetic acid bacteria and production of vinegar, Fermentation kinetics & optimization of Process -Introduction Framework for kinetic models Mass balances for bioreactors. Kinetic models Population models- Microbial fermentation as a chemical process. The utilization of fermentation inputs Growth and biomass profiles .The accumulation of fermentation outputs Process improvement

Control of Fermentations: An Industrial Perspective: Introduction Basic components of on-line process monitoring and control Enzymes- Transducers, Applications reported in the literature, Requirement for control Sensors Controller - Design of a fermentation control system, Fermenter control specification, Control of Incubation Advanced Incubation Control, Other advanced fermentation control options, Bioprocess scale up: Concerns and criteria: Introduction, Scale up concerns of microbial, mammalian and plant cell processes, Scale up criteria, Selection of scale up criteria, Scale up of genetically engineered cell culture fermentation

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of system of linear equations
- Identify the special properties of a matrix such as the eigen value, eigen vector, employ orthogonal transformations to express the matrix into diagonal form, quadratic form and canonical form

- Equip themselves familiar with the functions of several variables and mean value theorems

Familiarize with special functions to evaluate some proper and improper integrals using beta and gamma functions

References

1. *El-Mansi E.M.T. and Bryce C.F.A. 'Fermentation Microbiology and Biotechnology*
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3. *Enzymes: Trevor, Horwood, 2001*
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5. *T.D. Brock, Smaeur Associates. Biotechnology: A Text Book of Industrial Microbiology, 1990.*

Advanced Biomaterials

Introduction to Biomaterials: Definition and Characteristics of biomaterials according to US Pharmacopeia; Classes of biomaterials; Structure and properties of synthetic biomaterials: Bonding and crystal structure of metals and ceramics, Bio-polymers and types of polymerization, Composite materials, Physical, chemical, and mechanical properties; Structure and Properties of Biological Materials: Extracellular matrix, Hard and soft tissues, Interaction between cells and materials, In vitro and In vivo Evaluation and testing of biomaterials, characteristics for biomedical application; Characterization of biomaterials: Bulk properties, surface properties, mechanical properties, bio-inertness, Fundamentals of Manufacture and Processing of Biomaterials: relationship between material properties, processing methods and design; Molding, forging, casting, welding, hydrofoaming, Sintering: conventional, spark plasma; Design and development of bioreactor or bio-inspired methods for the production of structured biomaterials, challenges involved in developing shape-memory alloys; Modern techniques: Laser Assisted Net Shaping (LENS), Rapid Manufacturing techniques: Continuous 3D Printing, Fused Deposition, Modelling, Laser Sintering, Direct Laser Forming and Indirect Rapid Manufacture

Fundamentals of Synthesis and Processing of Polymers: methods of synthesis, Analysis of polymer surface characteristics; Synthesis of polymers with advanced properties for controlled drug delivery, targeted drug delivery; Biomimetics: processes, substances, devices, systems that imitate nature or copy biological systems, Efficient and active biomimetic materials with biological actuation, sensing, and conduction; Molecular Imprinting: chemical modification and organic and bioorganic synthesis, application of Biomaterials:Cardiovascular system, Dentistry,Bioadhesives, Ophthalmology, Orthopedics; Tissue Regeneration: Porous scaffolds for regenerative medicine: Design of new complex materials with hierarchical 3D structures and tailored mechanical and degradation properties; Trabecular metals, porous ceramics, synthetic and natural polymers; hard tissue and soft tissue regeneration

Nanomaterials: Synthesis, Characterization, Design and development for biomedical applications; Nanostructures of carbon; Biomedical Imaging – New materials for use as image enhancers and contrast agents, polymeric and nanoparticle-based contrast agents; Nanomaterials and quantum dots; Applications in protein and DNA delivery; Biosensors, Implant design and manufacture: Rapid Prototyping, sterilization; Regulatory approval; Informatics and modeling tools for the rational design and structure-properties development in biomaterials; New methods to access biocompatibility: low cost *in vivo* and *invitro* models for reliability, accelerated testing, failure analysis, imaging, and improved understanding of the biology-biomaterials interface.

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- Apply elementary transformations to reduce the matrix into the echelon form and normal form to determine its rank and interpret the various solutions of system of linear equations

- Identify the special properties of a matrix such as the eigen value, eigen vector, employ orthogonal transformations to express the matrix into diagonal form, quadratic form and canonical form

- Equip themselves familiar with the functions of several variables and mean value theorems

Familiarize with special functions to evaluate some proper and improper integrals using beta and gamma functions

Reference

1. *Buddy D Ratner, Biomaterial SCBEnce: An introduction to materials in medicine. Elsevier Academic Press, California, USA, 2004*
2. *BikramjitBasu, Dhirendraa S. Katti, and Ashok Kumar, (Ed.) Advanced Biomaterials: Fundamentals, Processing, and Applications. John Wiley & Sons, Inc., Hoboken, New Jersey. 2009*
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6. *L.L. Hench, E.C. Ethridge: Biomaterials, An interfacial Approach. Academic Press, New York, 1982*
7. *S. Frederick, H. Christiansen, L. Devid: Biomaterial SCBEnce and Biocompatibility. Springer-Verlag, New York, 1999*

Genomics and Proteomics

Introduction to Genomics and Proteomics, Human Genome project, sequencing strategies for whole genome analysis, sequence data analysis. The Structure, function and evolution of human genome, strategies for large scale sequencing, comparative Genomics: Protein evolution from exon shuffling, Protein structural, genomics, Gene function by sequence comparison, Global expression profiling: whole genome analysis of mRNA and protein expression, microarray analysis, types of microarrays and their applications, Functional genomics

High through put technologies in genomics, Next Gen sequencing, Pyrogen sequencing Capillary electrophoresis, SNPs and whole genome scans, Microarrays, disease genes, association studies, toxic genomics, Pharmacogenomics, Metagenomics, Applications of Genomics in drug discovery, molecular diagnostics, New target discovery, gene knockouts and miRNAs, Genomics of cancer and autoimmune diseases case studies

Proteomics;Protein structure, secondary structure and super-secondary structure, Mechanisms of protein folding, tertiary folds.Formation of oligomers, Relationship between protein structure and function, Prions, Structure prediction and human proteomics, Mutant proteins.Use of computer simulations and knowledge-based methods in the design process.De-novo design; making use of databases of sequence and structure.Protein structure and drug discovery, Proteins in disease Importance of Proteomics, Isolation and purification of proteins, expression of proteins, Strategies in Proteomics 2 D PAGE, Mass spectrometry. Databases and search engines in proteomics, Mapping of protein interactions: Two hybrid, phage display etc. Proteomics applications: Understanding the mechanism of pathogenesis, Drug discovery, Disease diagnosis, identification and characterization of novel proteins, Proteomics of cancer, autoimmune diseases

References

1. *Campbell, A. Malcolm and Heyer, Laurie J., Discovering Genomics, Proteomics & Bioinformatics, Benjamin Cummings, 2002*
2. *Lesk, Arthur M, Introduction to Protein SCBEnce, Oxford University Press, 2004, ISBN 0 19 926511 http://www.oup.com/uk/orc/bin/9780199265114/resources/figures/*
3. *S.Sahai, Genomics and Proteomics, " Functional an Computational Aspects ",Pienum Publications, 1999*
4. *Fersht, A. Structure and Mechanism in Protein SCBEnce, W. H. Freeman (1999)*
5. *Carey P. R. (Ed.) Protein engineering and design, Academic Press (1996)*
6. *Strachan T. and Read A. P. Human Molecular Genetics, 2nd edition. Bios (1999)*
7. *Glick, Bernard R. and Pasternak J. J., Molecular Biotechnology: principles and applications of recombinant DNA, 2nd ed. ASM Press (1998)*
8. *Brown T. A. Genomes, Bios (1999)*
9. *Attwood T. K. and Parry-Smith D. J. Introduction to Bioinformatics, Longman (1999)*
10. *Rees A R., Sternberg M. J. E. and Westsel R., Protein Engineering - a practical approach, IRL Press (1992).*
11. *Walker J. M. and Rapley R., Molecular Biology and Biotechnology, 4th ed. Royal SoCBEty of Chemistry (2000).*
12. *Nature,Genomegateway:http://www.nature.com/nature/supplements/collections/humangenome/index.html*

13. *SCBEnce, Human Genome special issue*[*http://www.sCBEncemag.org/content/vol291/issue5507/index.dtl*](http://www.sCBEncemag.org/content/vol291/issue5507/index.dtl)

Advanced Downstream Processing

Role of Downstream Processing in Biotechnology:Bio-molecules of commercial importance – Organic acids and alcohols, antibiotics, vaccines, steroids, vitamins, enzymes, proteins, antibodies etc, major contaminants, requirement of purification, Pitfalls and challenges in bio-separation processes, Product quality requirements, Regulatory aspects and validation, Economics of downstream processing, membrane based separation techniques: Membrane based separations-micro and ultra filtration theory, resistance in series model, other models for membrane separations, membrane modules, pervaporation, dialysis, design and configuration of membrane separation equipment, Molecular properties and selection of separation conditions, Equilibrium calculations

Product purification / Enrichment Extraction-Solvent selection and equipment design in extraction processes, aqueous two phase extraction, supercritical extraction, Precipitation - using salts, organic solvents, and polymers, crystallization of small and large biomolecules, product Resolution / Fractionation Adsorptive separation- Definition; Types of adsorption; adsorbents types, their preparation and properties; Types of adsorption isotherms and their importance Chromatographic Separations-Mechanism and modes of chromatographic separation, Reverse Phase, Hydrophobic interaction, Size exclusion, Affinity, Ion exchange, Gel Filtration, Equilibrium theory and column design, Process configurations (packed bed, expanded bed, simulated moving beds) Electrophoretic Separations-Various electrophoresis techniques, capillary electrophoresis Hybrid separation technologies- Membrane chromatography, electro chromatography etc, polishing of bioproducts

Downstream processing: overall strategy: Process integration-combining many bioseparation techniques, computed aided design, design and scale up of process-from biomass to product, emerging trends like pseudo-affinity chromatography, metal ion affinity chromatography, inclusion bodies-processing and refolding, case studies :Protein purification-sources of proteins (microbes, plants and animal sources using classical and modern biotechnology), Conventional strategies, associated problems, new trends, large scale separation and purification of *E. coli*, yeast and mammalian proteins;other examples: Baker's yeast, Ethanol, Power alcohol, Citric acid, Gluconic acid, Penicillin, Streptomycin, Insulin, Casein, interferon, Recombinant products

References

1. *J.E. Bailey and D.F. Ollis, Biochemical Engineering Fundamentals, McGraw-Hill*
2. *P.A. Belter, E.L. Cussler and W.S. Hu, Bioseparations, John Wiley and Sons Inc.*
3. *Aenjo J.A. and J.Hong, Separation, Recovery and Purification in Biotechnology*
4. *P F Stanbury and A Whitaker, Priniciples of fermentation technology, Pergamon press (1984)*
5. *M. Moo-Young , Comprehensive Biotechnology" Vol.2 (1985)*
6. *Biotreatment, Downstream Processing and Modeling" (Advances in Biochemical Engineering /Biotechnology, Vol 56) by T. Schepler et al, Springer Verlag*
7. *C.A. Costa and J.S. Cabral, Kluwer, Chromatographic and Membrane Processes in Biotechnology Academic Publisher*
8. *J.P. Hamel, J.B. Hunter and S.K. Sikdar,Downstream Processing, American Chemical SoCBEty*
9. *M.R. Ladisch, R.C. Wilson, C.C. Painton and S.E. Builder, Protein Purification, American Chemical soCBEty ,Verlag*

Biofuel and Bioenergy

Energy resources and their utilization Energy sources, present scenario, energy demand, Energy supply, Energy planning, Energy parameters (energy intensity, energy-GDP elasticity), conventional and renewable sources, Renewable Energy**:** Introduction to various sources of energy, biofuel, Solar thermal, Photovoltaic, Water power, Wind energy, Biomass, Ocean thermal, Tidal and wave energy, Geothermal energy, Hydrogen energy systems, Fuel cells, biofuel – Biodiesel Definition, advantages of biodiesel, properties of biodiesel, feedstocks - jatropha, Karanja, Neem, plantation, Transesterification, process issues, homogeneous and heterogeneous catalysis, biodiesel from microalgae, algae cultivation, types of photobioreactor, Indian perspective,biofuel – Bio-alcohols Feedstock for alcohol fuels, common methods for alcohol production, ethanol production from lignocellulosic materials, pretreatment-dilute acid, hot water, steam explosion, Ammonia; enzymatic hydrolysis, detoxification, fermentation, butanol fermentation, challenges in ethanol and butanol production, case studies, concept of biorefinery

Biofuel - Gaseous fuels:Biomethanization, microbiological aspects of biogas production, biogas anaerobic fermentation & process, raw materials, factors affecting biodigestion, classification of biogas plants, methods for maintaining biogas production, problem in biogas plants and solutions, thermal processes, case study on biogas production, introduction to hydrogen as a fuel, wind and Geothermal energy Wind energy,Characteristics of wind: Effect of density, Frequency variances, Angle of attack, Wind velocity, Principles of wind turbine: operation, siting and control, Process of electricity generation and supply to the grid - wind energy farms, Types of wind machines and their characteristics, Horizontal and Vertical axis wind mills, Elementary design principles, Coefficient of performance of a wind mill rotor, Aerodynamic considerations in wind mill design, Selection of a wind mill, Availability of wind energy in India Geothermal:Uses of geothermal energy and the geothermal power plants, Mechanisms for deep geothermal heat extraction and power generation, Dry-steam Flash-steam and Binary-cycle, Shallow geothermal and heat-pumps, Wave and Tidal; Solar energy and Photovoltaic ;Need of solar energy in the world and India, Basics of converting sunlight into electricity, Technologies of producing solar fuels, solar energy collectors, System components, Grid connection and applications, Solar thermal: Technologies and applications of solar thermal energy - Power production and heating applications, Solar heating and solar cooling, Concentrated solar power (CPV and CSP) for utility-scale applications, Domestic and industrial

References

1. *BansalKeemann, Meliss," Renewable energy sources and conversion technology", Tata McGraw Hill*
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9. *Bioenergy: Realizing the Potential, S. Silveira, (Ed), Elsevier SCBEnce, 2005*
10. *The Biomass Assessment Handbook: Bioenergy for a Sustainable Environment,Rosillo-Calle, P. D. Groot, S. Hemstock, J. Woods, Earthscan Publisher, 2006*
11. *Brenes, M. D. (Ed), Biomass and Bioenergy: New Research, Nova Publishers, 2006*

Advanced Genetic Engineering

Agarose gel electrophoresis, DNA hybridization, Southern Blotting, PCR-design and optimization, Reverse Transcriptase PCR, Real Time PCR, micro arrays. Enzymes used in GE: DNA modifying enzymes, restriction enzymes, modifying enzymes, DNA ligase, polymerase for GE, Cloning vectors, Plasmids, Multiple cloning sites, selection markers, lambda phage, phgemids, cosmids, M13 vectors, vectors for cloning in eukaryotic cells, Expression Vectors, artificial chromosomes (BACs, YACs)

Overview of cloning, Construction of Genomic libraries, random, arrayed and ordered libraries C-DNA library, DNA cloning, cDNA synthesis, amplification of gene libraries, isolation, selection of recombinants various cloning strategies,Screening of recombinant clones by hybridization, by PCR and by immunodetection, techniques of DNA sequencing, artificial DNA synthesis, PCR cloning

Gene transfer technologies, Transformation, Transfection, Translocation, Conjugation. Modification of bacteria and viruses: live vaccines, transgenesis and cloning, Animal transgenesis, Application of transgenic animals, transgenic plants and their applications,Applications of rDNA technology in health and agriculture: Humulin, Hep B, factorVIII, DNA diagnostics, BT cotton, Golden rice etc, DNA markers for improvement of quality and yield of crops. RFLP, RAPD, AFLP, Gene therapy, Human genome project

COURSE OUTCOMES

By the end of the semester, the student will be able to:

- develop an understanding of fundamental and applied aspects of genetics and molecular biology with the ability to use that knowledge in a wide range of modern science
- classical mendalian genetics, microbial and molecular genetics, and various aspects of molecular biology which include replication, transcription, translation, gene regulation, DNA binding motifs, DNA methylation and epigenetic regulation
- Students will understand the basics of gene cloning, role of enzymes and vectors for genetic engineering, Gene transfer methods, Techniques and safety measures of genetic engineering, genome mapping and gene therapy

References

1. *Primrose and Twyanman, Principles of Gene manipulation and Genomics (Blackwell Publishers)*
2. *Dale, J. W. and Schantz M.V. From genes to genomes: concepts and applications of DNA technology by (Wiely Publishers.)*
3. *Winnacker,From Genes to clones, PANIMA.*
4. *T. A. Brown, Gene cloning and DNA Analysis: An introduction (4th edition)*
5. *Sambrook, et al Molecular cloning*

Nutrition and Food Processing

Human nutritional Requirements – Development and Recent Concepts. Methods of determining human nutrient need, Basic terms and concepts in human nutrition Guidelines, Recommendations & Development of International and National Nutritional Requirements, Translation of nutritional requirements into Dietary Guidelines,Significance of body composition and changes through the life cycle, Methods for assessing body composition (both classical and recent) and their applications; Components of energy requirements: BMR, RMR,thermic effect of feeding, physical activity. Factors affectingenergy requirements, methods of measuring energy expenditure, Estimating energy requirements of individuals and groups, Regulation of energy metabolism and body weight: Control of food intake – role of leptin and other hormones

Nutritional significance of Biomolecules: Carbohydrates: Review of nutritional significance of carbohydrates and changing trends in dietary intake of different types of carbohydrates and their implications Dietary fibre: Types, sources, role and mechanism of action Resistant starch Proteins: Overview of role of muscle, liver and GI tract in protein metabolism Amino acid and peptide transporters Therapeutic applications of specific amino acids Peptides of physiological significance Proteins, amino acids and gene expression; Lipids: Nutritional significance of fatty acids – SFA, MUFA, And PUFA: functions and deficiency Role of n-3 and n-6 fatty acids, Prostaglandins, Trans Fatty Acids Conjugated linoleic acid Nutritional Requirements and dietary guidelines (International and National) for visible and invisible fats in diets. Lipids and gene expression Vitamins (A, D4, D10, E3, E8, K3, K8)historical background Structure and chemistry Food sources Metabolism (digestion, absorption, transport, storage and elimination), Bioavailability and factors affecting bioavailability, Biochemical and physiological functions, Assessment of status Interaction with other nutrients, regulation of gene expression (wherever applicable) Pharmacological and therapeutic effects

Introduction to Physical and chemicals methods of food preservation: Principles and methods of food preservation- Refrigeration, Freezing, heating, dehydration, drying, canning, extrusion cooking, hydrostatic pressure cooking, dielectric heating, microwave processing, aseptic processing, juices and concentrates, membrane technology, additives, irradiation. Storage of food, modified atmosphere packaging advanced Food Processing Role of Enzymes in Food Processing: Starch and sugar conversion processes or baking by amylases; de-oxygenation and desugaring by glucose oxidase; beer mashing and chill-proofing or cheese making by proteases and various other enzyme catalytic actions in food processing. Enzyme in bakery and cereal products, production of pectinases and utilization in food Processing

Technologies for Food Ingredients: Technologies used for microbial production of food ingredients, Biotechnology of microbial polysaccharides in food, Microbial biotechnology of food flavor production, microbial production of oils and fats, food applications of algae, butanol production from agricultural biomass,concept of public nutrition Relationship between health and nutrition. Role of public nutritionists in the health care Delivery Sectors and Public Policies relevant to nutrition and health; Primary Health Care of the Community. National Health Care Delivery System Determinants of Health Status, indicators of Health population Dynamic, demographic transition population structure Fertility behavior Population policy Fertility inter-relationship between Nutrition and Quality of Life

References

1. *KalidasShetty, GopinadhanPaliyath, Anthony Pometto, Robert E Levin, Food Biotechnology (Second Edition)–Taylor and Francis*
2. *Frazier, Food Microbiology,*
3. *Fellows P. , Ellis H., 1990 – Food Processing Technology Principles and Practice –New York*
4. *Shils, M.E.; Olson, J.; Shike, M. and Roos, C. (1998): Modern Nutrition in Health and Disease. 9th edition. Williams and Williams. A Beverly Co. London.*
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6. *Berdanier, C.D. and Haargrove, J.L. (ed) (1996): Nutrients and Gene Expression: Clinical Aspects. Boca Raton, FL CRC Press.*
7. *Baeurle, P.A. (ed) (1994) Inducible Gene Expression. Part I: Environmental*
8. *T.P.Coultate – Food – The Chemistry of its components, 2nd edition Royal Sociey, London,1992*
9. *B. Shivshanker – Food Processing and Preservation, Prentice Hall of India Pvt. Ltd. New Delhi 2002*

Herbal Drug Technology

General Introduction: Definition, source of herbal raw materials, identification, authentication, standardization of medicinal plants as per WHO guidelines & different herbal pharmacopoeias. Collection and processing of herbal drugs, Seasonal & geographical variations; natural & artificial drying methods, Packaging & labeling of herbal drugs prior to extraction, standardizations: Determination of physical and chemical constants such as extractive values, moisture content, volatile oil content, ash values, bitterness value and foreign matters applicable to the various herbal drugs, herbal Formulations: Principle, methods, single herb formulation, poly-herbal formulation &their merits and demerits. Standardization of various herbal formulations. Stability testing, Characterization, Bioavailability,analysis of Bioactive Components of Natural Sources: Phyto-chemical standardization of raw herbal extracts and their formulation by using TLC, HPTLC, GC, HPLC, UV& IR techniques. Heavy metal contaminations, pesticides, aflatoxins, microbial, nutraceuticals, Functional foods, regulations, DISHE, Types of nutraceuticals Supplementations, case examples Chyavanprash, shatavarietc, WHO GMP

Plant Tissue Culture Techniques & its Application in Pharmacy: Introduction, techniques of initiation and maintenance of various types of cultures. Immobilized pt cell techniques & biotransformation studiesincluding recent developments in production of biological active constituents in static, suspension and hairy root cultures. Molecular methods in Herbal Drug standardizations like DNA fingerprinting and microarrays

Reference

1. *S.S. Agrawal& M. Paridhavi, Herbal Drug Technology*
2. *PatwardhanBhushan, Ethnopharmacology and Drug Discovery, New India Publishing Agency, 2007, New Delhi.*
3. *Peach & Tracey, Modern Methods of Plant Analysis*
4. *S.S. Purohit, Biotechnology*
5. *Pulok K. Mukherjee, Quality control of herbal drugs: an approach to evaluation of botanicals*
6. *C.K. Kokate, A.P. Purohit and S.B. Gokhale,Pharmacognosy*

Enzyme Technology

Historical aspect of enzyme, Nomenclature and classification of enzyme, Enzyme cofactors - prosthetic groups, coenzymes, co-substrates, Role of Metal ions in enzyme catalyzed reaction, structure of enzymes - the monomeric and oligomeric enzymes. Concept of Active Site , Lock and Key and Induced Fit hypotheses. Multienzyme systems - basic concepts and significance with examples, structural aspects of pyruvate dehydrogenase and fatty acid synthetase,Isoenzymes - basic concepts with examples and their significance to the cells and to the medical field; Basic concept of enzyme catalysis - activation energy barrier and the transition state theory, Catalytic mechanisms in Chemistry and in Enzymes - acid-base, covalent and electrochemical reactions. Factors enhancing the catalytic efficiency of enzymes proximity and orientation, orbital steering, distortion and strain. Functional groups involved in the catalytic mechanisms – example of chymotrypsin, Isolation and purification of enzyme, criteria's of purity of enzyme, Enzyme turnover: Kinetics of enzyme turnover. Measurement of enzyme turnover, Ks and Kd. Correlation between the rates of enzyme turnover and structure and function of enzymes, significance of enzyme turnover.

Kinetics of Enzyme activity : Introduction of Chemical kinetics, Kinetics of Single substrate enzymes catalysed reactions - Michaelis and Menten derivations, Significance of Michaelis and Menten equation and Km. Modifications of the - Michaelis and Menten equation - Lineweaver - Burk, Eadie-Hofstee, Hanes and Eisenthal& Cornish - Bowden. Effect of pH and temperature on enzyme activity,regulation of enzyme activity by various means with one example of each, catalytic mechanism of allosteric enzymes, Enzyme inhibition and its kinetics: feedback inhibition, irreversible and reversible inhibition (competitive, non competitive, un competitive), allosteric inhibition, importance of inhibition studies, enzymes in clinical Diagnosis: LDH isozymes, SGOT, SGPT, creatine kinase, alpha amylase, phosphatase

Immobilization of enzymes: - Introduction, Methods of immobilization, kinetics of immobilized enzymes & application in production of L-amino acids, Other uses of immobilized enzyme, Industrial enzymes: like glucose-isomerase, cellulases,pectinases etc., their importance, source and production,enzyme based biosensors: Introduction to biosensors, Classification of biosensors based on various transducers, different biocomponents employed for the construction of biosensor of the sensor, Selected examples and further development of biosensors

References

1. *Lubertstryer Biochemistry, Freeman WH & Company, New York*
2. *Yang V.C. and T.T.Ngo.2000.Biosensors and their Applications, Academic/Plenum Publishers*
3. *Conn and Stumph, Outlines of Biochemistry JH Weil, General Biochemistry, New Ages International (P) Ltd. 1997*
4. *David T. Plummer, An Introduction to practical biochemistry, Tata McGraw Publishing Company Ltd*
5. *I.A.L. Lehninger, DL Netson, MM Cox Principles of Biochemistry, CBS Publishers and Distributors*
6. *Ashok Mulchandani and Kim R Rogers, Enzyme and Microbial bio sensors: Techniques and Protocols,(Eds.);Humana Press Totowa ,NJ,1998*
7. *A.P.F. Turner, G.S. Wilsons Biosensors: Fundamentals and Applications, OxfordSCBEnce Publications, Oxford.*

Alcohol and Brewery Technology

An overview of Brewing: Introduction, Raw Materials: Barley, Hops, Water, Yeast, outline of the Brewing steps, Malting, Milling and Adjunct Use, Mashing, Wort separation, Wort boiling, Trub removal, Wort cooling/Aeration, Yeast handling, Yeast pitching, Fermentation, Yeast removal, Aging, Clarification, packaging warehousing and distillation, vine cultivation: Pruning the vines; Methods of cultivation. Vine Pests & Diseases: Vine diseases; Vineyard pests; Phylloxera; Bacterial diseases of the Grapevine, grapevine and its varieties including Indian Varieties of grapes: white wine grape Red wine grape varieties, Adjuncts: Introduction, Corn Grits, Rice, Barley, Sorghum, Refined Corn Starch, wheat starch, cereals, liquid adjuncts, Malt from cereals other than Barley. Wheat Malt, Oats and Rye Malt, Sorghum

Malt Production drying of the intake grain, storage, Screening of the barley to produce an even size corn, dust removal etc. Two or three immersions under water, design of kiln Beer Production: Fermentation, Maturation, Filtration, Stabilization Filling the beer: Glass Bottles, PET, Cans, Kegs, Cleaning and disinfection Water usage in the Brewery, Brewery water consumption, Brwery water, Calgary's: Brewing water, water standards: chemical and microbial for ingredient use and influence of inorganic ions from water on Beer Quality, ingredient effect of ions on Beer flavor and quality, control of pH, water treatment systems; processing: Equipment configuration, milling, mashing Lautering, Boiling time, Fermentation Temperature, Maturation time, filtration, Packaging, Marketing, Cultural Origins of style, Analytical and Sensor variables, Beer style guidelines, analysis, tasting &, Brewing Beer. The Beer Styles-Ales British Origin, Irish Original, German Origin, Belgian and French Origin, Lager Beer, European- Germanic origin, North American Origin

Sugar cane molasses, beet molasses and sweet Sorghum: Composition and Usage, Grain Milling and Cooking for Alcohol Production: Designing for the Options in Dry Milling Wet Milling and Mash Preparation, Molasses dilution practices adopted and design of diluter, quality of dilution water used, pre clarification of molasses advantages and draw back, molasses sterilization/pasteurization,Batch Fermentation and Fermenter Design, Continuous Ethanol Fermentation, Management, process of Batch fermentation, factor influencing efficiency of fermentation, characteristics of Batch Fermentation Process, Control over fermentation

operation, contamination control, design and material of construction of fermenters, maintenance of fermenter and operational conditions on plant scale, flow sheet of Batch Fermentation process, Efficiency of Fermentation and Attenuation data calculations – Related examples and solutions, distilled Beverage Production: Unique Aspects ,Whiskey: Grain Mashing and Fermentation ,Beverage Alcohol Distillation ,Whiskies Around the World Vodka, Gin, and Flavoured Spirits ,Rum: Fermentation and Distillation

References

1. *The Alcohol Textbook , WM Ingledew Et al , 5th Edition (2009),NottinghamUniversity Press*
2. *Jacques, T. P. Lyons & D. R. Kelsall, The Alcohol Textbook.*
3. *SatyanarayanaRao, Alcoholometry*
4. *A.C. Chatterjee, Handbook of Fermentation and Distillation*

5. *Hough,J.S., Briggs,D.E., Stevens,R., Young,T.W, Malting & brewing sCBEnce, vol. 2 : London, Champman& Hall, 1982. (663.3HOU)*
6. *Pollock, J.R.A., Brewing sCBEnce vol. 1. London, Academic Press, 1979*
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8. *Prescott, S.C. & Dunn, C.G.Industrial microbiology. : Agrobios (India), 2002.*
9. *Priest, F.G Brewing microbiology, 2nd ed.. (1996) U.K. Chapman & Hall, 1996*
10. *Priest, Fergus G.; & Stewart, Graham G, Handbook of brewing. (2nd) U.S.A. CRC Press*

Stem Cell and Cancer Biology

Introduction to stem cell biology and regenerative medicine; Definitions: stem cell, progenitor cells, precursor cells, transit amplifying cells; General properties of stem cells; Defining Totipotency, pluripotency, multipotency, unipotency of stem cells; Differentiation and trans-differentiation. Stem cell niche, growth and differentiation factors. Stem cell lineage tracing: adult and embryonic stem cells, pluripotent stem cells, germ line, neuronal stem cells, hematopoietic stem cells, pancreatic stem cells, cancer stem cells. Isolation and culture of various stem cell types, stem cell research: Techniques. Lineage – tracing technique, gene knock-out and knock-in studies, inducible gene expression or repression, transfection, DNA sequencing, Chromatin Immunoprecipitation, Fluorescent-Activated Cell Sorting (FACS), Immunolabeling and Magnetic separation (AUTOMACS Miltenyi Biotech, Dynal Biotech Dynal technology), confocal microscopy

Stem cell research: legal and ethical issues; Guidelines for stem cells research and therapy in India: introduction, general mechanisms, aim and scope, categorization of research on stem cells, clinical application of umbilical cord blood stem cells, criteria on use of placental / fetal stem cells for research, approval of procurement. Human embryonic stem cell Bank: preservation and distribution of cells. International collaboration and patent issues, Ethics for stem cell research, stem cells and degenerative diseases**:** Introduction to Parkinson disease, diabetes, burn, retinal replacement therapy, cardiomyopathies; derangement patterns, clinical manifestations: symptoms and diagnosis; treatment; Application of stem cells in degenerative medicine: Stem cell therapy; Cell replacement and cell regeneration: principles and techniques; Cell and tissue regeneration; Regeneration of different types of stem cells for different degenerative diseases; gene therapy

Cancer Biology**:** Cell cycle,Cell proliferation, Differentiation and Apoptosis,Initiation, Progression: tumor microenvironment, translational and transcriptional mechanisms Invasion and metastasis; Cancer Genetics: Oncogenes, Tumor suppressor genes; Tumor immunology: dysregulation of signal transduction, cancer therapy:Molecular diagnosis: PCR, FISH, RFLP and Southern Blotting, Microarray technology, Biomarkers, Therapy: Chemotherapeutic agents, endocrine therapy, Biotherapeutics, Stem cell therapy

References

1. *RA Weinberg, The Biology of Cancer, John Wiley And Sons Ltd, 2007*
2. *Raymond W Ruddon, Cancer Biology, 4th Edition, OxfordUniversity Press, 2007*
3. *S Pelengaris and M Khan, (eds) The Molecular Biology of Cancer, Blackwell Press, 2006*
4. *Kufe, Pollock, Weischbaum, Bast, Gansler, Holland and Frei, Cancer Medicine Review, 6th edition 2003 (BC Decker)*
5. *Vogelstein and Kinzler, The Genetic Basis of Human Cancer, 2nd edition 2002 (McGraw-Hill Education)*
6. *Alberts, Johnson, Lewis, Raff, Roberts and Walter, Molecular Biology of the Cell, 4th edition 2002 (GarlandSCBEnce)*
7. *Lodish, Berk, Zipursky, Matsudaira, Baltimore and Darnell, Molecular Cell Biology, 4th edition (WH Freeman)*
8. *Souhami, Tannock, Hohenberger and Horiot, Oxford Textbook of Oncology, 2nd edition 2001 (OxfordUniversity Press)*
9. *Lewin B, Genes, 8th Edition 2004 (Pearson, Prentice, Hall)*

10. *Eeles, Easton, Ponder and Eng (eds.), Genetic Predisposition to Cancer, 2nd edition 2004 (Chapman and Hall)*
11. *"Insight: Stem Cell Biology". Nature. 2006; 441:1059-1102*
12. *"Insight: Regenerative Medicine". Nature. 2008; 453:301-352*
13. *Roger JB King and Mike W Robbins, Cancer Biology. 3rd Edition, Pearson Education Ltd, 2006*
14. *Tannock and Hill, The Basic SCBEnce of Oncology, 4th edition 2004 (McGraw- Hill Education)*

Advanced Bioinformatics

Macromolecular Structure as Protein - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure Nucleic acid–DNA and RNA, Carbohydrates, 3D Viral structures,

Protein–protein interactions, protein–DNA interactions, DNA binding proteins, Different forces involved in the interactions,Methods to study 3D structure - Principles of crystallography, Principles of protein folding and methods to study protein folding, Mass spectrometry and computational approaches in structural biology

Introduction to cheminformatics, History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation, chemical database design, basic database theory, Types of database system, Relational model, Object based model, Structure databases, Reaction databases, Chemical abstracts file, Crystallographic databases, Inorganic Crystal Structure Database (ICSD), Cambridge Structural Database (CSD)

Structure representation systems, 2D and 3D structures, General introduction to chemical structure-hybridization, tetrahedron geometry etc, Wiswesser Line Notationand Applications ROSDAL and Applications, the SMILES coding and Applications, Reaction transformations notation like SMIRKS, characterization of chemicals by Class & by Pharmacophore, application in HTS Analysis as Introduction to pharmocophore, Identification of pharmacophore features Building pharmacophore hypothesis, Searching databases using pharmocophores, Introduction to Quantitative Structure Activity Relationship

References

1. *Introduction to Protein Structure by Branden, Carl &Tooze, John, Garland Publishing, 1991.*
2. *Chemoinformatics by Johann Gasteiger and Thomas Engel, 2004.*
3. *An introduction to Chemoinformatics by Andrew R. Leach and Valerie J. Gillet, Kluwer Academic Publisher, 2003.*
4. *Chemometrics and Chemoinformatics by Barry K. Lavine, ACS Symposium series 894*
5. *Molecular Modeling: Basic Principles and application by Hans Dieter and Didier Rognan. Wiley VeHGmbh and Co. KGA, 2003*

Metabolic Engineering

Introduction, Synthesis of primary metabolites, Biosynthesis of secondary metabolites, Bioconversions, Regulation of enzyme production, Induction-Jacob Monod model, catabolite regulation, glucose effect, cAMP deficiency, feed back regulation, regulation in branched pathways, differential regulation by isoenzymes, concerted feed back regulation, cumulative feed back regulation, amino acid regulation of RNA synthesis, energy charge, regulation, amino acid regulation of RNA synthesis, energy charge, regulation, permeability control passive diffusion, active transport, group transportation, biosynthesis of primary metabolites: Alteration of feed back regulation, limiting accumulation of end products, feedback, resistant mutants, alteration of permeability, metabolites; Biosynthesis of secondary metabolites: Precursor effects, prophophase, idiophase relationship, enzyme induction, feedback regulation, catabolite, regulation by passing control of secondary metabolism, producers of secondary metabolites

Bioconversions: Advantages of Bioconversions, specificity, yields, factors important to bioconversion, regulation of enzyme synthesis, mutation, permeability, co-metabolism, avoidance of product inhibition, mixed or sequential bioconversions, conversion of insoluble substances, regulation of enzyme production, Strain selection, improving fermentation, recognising growth cycle peak, induction, feed back repression, catabolite repression, mutants resistant to repression, gene dosage, case studies in metabolic engineering, enhancing yield of shikimate, APS and other economically important secondary metabolites. Industrial applications

Metabolic Engineering,CellularMetabolism,Solute transport processes in the cell,Catabolism and metabolic fueling processes,Biosynthesis of cellular building blocks,Polymerization of building blocks to macromolecules,Rare metabolic conversions,Balances and reaction models,Growth nutrients and diversity,Mass balances, rates and experiments,Data reconciliation and error detection,Black box models for growth and product formation,Metabolic models for growth and product formation,A thermodynamic description of microbial growth and product formation,Bacterial transcriptional regulation of metabolism,Transcribing metabolism genes,Regulation of secondary metabolism in bacteria,A synthetic approach to transcriptional regulatory engineering, Modeling tools for metabolic engineering,Metabolic flux analysis,Metabolic control analysis,Structure and flux analysis of metabolic networks,Constraint-based genome-scale models of cellular metabolism,Multiscale modeling of metabolic regulation,Validation of metabolic models,Developing appropriate hosts for metabolic engineering,Escherichia coli,Yeast,Bacillus subtilis,Streptomyces,Filamentous fungi,Mammalian cells,Evolutionary tools in metabolic engineering,Evolutionary engineering of industrially important microbial phenotypes,Improving protein functions by directed evolution,Engineering DNA and RNA regulatory regions through random mutagenesis and screening,Evolving pathways and genomes for the production of natural and novel compounds,Models predicting optimized strategies for protein evolution,Gene expression tools for metabolic pathway engineering,Low-copy number plasmids,Chromosomal engineering strategies,Regulating gene expression through engineered RNA technologies,Tools designed to regulate translational efficiency,Metabolic engineering of the secretory processing pathway in eukaryotes,Engineering multifunctional enzyme systems for optimized metabolite transfer between sequential conversion steps,Application of emerging technologies,Genome-wide technologies – DNA microarrays, phenotypic microarrays and proteomics,Monitoring and measuring the

metabolome,Tools for experimentally determining flux through pathways,GC-MS,AEX-HPLC-ESI-MS,Applications,Biosynthesis of fine chemicals,Drug discovery,Biosynthesis of alternative fuels

References

1. *Fermentation and Enzyme Technology Wang D.I.C., Cooney C.L., Demain A.L., Dunnil.P. Humphery A.E., Lilly M.D., John Wiley and Sons., 1980.*
2. *Biochemistry, Zubay G., Macmillan Publishers, 1989.*
3. *Principles of Fermention Technology, Stanbury P.F., and Whitaker A., Pergamon Press., 1984.*

STRUCTURAL BIOLOGY

Introduction to structural biology: interactions in biological systems, Intra and inter molecular forces, electrostatic interactions and Hydrogen bonding interactions, van der Waals and Hydrophobic interactions, Disulphide bridges, Role of water and weak interactions, structure of Proteins: Conformational properties of polypeptides, Primary and secondary structure α-helix, β-sheet structures etc., Tertiary and quaternary structure, Structural features of membrane proteins, Secondary and tertiary structure prediction of protein conformation, Protein Folding Mechanisms, Chaperones and Chaperonins

Multiple equilibrium: Titration of proteins to evaluate net and total charge, Scatchard and Hill plots, Folding-unfolding equilbrium and denaturation of proteins, Effect of temperature and solvent conditions on the thermodynamics of protein folding-unfolding equilibrium, Kinetics of protein folding, nucleic Acid Structure : Nucleic Acid Structure: DNA/RNA, Protein/Nucleic Acid Interactions, Genome Structure: Nucleosomes, Chromatin, Chromosome

Techniques for the study of Macromolecular Structure**:** Analytical Ultracentrifugation : Sedimentation velocity and equilibrium, determination of molecular weights, Micro calorimetry (DSC and ITC) and its application, Circular Dichroism spectroscopy, UV, visible and Fluorescence spectroscopy, X-ray Diffraction, Diffraction: overview, crystallization, nuclear Magnetic Resonance (NMR),Mass Spectrometry Mass spectroscopy: application to complex proteins. , MALDI TOF, Gel filtration analysis of ligand binding association equilibria and kinetics

References

1. *Tinoco, Ignacio, Jr., Sauer, Kenneth, Wang, James C., & Puglisi, Joseph D. (2001) Physical Chemistry: Principles and Applications in Biological Sciences, 4th ed. Prentice Hall, ISBN: 0-13-095943-X (in our bookstore)*
2. *vanHolde, Kensal E., Johnson, W. Curtis, & Ho, PuiShing (1998) Principles of Physical Biochemistry. Prentice Hall. ISBN 0-13-720459-0*
3. *Cantor, Charles, and Schimmel, Paul (1980) Biophysical Chemistry, Vols. I-III, W. H. Freeman and company, San Francisco, 0-7167-1188-5, 0-7167-1192-3, QU 4 C232b 1980*
4. *Drenth, Jan (1994) Principles of Protein X-Ray Crystallography, Springer-Verlag, QU 55 D772P 1994*
5. *Kinter, M. & Sherman, N. E. (2000) Protein Sequencing and Identification Using Tandem Mass Spectrometry, Wiley-IntersCBEnce*
6. *Chapman, J. R. Ed. (2000) Mass Spectrometry of Proteins and Peptides, Humana Press, QU 55 M414 2000*
7. *Cavanagh, J., Fairbrother, W.J., Palmer III, A.G. and Skelton, N. J. (1996) Protein NMR Spectroscopy: Principles and Practice, Academic Press, QD 96 .N8 P967 1996*
8. *Evans, J. N. S. (1995) Biomolecular NMR Spectroscopy, Oxford University Press*
9. *Hansen, J. C., and Cole, J. L. (1999) Analytical Ultracentrifugation as a Contemporary Biomolecular Research Tool. Journal of Biomolecular Techniques 10(4, December):163-176. (pdf on course website)*

Nanotechnology

Introduction: Overview of nanoscience, Theory, definitions and history; Societal implications of nanoscience –nanotoxicology, Physical basis and principles of nanotechnology: Overview of chemistry fundamentals for nanotechnology, Engineering principles for nanotechnology; Self-assembly and overview of Complex Adaptive Systems (CAS), structure: 0D, 1D, 2D and 3D nanomaterials; Properties at nanoscale: electrical, optical, mechanical, Energy at nanoscale – Surface energy, The Material Continuum-Basic quantum mechanics; Different classes of Nanomaterials – Metal and Semiconductor Nanomaterials, Quantum Dots, Wells and Wires, Molecule to bulk transitions, Bucky balls and Carbon Nanotubes, Nanofabrication and Synthesis of nanomaterials: "Top-down" approach: Nanolithography, CVD, MEMS; "Wet deposition" techniques (LB, spincoating, dip-coating); "Bottom up approach" – Sol-gel processing, colloidal, nanoparticles, organic nanomaterials and self assembly

Characterization of nanomaterials; Analysis and metrology techniques in nanotechnology; Diffraction techniques, spectroscopy and modeling; Imaging techniques: Scanning and transmission electron microscopy; Scanning probe microscopy – atomic force microscopy; Traditional surface and materials analysis techniques, industry applications: Nanomaterials in consumer markets, Electronics, photonics: solar energy conversion, storage and catalysis, nano-opto, MEMS, NEMS, Microarray, nano-bio applications, Computing technologies - present and future, Nano medicine; MEMS - Micro Electro Mechanical Systems: Overview and history of development; Industry applications, Challenges and future development

Carbon Nanotube Technologies (CNT): From graphite to buckyballs to CNT, Carbon nanotube applications and MWNT, Fabricating carbon nanotubes and nano-wall structures, Key applications of CNT and MWNT,semiconductors: Moore's Law, history 1950-2025; Materials requirements for silicon; Quantum effects - desired or not, Nanofabrication techniques in semiconductors, Quantum computing, Basic physics and Moore's Law, Quantum computing algorithms / quantum informatics, Quantum devices - e.g. quantum dots, Applications of qdots

References

1. *Hari Singh Nalwa, "Nanostructured Materials and Nanotechnology", Academic Press, 2002*
2. *G.L.Hornyak, J.Dutta, H.F.Tibbals, A.K.Rao, Introduction to Nanoscience, CRC Press, 2008, ISBN: 978-1-4200-4805-6*
3. *Ozin, Geoffrey A., Arsenault, André C., Cademartiri, Ludovico, Nanochemistry, Springer, 2nd ed., 2009, ISBN 978-1-84755-895-4*
4. *A.Nabok, Organic and Inorganic Nanostructures, Artech House 2005*
5. *C. Dupas, P. Houdy, M. Lahmani, Nanoscience: Nanotechnologies and Nanophysics, Springer-VerlagBerlin Heidelberg 2007*
6. *Jeremy Ramsden, Essentials of Nanotechnology, ISBN 978-87-7681-418-2*
7. *Carl C. Koch, Nanostructured Materials, Second Edition: Processing, Properties and Applications William Andrew Publishing Norwick, NY, USA, 2006. ISBN 10:0-8155-1534-0(0-1855)*

Intellectual Property Rights and Bioethics

Ethics, definition, ICMR guidelines for ethics in biomedical research, consent form, composition of ethics committee, Ethics at workplace, various scenarios, defining the moral standards of right and wrong, morals and laws, an organizational perspective, legal vs. ethical, ethics in business, ethics and profits, Bioethics, Case studies: ethics in life sciences, ethics in medicine, ethics in biotechnology, recombinant DNA, ethics in food biotechnology, agricultural biotechnology, environmental ethics, animal ethics, discuss moral righteous of an action, procedure or policy, moral wrongness of the action, philosophical Aspects of Intellectual Property Laws, Basic Principles of Patent Law, Patent Application procedure, Drafting of a Patent Specification, Patent, objects of patent law, benefits of patenting, remedies against infringement

Understanding Copyright Law, Basic Principles of Trade Mark, Requirements for registration for a trademark, copyright, assignment and transfer of copyright, copyright infringement, registration and piracy, Basic Principles of Design Rights, International Background of Intellectual Property, requirements of patentability, rights of patentee, patenting in biotechnology, patent search, patents from an international perspective, study of patents – Case studies, Biotechnology and the Law-Objective, Evolution, Basic Structure of Gene Techniques, Applications, Commercial Potential of Biotech Inventions, Rationale for Intellectual Property Protection. Patenting Biotechnology Inventions-Objective, Concept of Novelty, Concept of inventive step, Microorganisms, Moral Issues in Patenting Biotechnological inventions

Plant Varieties Protection-Objectives, Justification, International Position, Plant Protection in India, Protection of Geographical Indications-Objectives, Justification, International Position, Multilateral Treaties, National Level, Indian Position, Protection of Traditional Knowledge-Objective, Concept of Traditional Knowledge, Holders, Issues concerning, Bio-Prospecting and Bio-Piracy, Alternative ways, Protectability, Traditional Knowledge on the International Arena, at WTO, at National level, Traditional Knowledge Digital Library

References

1. *Frederic H. Erbisch, Karim M. Maredia, Intellectual property rights in agricultural biotechnology*
2. *Jonathan Morris -The ethics of biotechnology*
3. *Karla C. Shippey -A short course in international intellectual property rights*

Analytical Chemistry

Principle of Analytical Methods: Quantitative analysis, Precipitation, types of precipitates, impurities, co-precipitation, post-precipitation, conditions for participation, precipitation from homogeneous solution, Gravimetric determination of Fe, Ni and Cu, calculations, volumetric analysis: Acid base titrations, Indicators, Oxidation-reduction titrations, Complexation using ligands, complexometric titration with EDTA, metal ion indicators, spectrophotometry: Molecular Spectrophotometry: Absorption spectra, Lamberts Law, Beer's Law - Combined law equation, Derivations from Beer's Law, quantitative analysis, Spectrophotometer (UV and Visible)- Principle, single beam and double beam, factors influencing the absorption spectra, overview of empirical rules, solvent perturbation method; spectrofluorimetry: Principle and significance,ColorimetryAtomic absorption Spectrophotometry: Principle, instrumentation details, various interferences in atomic absorption spectroscopy and various applications of absorption spectroscopy in biotechnology

Spectrometry Principles, time and frequency domain, Ultraviolet-visible spectroscopy, solvent effects, Woodward rules, Infrared Spectroscopy : Interaction of infra-red radiation with molecules, Sources of IR Radiation, Spectral regions, Application of IR Spectroscopy to functional group analysis (-OH, -NH2, -CHO, -CO-R, -CONH), overview of different class of compounds and their IR spectra Mass spectrometry, mass spectrum, fragmentation patterns, isotopes in mass spectrometry, Ionization techniques, ESI-MS, MALDI –TOF, Tandem MS, applications in proteomics Raman Spectroscopy: Principle, factors deciding the spectra, Introduction to Raman scattering

Chromatography: Theory of chromatography, Retention, plate theory, separation with a stationary bed column, planar chromatography, paper chromatography, RF value, thin layer chromatography, identification of spots by spraying and other methods Gas Chromatography: Principle, stationary phase for column, mobile phase, chromatogram, qualitative analysis, quantitative analysis, retention time, retention volume, capacity factor, area, normalization method, HPCL: Principles of high performance liquid chromatography, stationary phases, eluting solvents, quantitative applications, Interface of mass-spectra with liquid and gas chromatography (LC-MS and GC-MS), X-ray crystallography and X-ray diffraction X-ray diffraction and Bragg's law, crystal systems, point groups and space group, application for molecular structure determination, nuclear Magnetic resonance :Chemical shifts, coupling constants, Karplus equation and torsion angles, application to structure determination of biomolecules, phenomena of resonance, diamagnetic shielding, anisotropy, free induction decay (FID), population distribution of nuclei, and prediction of NMR spectra on the basis of (n+ 1) rule for basic class of compounds, Overview of electron spin resonance spectroscopy (ESR) and magnetic resonance imaging (MRI)

References

1. *R.A. Day & A. L. Underwood, Quantitative analysis, Prentice-Hall of India, 5th edition*
2. *J. Mendham, R.C Denny, J. D. Barnes, J.K.Thomas, Vogels Text book of Quantitative chemical analysis, Pearson education, 6th edition, 2002*
3. *WillandMerrit and Dean, Instrumental methods of analysis, Caps publications & Distribution, 1999*
4. *Chatwal&Anand, Instrumentation methods of analysis, Himalaya Publications, 2003*

5. *Principles of Analytical Chemistry by Vacarcel, Springer Publications, 2005*
6. *D Pavia, G Lampman, G Kriz,Introduction to Spectroscopy, Second edition (1996), Saunders Golden Sunburst Series*
7. *P Crews, J Rodriguez, M Jaspars, Organic Structure Analysis, (1998), OxfordUniversity Press*

Instrumentation and Process Control

Review of basic concepts Laplace transforms, solving differential equations, ideal forcing functions – step, impulse, sinusoid and their characteristics, Process variables, input variables, set point, Load variables,open Loop Systems:Open-loop systems, first order systems and their transient response for standard input functions, first order systems in series- Interacting and non-interacting system, linearization and its application in process control, second order systems and their dynamics, transportation lag

Closed Loop Systems: Closed loop control systems, Basic control actions-characteristics of two position, three positions, proportional, single speed floating, Integral and derivative control modes- PI, PD and PID control modes, development of block diagram for feed-back control systems, servo and regulatory problems, transfer function for controllers and final control element, transient response of closed-loop control systems,types of controllers and final control element: Principles of pneumatic, hydraulic and electronic controllers, problems on pneumatic, hydraulic and electronic controllers to realize various control actions, I/P Converter-pneumatic, electric and hydraulic actuators- valve positioner- control valves-characteristics of control valves - valve body-Globe, butterfly, diaphragm, Ball valves- Control valve sizing - Cavitation, flashing problem

Stability analysis: Stability of closed loop control system, Routh's test, Root locus analysis, Introduction to frequency response of closed-loop systems, control system design by frequency response techniques, Bode diagram, stability criterion, tuning of controller settings, Tuning process reaction curve method - continuous, oscillation method-damped oscillation method-problems,multi-loop Control Systems: Introduction to advanced control systems, cascade control, feed forward control, model predictive control, split range control, ratio control, and adaptive control, multivariate control of biochemical processes, control and automation of fermenter operation.Computer aided design of control systems Formulating process models, input-out models, state-space model, transfer function model, Computer aided design of control systems- use of MATLAB, Supervisory control (SCADA), introduction to neural and fuzzy control

References

1. *Pollard A. Heinemann, "Process control", Educational Books. London, 1971*
2. *Harriott P., "Process control", Tata McGraw- publishing Co.New Delhi. Reprint 1991*
3. *J. R. Leigh: "Modeling and control in bioprocesses"*
4. *Donald R. Coughanowr, "Process Systems Analysis and Control", McGraw-Hill, 1991*
5. *Eckman D.P., "Automatic process control", Wiley Eastern Ltd. New Delhi, 1993*
6. *Stephanoupoulis, G., "Chemical Process Control:, Prentice Hall, New Delhi, 1990*

Thermodynamics

Availability, Irreversibility and Second-Law Efficiency for a closed System and steady state Control Volume, Availability Analysis of Simple Cycles, Thermodynamic Potentials, Maxwell relations, Generalized relation for changes in Entropy, Internal Energy and Enthalpy, Generalized Relations for Cp and Cv, ClausiusClaypeyron Equation, Joule-Thomson Coefficient, Bridgman Tables for thermodynamic relations, different Equations of State, Fugacity, Compressibility, Principle of Corresponding States, Use of generalized charts for enthalpy and entropy departure, fugacity coefficient, Lee-Kesler generalized three parameter tables, Fundamental property relations for systems of variable composition, partial molar properities, Real gas mixtures, Ideal solution of real gases and liquids, Equilibrium in multi phase systems, Gibbs phase rule for non-reactive components

Thermo chemistry, first Law analysis of reacting systems, Adiabatic Flame temperature, Entropy change of reacting systems, Second Law analysis of reacting systems, Criterion for reaction equilibrium composition,microstates and Macrostates, Thermodynamic probability, Degeneracy of energy levels, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein Statistics, Microscopic Interpretation of heat and work, Evaluation of entropy, Partition function, Calculation of the Microscopic properties from partition functions, Collision Theory and Transport properties,conjugate Fluxes and Forces, Entropy Production, Onsager's Reciprocity relations,thermo-electric phenomena and formulations. Thermodynamics of High-Gas flow, thermodynamics of biological systems: Energy flows in biological systems, cellular thermodynamic reactions, thermodynamic cycles, Gibb's free energy and work obtainable from biological systems, study interactions between living organism and surrounding quantitatively

References

1. *Kenneth Wark Jr., Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 2001*
2. *Bejan, A., Advanced Engineering Thermodynamics, John Wiley and Sons, 1998*
3. *Holman, J. P., Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1998*
4. *Smith, J. M and Van Ness., H. C., Introduction to chemical Engineering Thermodynamics, Fourth Edition, McGraw-Hill Inc., 1987*
5. *Sonntag, R. E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991*
6. *Sears, F. W. and Salinger G. I., Thermodynamics, Kinetic Theory and Statistical Thermodynamics, third Edition, Narosa Publishing House, New Delhi, 1993*
7. *DeHoft, R. T. Thermodynamics in Materials SCBEnce, McGraw-Hill Inc., 1993*
8. *Rao, Y. V. C., Postulational and Statistical thermodynamics, Allied Publisher Limited, New Delhi, 199*

Strain Development

Economically important microorganisms, Industrial importance of microbial cultures, High Yielding and stable strains, maintenance and preservation of cultures for industrial use, industrial products produced by microorganisms - Enzymes (amylase, proteases), organic acids (lactic acid, citric acid, vinegar), amino acids (L-lysine, L-glutamic acid), food supplement and hormones. Production of important antibiotics - penicillin, streptomycin, erythromycin, bacitracin and tetracyclines, Production of Vitamins B12 & Ethyl alcohol, beer & wine.Baker's yeast production. Microbial transformation, Selective and enrichment techniques for isolation and screening of biotechnologically useful high yield microorganisms, Primary and secondary screening, Stability, Strain improvement through recombinant DNA technology, Bacterial genomes and basic functions, Mutations and phenotypes, Nature of mutations, mutagenesis, selection of mutants, Complementation and suppression, Transposes Conjugation Mechanisms of gene regulation

Techniques in molecular biology, Restriction enzymes, vectors for gene cloning, ligation, transformation, expression in various systems like bacteria, mammalian cells, Baculovirusetc, genomic and cDNA libraries, shotgun cloning, PCR cloning, Isolation screening and characterization of lipolytic, proteolytic, lignolytic, amylolytic microorganisms and enzymes such as cellulose, xylanase, laccase, etc, Screening of antibiotics producing bacteria from marine source and other sources, Bioassyas for new products, media optimization and yield improvement, metabolic pathways and metabolic engineering

Strain improvement: Isolation from natural habitats, Rational selection of habitats, Isolation techniques, Preliminary characterization, Growth curve, growth rate, doubling time, Substrate utilization rate, Screening based on product of interest, Culture preservation, Stability checking, Long term, short term, High throughput techniques, Non culturable microbes, Why Unculturable, How to utilize such microbes, Related techniques, Isolation of genes of interest without microbe isolation, Classical strain improvement, Mutagenesis, Physical and chemical mutagenesis, Random/rational screening, Stability check, Establishment of phylogeny of mutants, High throughput techniques, Culture preservation, Adaptation, Classical methods, Chemostat operations, Mutant mining, Advantages, Techniques

References

1. *Stanbury PF, Whitaker A and Hall SJ,Principles of Fermentation Technology, 1997, Elsevier.*
2. *S.N.Mukhopadyay,Process Biotechnology Fundamentals, Viva Books Pvt. Ltd. 2001*
3. *S SPurohit, Microbiology Fundamentals and Applications*
4. *Prescott and Dunn 1999. Industrial Microbiology 4th Ed., Cambridge Uni. Press*

Evaluation

1. The concerned course faculty will assess the candidate throughout the semester through quizzes/test/mid-term test/assignments etc. and submit the grades to the department
2. There shall be mandatory end semester theory examination of 100 marks of duration of three hours for each course

Optimization Techniques

Need of Optimization, Optimal Problem Formulation, Analytical Solving of Minimization Problem, Engineering Optimization Problems, Regression and Data Fitting

Single Variable Optimization: Optimality Criteria, Unimodal multimodal functions Bracketting Methods, Region Elimination Techniques, Golden Section Search, Fibonacci Search

Gradient Based Methods: Gradient Computation, Usefulness of Gradient Based Algorithms, Newtons Method, Bisection Technique, Secant Search, Practical Applications

Multivariable Optimization: Optimality Criteria for Multivariable Problems, Computation of Hessian Matrix, Unidirectional Search, Direct Search, Simplex Search Method, Hooke-Jeeves Pattern Search, Conjugate Gradient Direction Technique, Gradient Based Search, Steepest Descent Techniques, Multivariable Newtons Method, Marquardt's Technique, Conjugate Gradient Method

Constrained Optimization: Handling Constraints, Variable Elimination, Transformation Methods, Lagrange Multiplier Technique, Penalty Function Methods, Random Search, Kuhn-Tucker Conditions, Quadratic Programming

New-generation Global Optimization Tools: Genetic Algorithm, Working Principles, GA Operators, Real Coded GA, Multiobjective GA, Simulated Annealing, Particle Swarm Optimization, Ant Colony Optimization, Multi-criteria Multiobjective Problem Formulation, Pareto Optimization.

Course Outcome:

1. Understand basic mathematics and numerical aspects of optimization techniques.
2. Formulate objective functions of real-life problems.
3. Understand the concept of optimality criteria for various types of optimization problem.
4. Analyse optimization algorithms for Linear Programming
5. Solve various constrained and unconstrained nonlinear programming problems.
6. Apply the modern optimization methods and evolutionary techniques to provide optimal solution for a given problem.

Reference Books:

1. Edgar, T. F., Himmelblau, D. M., and Lasdon, L. S., "Optimization for Chemical Processes", 2nd Edition, New York, McGraw-Hill (2001).
2. Deb, K., "Optimization for Engineering Design: Algorithms and Examples", 2nd Edition, Prentice Hall of India, New Delhi (2012).
3. Rao, S. S., "Optimization Theory and Practice", 4th Edition, John Wiley and Sons, New York (2009).
4. Ravindran, A., Ragsdell, K. M., Reklaitis, G. V., "Engineering Optimization Methods and Applications", 2nd Edition, John Wiley and Sons, New York (2006)

5. Chong, E. K. P., Zak, S. H., "An Introduction to Optimization" 2nd Edition, John Wiley, New York (2001).
6. Fletcher, R., "Practical Methods of Optimization", John Wiley and Sons (1998).
7. Dutta, S., "Optimization in Chemical Engineering" Cambridge University Press (2016).
8. Roy, D. and Rao, G. V., "Stochastic Dynamics, Filtering and Optimization" Cambridge University Press (2017).

Biopharmaceutical Technology

1. **Process Principles of Biopharmaceutical Engineering**
   Pharmaceuticals, biologics and biopharmaceuticals; heat transfer and flow chemistry

   *Applied***:** Expression of recombinant systems, Upstream and downstream processing, Microbial cell fermentation; Vaccine technology; sophisticated tunnel systems, high speed vial washing, filling, stoppering and sealing machines.

2. **R&D Principles of biopharmaceutical technology**
   a. Design aspects: CADD for Biopharmaceutical: Challenges and Opportunities
      i. Biopharmaceutical delivery; Oral delivery systems, Pulmonary delivery, Nasal, trans mucosal and transdermal delivery systems; Injectables; Targeted delivery; Drug release
      ii. **Production of Final Product, Packaging Technology:** Final product formulation, Stabilizing excipients used in final product formulations, Analysis of the final product, Product potency; Packaging Materials used in Pharmacy; Types of Packaging; Equipments used in packaging of Pharmaceuticals
   b. Advanced Biopharmaceutical discovery tools: HPLC with PDA detector, Liquid Particle Counters, Capillary Zone Electrophoresis.
3. **Regulatory guidelines for Biopharmaceutical technology**
   a. cGMP regulations accredited by the World Health Organization, Geneva.
   b. International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use

References

1. Groves M, Pharmaceutical Technology
2. Gary Walsh, Biopharmaceuticals Biotechnology: Concepts and Applications, Wiley
3. DA Dean, ER Evans, IH Hall: Pharmaceutical Packing Technology, ISBN-10: 9780748404407
4. B. M. Mittal: Textbook of Pharmaceutical Formulation, 4th Edition, VallabhPrakashan, Delhi
5. Pharmaceutical Technology – Eugene Parrott
6. Pharmaceutical Dosage forms - Ansel - Popovich & Allen. (Text book) and Drug Delivery system - (Williams & Wilkins)

7. Handbook of packaging of medicinal devices – Dekker