VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM 59 014

BIO-TECHNOLOGY

MOLECULAR BIOCHEMISTRY

Types of chemical reactions, pH, buffers and their properties, concentration of solutions. Stereo chemistry of carbon compounds.

Carbohydrates, fats and lipids, structure and properties of phospholipids, glycolipids, steroids, amino acids and proteins. Biologically important peptides, purines, pyrimidines, nucleic Acids- DNA and RNA.

Introduction to enzymes, mechanism of enzyme action, kinetics and thermodynamics aspects of enzyme catalyzed reactions.

Biological membranes: structure, permeability, properties, passive transport and active transport, facilitated transport, energy requirement, mechanism of Na^+ / K^+, glucose and amino acid transport. Organization of transport activity in cell. Action Potentials. Role of transport in signal transduction processes.

Glycolysis –metabolism. Aerobic and anaerobic pathway and regulation, TCA cycle, NADPH Cycle, Calvin Cycle, Glyoxylate cycle, Pentose Phosphate Pathway. Electron transport chain and oxidative phosphorylation, energetics, energy balance sheet, oxidative stress. Gluconeogenesis –regulation of gluconeogenesis. Biosynthesis of polysaccharides. Disorders of carbohydrate metabolism.

Biosynthesis of fatty acids, cholesterol, phospholipids, glycolipids, biodegradation of fatty acids. Disorders of Lipid metabolism.

Biosynthesis of amino acids starting from acetyl CoA (with reference to oxaloacetate family). Biodegradation of amino acids, deamination, transamination and urea cycle. Disorders of amino acid metabolism.

Biosynthesis, biodegradation and regulation of Purines, pyrimidines and nucleic acids.
Disorders of nucleic acid metabolism.

CELL & MICROBIOLOGY

Eukaryotic and prokaryotic cells, Plant and animal cells, Principles of membrane organization. Cytosketal elements, Microtubules: structure & functions, shaping of the cells and mechanical support. Microfilaments: structure & functions. Strcuture of intermediate filaments. Cytoplasmic microtrabecular system (lattice). Covalent modifications of cytosketal proteins. Cytoskeletal architechture.

Types of cell functions, cell division, Mitosis and Meosis. Structure of cytolplasm, Nucleus, Mitochondria, Ribosome, Golgi bodies, Lysosomes. Endoplasmic Reticulum, Peroxisomes, Chloroplast and Vacuoles. Cell to cell integration, Cell locomotion (Ameoboid, Flagella, Cillar).

Hemopioesis, Erthropoiesis, Leucopoiesis, Components of blood plasma cell (R B C, W B C, Platelets).

Structure, Mechanism, Action of receptors (cytosolic, Nuclear, Membrane bound receptors) Autocrine, paracrine, Endocrine models, Action, Characterization of receptors. Plant growth factors and hormones - Auxins, Gibberlins, Cytokinins and others. Stoichiometry of cell growth and product formation.

The morphology and fine structure of Bacteria, Cultivation of Bacteria, Media and types of media Nutritional requirements, Reproduction and Growth, Factors affecting growth, Measurement of growth, Pure culture and cultural characteristics.

Structure, Classification, Modes of Reproduction and growth of Algae, fungi, protozoa and viruses.

Pure culture Techniques (streak-plate, spread plate, pour plate), Staining of Microorganisms (Simple staining, differential staining), types of stains, theories of staining, Enumeration of Microorganisms (Direct Microscopic Count, by Pour plate technique, Streak plate, membrane filtration, Electronic Methods, etc), Characterization: Biochemical tests and 16-s rRNA homology studies.

Control of Microorganisms by physical methods (heat, filtration, radiation), Control by chemical methods (phenol & phenolic compounds, Alcohols, Halogens, Dyes, Detergents, Aldehydes, Heavy metals, etc), Antibiotics and other chemotherapeutic agents.

Aerobic and anaerobic growth, Metabolic pathways, Primary and Secondary Metabolism.

GENETICS & GENETIC ENGINEERING

Concept of gene, Organization of genetic material in prokaryotes, organization of genetic material in Eukaryotes: Ultrastructure of Eukaryotic chromosomes, genomes in organelles - mitochondrial and chloroplast DNA.

Central dogma, updated central dogma, molecular structure of nucleic acids – structure & forms of DNA & RNA, Replication: structure & function of DNA polymerases, replication in prokaryotes and eukaryotes, replication of chromatin. Transcription - components of transcription machinery, RNA polymerases, processing of RNA. Transcription in prokaryotes & eukaryotes, genetic code. Translation – mechanism, post-translational modification.

Gene regulation in prokaryotes – Operon concept, Lactose and Tryptophan operon, Gene regulation in eukaryotes – Britten & Davidson model, mechanism of gene regulation in eukaryotes, control elements -enhancers & silencers.

Vectors in recombinant DNA technology, biology and salient features of vectors, types of vectors – plasmids, cosmids, phages and viruses, restriction endonucleases -classification, exo and endonucleases, modifcation enzymes - Polynucleotide phosphorylase, Kinases, phosphatases, Ligases. Gene transfer techniques, electroporation, micro projectile system, liposome mediated transfer,Ti plasmid mediated gene transfer and other methods, PCR, construction and screening of c-DNA.

Transgenic science in plant improvement, biopharming – plants as bioreactors, transgenic crops for increased yield, resistance to biotic and abiotic stresses. Techniques of gene mapping in plants. Marker-assisted selection and breeding for improvement. Biosafety regulations and evaluation of transgenics crops. Transgenic science for animal improvement, biopharming - animals as bioreactors for proteins, Gene mapping in farm animals. Marker-assisted selection and genetic improvement of livestock.

Developments in microbial biotechnology and Genetic manipulation, engineering microbes for the production of antibioties, enzymes, Insulin, growth hormones, monoclonal antibodies, clearing oil spills.

UNIT OPERATIONS

Units, Dimensions, Basic and Derived units, Dimensional homogeneity, Dimensionless numbers, Rayleigh method, Buckingham's pi theorem, Similitude, Geometric, Kinematics and Dynamic criteria.

Fluid definition and classification (Types of fluids – Newtonian and Non Newtonian); Pressure measurement; Types of flow - laminar and Turbulent; Reynolds number; Basic equations of fluid flow - Continuity equation and Bernoulli equation; Flow through circular and non circular conduits - Hagen Poiseuille equation; Flow past immersed bodies – Kozney-Karmen equation; Flow through stagnant fluids – Settling and sedimentation. Conceptual numericals.

Flow measurements – Orifice meter, Venturimeter, Rotameter. Pumps, Energy calculations, Centrifugal & Reciprocating pumps, Characteristics of centrifugal pumps. Conceptual numericals.

Size reduction and Sieve analysis ; Sedimentation – Equipments; Mixing – types of mixers, power number, power consumption in mixing operation; Filtration – constant rate and constant pressure filtration, filtration equipments. Conceptual numericals.

Modes of heat transfer ; Conduction – steady state heat conduction through uni-layer and multilayer walls; Insulation – types, critical thickness of insulation. Forced and Natural convection; Condensation – film wise and drop wise ; Thermal death kinetics; Heat transfer equipments – double pipe heat exchanger, shell and tube heat exchanger. Conceptual numericals.
Modes of mass transfer; Diffusion - Fick's law of diffusion. Measurement of diffusivity, Mass transfer coefficients and their correlations. Distillation – Methods of distillation, distillation of binary mixtures using McCabe Thiele method; Extraction. Conceptual numericals.

NEUROBIOLOGY

Organization of the nervous system macroscopic and histological features. Fine structural features of the nervous system, Cytogenesis of brain cells, Blood Brain Barrier - structural and functional aspects, Peripheral nerves - structure, development and diseases, Dystrophinopathies and congenital myopathies, Regeneration of the nervous system.

Signal transduction, Cellular neurochemistry, neurotransmitters and receptors, biochemical mechanisms of higher brain functions**.** Molecular Neurobiology. Synaptic transmission and cellular signaling, Neurotransmitter synthesis and Metabolism, Peptides and growth factors, Receptors, effector system, G-protein Intracellular messengers i) Phosphoinositides ii) Cyclic nucleotides & calcium

Energy metabolism/glycolysis, Lipids of CNS: Carbohydrates, proteins, amino acids, Neural processing and behavior, Endocrine effects on brain, Learning, memory and behavior, Biochemistry of CNS development, Biochemistry of ageing and age related disorders.

Inherited and Neurodegenerative diseases: Disorders and carbohydrate, lipids and Mitochondria metabolism, Disorders of muscle, Disorders of amino acid metabolism Disorders of basal ganglia, Biochemistry of dementia.

Neuronal membrane structure and ion permeability Resting and action potentials, Nernst equation, Goldman-Hodgkin-katz equation, erve conduction. Equivalent electrical circuits. Structure and properties of ion channels, voltage and patch clamp techniques. Basics of EEG and evoked potential Introduction to neural networks Role of ion-channels in brain pathology. Description of membranes, Diffusion, Facilitated transport, Nernst Equation, Donnan Equilibrium Neurons, Action Potential, Propagation of action potential, measurements in membrane biophysics, Synaptic transmission.

STRUCTURAL BIOLOGY

Primary structure and its determination, Secondary structure prediction and determination super secondary structure, Protein folding path ways, tertiary structure and domain in proteins, Quaternary structure.

Peptide synthesis, organization of amino acids in peptide chain, organization of peptide chain in protein, Ramachandran's plot. Determination of amino acid sequence- insulin. Proteins- Backbone dihedral angles and hydrogen bonding, Local determinants of folding, Folding kinetics, The Folding Landscape, The Levinthall Paradox; compensation of energy and entropy in the overall free energy, Hydrophobic bonding, likelihood potentials, and tertiary templates, Mutational analysis of protein folding: Kinetics and transition states. Quaternary structure: Hemocyanin, Nucleosome illustration of the functionality of broken symmetry, Conformational change I, Hemagglutinin pH transition, illustratation of conformational regulation and its use in infection, Quaternary constraints of oligomeric proteins. Fibrous proteins. Protein Degradation : Chemical aging, protein turn over in vivo, Mechanism of protein degradation, Proteases involved in protein turn over, Lysosomes, Ubiquitin mediated path way.

Protein stability and binding affinity in water and inside proteins. Cooperatively, binding and conformational free energies. Properties of proteins in aqueous solutions: isoelectric pH, acid base properties, electrophoretic mobility, influence of ionic concentration on the protein solubility, hydrolysis of proteins, denaturation and renaturation of proteins, protein stability Design and synthesis of peptides, use of peptides in biology, Methods of detection and analysis of proteins. Protein database analysis, Methods to alter primary structure of proteins. Examples of engineered proteins, protein design principles and examples.

Physics of Biomembranes: Plasma Membrane: Biochemical composition of plasma membrane, molecular organization, Isolation: Membrane proteins glycophorin, bacteriothodopsin, membrane bound enzymes-cell surface antigens, Molecular organization, freeze fracture technique and fluid mosaic model, lipid and protein fluidity and molecular mobility of proteins.
Components of membranes Lipids, Neutral Lipids Triglycerides. Cholesterol, Charged lipids (free fatty acids) phospholipids, glycolipids, polyisoprenoids, e.g. dolichol, Lipids-synthesis in SER and Golgi, translocation, Transport by carries (Mitochondria) and synthesis on Ribosome's
Membrane Proteins**:** Integral membrane proteins, types of anchoring domains, detergents, Peripheral membrane proteins, types of attachment to membranes Experimental ways of identifying PMPs, Glycoproteins, Glycolipids. Proteolipids, Lipid bilyer, fluid mosaic, Types of diffusion. Rotation, lateral translation in plane of lipid bilayer, flip-flop ("translocation"). Orientations of integral membrane

proteins, Type I, Type II. Multi-pass, Experimental methods, Functional properties of biological membranes. Closed compartments or microenvironments for specialized Reactions, sequential reactions, redox potential; Cytoplasmic, Luminal/intravesicular /extra cellular, Barrier to hydrophilic molecules Ions. Metabolites, ATP, cAMP, sugars, H+, nucleic acids, other small Molecules, Selective permeability.

General characteristics of nucleic acid structure, geometries, glycosidic bond rotational isomers and ribose puckering forces, stabilizing ordered forms (A, B and Z), base pairing, base stacking, tertiary structure of nucleic acids, Intra-molecular interactions in the double helix, Thermodynamics of melting of the double helix, kinetics of unwinding of the double helix, Interaction with small ions and DNA replication.

BIOSTATISTICS

Scope of biostatistics, definition, data collection, presentation of data, graphs, charts (scale diagram, histogram, frequency polygon, frequency curve, logarithmic curves).
Sampling & selection bias, probability sampling, random sampling, sampling designs. Descriptive statistics: Measure of central tendency (arithmetic mean, geometric mean, harmonic mean, median, quartiles, mode); Measure of dispersion (range, quartile deviation, mean deviation and standard deviation, coefficient of variation).

Correlation and regression analysis (simple and linear) curve fitting (linear, non-linear and exponential).

Axioms, models, conditional probability, Bayes rule, Genetic Applications of Probability, Hardy - Weinberg law, Wahlund's Principle, Forensic probability determination, Likelihood of paternity, Estimation of probabilities for multi-locus/multi-allele finger print systems. Discrete probability distributions - Binomial, Poisson, geometric – derivations. Central limit theorem. Continuous probability distribution – normal, exponential, gamma distributions, beta and Weibull distributions, T & F distributions.

Estimation theory and testing of hypothesis, point estimation, interval estimation, sample size determination, simultaneous confidence intervals, parametric and non-parametric distributions (T-test, F-test, Chi Squared distribution, goodness of fit test) analysis of variance (one-way and two-way classifications). Case studies of statistical designs of biological experiments (RCBD, RBD).

Sample surveys, comparisons groups and randomization, random assignments, single and double blind experiments, blocking and extraneous variables, limitations of experiments. Cigarette smoking, Lung cancer, endangered plants species, epidemics. Microbial Growth in a Chemostat, Growth Equations of Microbial populations, Models of Commensalisms, Mutualism, Predation and Mutation. Volterra's Model for n Interacting Species. Basic Models for Inheritance, Selection and Mutation Models, Genetic Inbreeding Models.

DEVELOPMENTAL BIOLOGY

Developmental biology (basics of sexual reproduction) - Gametogenesis: Spermatogenesis - formation of spermatids and spermiogenesis (details of spermiogenesis are not required). Ultrastructure of human sperm. Oogenesis. Generalized structure of ovum. Fertilization - Definition. Types - external and internal. Mechanism. Significance. Early development of frog - Structure of egg. Cleavage. Blastulation. Gastrulation. Derivatives of primary germ layers.

Human Reproduction: A brief account of Fertilization, Implantation, Placenta. Role of gonadotropins and sex hormones in males and females (meaning of menstrual cycle to be highlighted). Fertility control - Need for fertility control. Survey of family planning methods: Spacing methods (Barriers, IUDs, Hormonal and Physiological) and Terminal methods (Tubectomy and Vasectomy). Infertility control - Meaning and causes of infertility in males and females. Remedical methods (Assisted conception methods) - IVF,ET,GIFT and ZIET. (details of GIFT AND ZIFT not required). Sexually transmitted diseases - Meaning, causative organisms, mode of infection, symptoms and preventive measures of gonorrhoea, syphilis and AIDS.

Structure, chemistry, dynamics and regulation of sperm locomotion, capacitation and egg-surface targeting. Molecular biology, cytology and biochemistry of ovogenesis: Synthesis and storage of maternal transcripts, proteins and cell organelles. rDNA amplification in amphibia; transcription on lampbrush chromosomes, ovulation and hormonal control in mammals.

Molecular and cellular biology of fertilization: acrosome reaction and signal transduction, monospermy and species-specificity. Egg activation, early cleavages and blastocyst formation in mammals and biochemical and cellular changes during the passage down the oviduct to the uterus. Implantation and formation of the placenta in mammals Gastrulation in mammals-formation of primitive streak, morphogenetic movements and neural induction.

Organogenesis and foetal development Pattern forming genes and expression in Drosophila and mammalian embryos. Development of the mammalian brain-cerebral cortex-cell lineages. Lens development-fibre differentiation, programmed morphogenetic histogenetic cell death (apoptosis). Erythropoeisis, myelopoeisis. Ageing.

Recapitulation of Mendelian principles. Concept of a gene, multiple alleles, gene interactions Dominance. Chromosomal basis of inheritance: Consequences of chromosomal organization; segregation, linkage, linkage groups, recombination maps in diploids. Inheritance of quantitative traits, genetic basis and influence of

environment. Homeobox in the control of development of insects and vertebrates. Principles of population genetics: Hardy-Weinberg law and its application for autosomal genes. Organization and mutational analysis of *lac* and arabinose operons. Mobile genetic elements: Trasposons: Molecular basis of spontaneous and induced mutations.

BIOCHEMICAL ENERGETICS

Definition, energy, work, energy flow in the biological world (photosynthesis, respiration and biosynthesis). Biological work- chemical. osmotic and mechanical. Dissipation of energy. Size and immensity of biological energy cycle. Bioenergetics and metabolism- autotrophs, heterotrophs, carbon, oxygen and nitrogen cycles.

Laws of thermodynamics and energy transformations, standard free energy Change, phosohoryl group transfers and ATP, ATP in assembly of informational molecules, ATP in phosphoryl, pyrophosphoryl and adenylyl group transfers. Coupling reactions of ATP and NDP (Nucleotide di phosphate); photosynthesis, ancillary Pigments, Photosystems PS I & II; Biological oxidation reduction reactions, half reactions, dehydrogenations, standard reduction potentials, NAD^+ and FAD as universal electron carriers.

Gluconeogenesis. Glycogen metabolism, regulation of metabolic pathways, coordinated regulation of glycolysis and gluconeogenesis, coordinated regulation of glycogen synthesis and breakdown (cascade mechanism). Citric acid cycle, anaplerotic sequences, regulation of citric acid cycle. Glyoxalate cycle.

Miotochondrial electron transfer reactions. ATP symthesis, regulation of oxidative phosphorylation. Mitochondrial genes- their origin and mutational affects. Role of mitochondria in cellular apoptosis. General features of photophosphorylation, light absorption, electron flow and ATP synthesis.

Hormones- diverse structures and functions. Tissue specific metabolism- the division of labour, hormonal regulation of fuel metabolism (endocrine system of pancreas), diabetes mellitus and defects in insulin action/production.

Composition and architecture of membranes, micelles, bilayers, liposomes, integral and peripheral proteins membrane dynamics, solute transport across membranes-passive and active transport, glucose transporters, ABC transporters, aquaporins, ion selective channels- voltage gated and ligand-gated channels.

Molecular mechanisms in signal transduction- gated ion channels. Receptor enzymes. G protein-coupled receptors and secondary messengers.

BIOINSTRUMENTATION

Basic concepts of error, resolution, accuracy, precision, sensitivity, and calibration. Analysis and interpretation of data. Electrical quantities and Units. Static and Dynamic characteristics. Transducers for the sensing of strain, displacement, velocity, acceleration, pressure, flow, temperature, humidity, moisture content, and electromagnetic radiation. Signal conditioning for noise reduction and control. Operational amplifiers, filters, and bridges. Systems for data acquisition, telemetry, display, recording and processing. Microcomputer interfacing.

Instrumentation and principle of working: ultracentrifugation; Sedimentation equilibrium and sedimentation velocity methods, Analytical and Preparative centrifuges, application of density gradient and differential centrifugation.

Instrumentation and principle of working: Electrophoresis. Types of electrophoresis; Paper and gel electrophoresis, Immuno electrophoresis, isoelectric focusing, two - dimensional electrophoresis, capillary electrophoresis, PFGE.

Instrumentation and principle of working: Paper, TLC, gas chromatography, gel filtration, ion-exchange chromatography, affinity chromatography and HPLC.

Instrumentation and principle of working: Transmission and Scanning Electron Microscopy, Tunneling Electron Microscopy, Atomic Force Microscopy.

Instrumentation and principle of working Stop flow measurements, Rayleigh Scattering, X-ray crystallography, NMR, MRI, Neutron Scattering, Luminescence, UV, Visible, CD, IR, laser- Raman, ESR/EP, Mass Spectroscopy.

Instrumentation and principle of working: Radio tracers, GM Counter, Proportional and Scintillation Counters, autoradiography, radio - immunoassay, enzyme linked immunosorbant assay (ELISA).

BIOPROCESS PRINCIPLES

Fundamental and derived quantities, inter-conversion of units from one system to another (FPS, CGS, MKS, SI).

Concept of mole and Molecule, Composition of mixtures of Solids, liquids and gases. Composition of mixtures and solutions- Percentage by weight, mole and Volume; Normality, Morality, Molality, and ppm, pH and pK Buffer Calculations.

Material balances in Distillation, Absorption, Extraction, Crystallization, Psychrometry, Drying, Mixing and Evaporation Operations, Material balances involving bypass, recycle and purge.

Stoichiometry, Definitions of limiting and excess reactants, fractions and percentage conversion, yield and percentage yield, Selectivity and related problems. Fuels and Combustion: Ultimate and proximate analyses of fuels; calculations involving Excess air and Air-fuel ratio.

General energy balance equation for steady state. Thermo physics and Thermo chemistry: Heat capacity, estimation of heat capacity for solids, liquids, gases and their mixtures. Enthalpy, Standard Heat of formation, standard heat of reaction, Standard heat of combustion and calorific value, Calculation of Delta(H_R) at elevated temperature. Biochemical equilibrium constants and conversions.

Historical development of bioprocess technology; An overview of traditional and modern applications of biotechnological processes; Bioprocess principles and operations, Role of a bioprocess engineer in the biotechnology industry, outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses.

Generalized process flow sheets. Comparison of Process flow sheets and unit operations in chemical and bioprocess industries; General material balance equation for steady and unsteady states with a typical examples.

Introduction, definitions and determination of specific growth rate and yield. Stiochiometry of microbial growth and product formation.

NANOBIOTECHNOLOGY

A Brief History of the Super Small; Bottom-Up versus Top-Down; What Is Nano*bio*technology. Discussions on nanofabrication, nanolithography, nanobiotechnology, nanotubes, buckyballs, structure-property relationships in materials, materials characterization techniques, microelectronic fabrication, scanning tunneling and atomic force microscopy, biomolecule-surface interactions, DNA microarrays, quantum dots, and hybrid biological/inorganic devices.

Introduction and Overview of BioMEMS, Biosignal Transduction Mechanisms, Electromagnetic Transducers: Basic Sensing Mechanisms, Basic Actuating Mechanisms, Case Studies in Biomagnetic Sensors; Mechanical Transducers: Basic Sensing Mechanisms, Basic Actuating Mechanisms, Case Studies in Microfluidic Devices; Chemical Transducers: Basic Sensing Mechanisms, Basic Actuating Mechanisms; Optical Transducers: Basic Sensing Mechanisms, Basic Actuating Mechanisms, Fluidics, Ultimate Limits of Fabrication and Measurement, Recent Developments in BioMEMS.

Manufacturing, Diagnostics and Sensors, Drug Delivery, Valuing Nanobiotechnology, Nanobiotechnology Overview, Drug Delivery Revenues, Biosensors Revenues, Drug Delivery, Nanobiosensors, Health Risks, and Challenges. Fullerenes, Carriers, Dendrimers, Nanoparticles, Membranes / Matrices, Nanoshells, Quantum Dot Nanocrystals, Nanotubes, Targeting and Functionalization, Leading Segments of Nanobiotechnology, Leading Applications of Nanobiotechnologies, Drug Delivery, Drug Delivery Applications, Bioavailability, Suistained and targeted release, Nanorobots, Benefits of Nano-Drug Delivery, Drug Discovery Using Nanocrystals, Drug Discovery Using Resonance Light Scattering (RLS),Technology, Rapid *Ex-Vivo* Diagnostics, Benefits of Nano-Imaging Agents, Nanoscale Biosensors, Nanosensors in Drug Discovery, Nanosensors as Diagnostics, Nanotherapeutics.

BIOPHYSICAL TECHNIQUES

Diffusion and Osmosis, Osmotic pressure, osmolarity of fluids and electrolyte balance. Donnan membrane equilibrium, dialysis. Viscosity, Measurement and applications, Surface tension, Measurements and viscosity of blood. Electrochemical Techniques - principles of redox reactions.

Centrifugation principles, basic principles and laws of sedimentation. Preparative and analytical ultracentrifuges. Sedimentation equilibrium methods. Types of separation methods in preparative centrifuges. Differential and density gradient centrifugation. Analysis of sub-cellular fractions. Estimation of purity of macromolecules and detection of conformational changes. General approaches to biochemical investigations. Organ and tissue slice technique. Cell disruption and homogenizing techniques. Cell sorting and cell counting. Cryopresevation. Microscopy, Cytophotometryand Flow cytometry, manometric techniques.

Theory and practice, column chromatography, column efficiency and resolution. Types of adsorption chromatography- hydroxyapatite chromatography and hydrophobic-interaction chromatography (HIC). Types of partition chromatography- normal phase and reverse phase- liquid chromatography, chiral and counter current chromatography. Paper chromatography, ion-exchange chromatography. Exclusion chromatography, chromatofocussing, affinity chromatography. Principles and application of GLC, LC, LPLC and HPLC. Selection of chromatographic systems.

Electrophoretic principles, support media, factors affecting electrophoresis. Types of electrophoretic techniques-zonal and disc electrophoresis. High and low voltage electrophoresis. Principles and applications of PAGE. Isoelectric focusing, Isotachophoresis, PFGE and capillary electrophoresis. Electrophoresis of proteins and nucleic acids.

Absorption Spectroscopy basic principles, analysis of biopolymers, effects of absorption, basic laws of light absorption, optical rotatory dispersion, circular dichroism, Rayleigh Scattering, Size and shape of Macro molecules, Method of Direct visualization, Macro molecules as Hydro dynamic particles, Macro molecular Diffusion, Ultra centrifugation, Viscometry, X-ray crystallography (Determination of 3D structure By X-ray Diffraction) single crystal diffraction, Fibre diffraction, NMR spectroscopy (3D structure determination), of biological systems, Electron Microscopy, Neutron Scattering, Light Scattering, Luminescence, optical activity, Magnetic optical activity, IR, laser- Raman and ESR/EPR Mass Spectroscopy.

Basics and fluorescence-emission spectrum, Stokes' shift, quenching of fluorescence, fluorescence lifetime, fluorescence quantum yield-method of determination, anisotropy, environmental influence on fluorescence properties and instrumentation - Fluorophores (Intrinsic, extrinsic, membrane and protein probes, DNA probes and biochemical Sensing probes) Fluorescence quenching (protein accessibility, membrane quenching) Energy transfer- (FRET, protein folding, energy transfer in membranes, biopolymers, energy transfer and DNA hybridization)- protein fluorescence.

BIOSEPARATION PROCESSES

Distillation, Liquid - liquid extraction, Absorption and Adsorption, Crystallization, Centrifugation, Ultra Centrifugation, differential centrifugation, Centrifugation, Ultra Centrifugation, differential centrifugation, Dialysis, Salt Fractionation (Precipitation with Ammonium sulphate).

Partition chromatography - Single dimensional (Both Ascending and Descending) and two dimensional chromatography - Thin layer chromatography, Gas liquid Chromatography, Adsorption Chromatography: Adsorption column chromatographs and TLC. Ion Exchange Chromatography: cation Exchange and anion Exchange chromatography. Gel Filtration Chromatographs, Molecular Sieving, Molecular Exclusion Chromatography, Affinity Chromatography, High Performance liquid chromatography (HPLC).

Moving boundary electrophoresis, Zone Electrophoresis, Gel Electrophoresis, Continuous Gel Electrophoresis, Disc gel Electrophoresis, Agarose Gel Electrophoresis, Cellulose Acetate, Starch Gel and page (Polyacrylamide gel electrophoresis) and SDS - Polyacrylamide, High voltage electrophoresis, Isoelectric focusing, Immunoelectrophoresis.

Colorimeter and spectrophotometer, Beer – Lambert's law, Fluorimeter and flame photometry. Radio immuno Assay - Principle and applications. ELISA (Enzyme linked Immuno Sorbant Assay) - Principle and applications. Hydridoma Technology, Monoclonal antibodies - Principles and applications.

BIOMOLECULAR THERMODYNAMICS

System, Surrounding & Processes, Closed and Open systems, State and Properties, Intensive & Extensive Properties, State and Path functions, Equilibrium state and Phase rule, Zeroth law of Thermodynamics, Heat reservoir and Heat engines, Reversible and Irreversible processes.
General statement of First law of Thermodynamics, First law for Cyclic Process, Non-Flow Process, Flow process, Heat capacity.

P-V-T behaviour of pure fluids, equations of state and ideal gas law, Processes involving ideal gas law: Constant volume, constant pressure constant temperature, adiabatic and polytropic processes. Equations of state for real gases: Van-der Waals equation, Redlich- Kwong equation, Peng- Robison equation, virial equation. Discussions with respect to biological fluids.

Principles of corresponding states, Generalised compressibility charts. Heat effects accompanying Chemical reactions Standard heat of reaction, formation, combustion, Hess's law of constant heat summation, effect of temperature on standard heat of reaction.
General statements of the second law, Concept of entropy, The Carnot principle, Calculation of entropy changes, Clausius inequality, Entropy and Irreversibility, Third law of Thermodynamics.

Reference properties, energy properties, Derived properties, Work function, Gibbs free energy, Relationships among thermodynamic Properties: Exact differential equations, fundamental property relations, Maxwell's equations, Clapeyron equations, Entropy heat capacity relations, modified equations for internal energy (U) & enthalpy (H), Effect of temperature on U, H & Entropy (S), Relationships between C_p & C_v, Gibbs- Helmholtz equation. Fugacity: Fugacity, Fugacity coefficient, effect of temperature and pressure on fugacity, Determination of fugacity of pure gases, Fugacitities of solids and liquids, Activity: Effect of temperature and pressure on activity. Departure functions and generalized charts, thermodynamic diagrams.
Partial molar properties, chemical potential, fugacity in solutions, Henry's law and dilute solutions, Activity in solutions, Activity coefficients, Gibbs - Duhem equation, Property changes of mixing, excess properties.

Criteria of phase Equilibria, criterion of stability, Duhem's theorem, Vapour-Liquid Equilibria, VLE in ideal solutions, Non-Ideal solutions, VLE at low pressures, VLE at high pressures, Consistency test for VLE data, calculation of activity coefficients using Gibbs - Duhem equation, Liquid-Liquid Equilibrium diagrams. Liquid phase reactions, heterogeneous bioreaction equilibria, phase rule for reacting systems.

RNA & DNA TECHNOLOGIES

Nucleic acids: DNA - Occurrence, DNA as the genetic material (with the experiment of Avery as evidence), chemical composition, structure (Watson - Crick model), Semiconservative method of replication. RNA - Occurrence, chemical composition, brief account of structure and functions of genetic RNA, rRNA, mRNA and tRNA (clover - leaf model). Central dogma, updated central dogma, molecular structure of nucleic acids – structure & forms of DNA & RNA, Replication: structure & function of DNA polymerases, replication in prokaryotes and eukaryotes, replication of chromatin. Transcription - components of transcription machinery, RNA polymerases, processing of RNA. Transcription in prokaryotes & eukaryotes, genetic code. Translation – mechanism, post-translational modification.

Gene: The gene, the genetic code and genetic control of protein synthesis - Concept of gene (prokaryotic and eukaryotic), genetic code and its characteristics, genetic control of protein synthesis (transcription and translation) and Lac operon concept. Gene regulation in prokaryotes – Operon concept, Lactose and Tryptophan operon, Gene regulation in eukaryotes – Britten & Davidson model, mechanism of gene regulation in eukaryotes, control elements -enhancers & silencers.

Tools used in genetic engineering - Vectors (plasmid- pUC18), Enzymes (REN and Ligase), Host cell (E.coli) and Bioreactors. Recombinant DNA technology and its applications: Insulin synthesis to be used as an example. DNA fingerprinting, Gene therapy, Human genome project, Monoclonal antibodies.Improvement of crop plants: Breeding techniques; Tissue culture technique - organ culture example: stem; transgenic plants example: Golden rice. Improvement of animals: Breeding techniques and stem cell culture, transgenic animals example: Cattle. Hazards and safeguards of genetic engineering.

Early sequencing efforts. Methods of preparing genomic DNA for sequencing, DNA sequence analysis methods, Sanger Dideoxy method, Fluorescence method, shot-gun approach. Genome projects on *E.coli*., Arabidopsis and rice; Human genome project and the genetic map. Raw genome sequence data, expressed sequenced tags (ESTs), Gene variation and (Single Nucleotide Polymorphisms) SNPs, disease association, diagnostic genes and drug targets, genotyping - DNA Chips, diagnostic assays, diagnostic services; comparative genomics. Functional Genomics of the trans-proteome using genomes as the "glue" to connect disparate data. Studies with model systems such as Drosophila, Yeast or Celegans, for human disease and drug targets.

C-Values of genomes, Repetitive and coding sequences, Genetic and physical maps, breeding requirements for physical mapping, Methods of physical mapping – RFLP, RAPD and AFLP, Marker aided selection, Cloning of genes by map-based cloning, T-DNA tagging, Transposon tagging, Differential Screening of cDNAs, differential display via RT-PCR. Micro-array Techniques.

PROTEOMICS & PROTEIN TECHNOLOGIES

Proteins: Nature, types, structure, conformation, folding patterns, post-translational modification.
Primary structure and its determination, secondary structure prediction and determination super secondary structures, protein folding pathways, tertiary structure and domain in proteins, quaternary structure, methods to determine tertiary and quaternary structure, post translational modification.

Methods of protein isolation, purification and quantification; large scale synthesis of proteins, design and synthesis of peptides, use of peptides in biology, methods of detection and analysis of proteins. Protein database analysis, methods to alter primary structure of proteins, examples of engineered proteins, protein design, principles and examples. Protein structure prediction and modeling. Directed evolution and protein design, Protein complexes and aggregates, Multi-subunit proteins.

Production of recombinant proteins- Insulin, Coagulation factors, FSH, Thrombolytic agents vaccines- Polio vaccines and chicken pox vaccines, vitamins, Antibiotics and therapeutic hormones.

Proteomics - database subscription and protein drugs; Bioinformatics analysis - clustering methods. Proteome functional information, two hybrid interaction screens, Mass-spec based protein expression and post-translational modification analysis, "Protein Chip" interaction detection. Methods of measurement of mRNA expression, DNA array hybridization, Non-DNA array hybridization, Two dimensional PAGE for proteome analysis, Detecting proteins in polyacrylamide gels and on electroblot membranes, MS methods for protein identification and phosphorylation site analysis, Image analysis of 2D gels, High through put proteome analysis by stable isotope labeling, Automation in proteomics, Applications of proteome analysis to drug development and toxicology, Phage antibodies as tools for proteomics, Glycobiology and proteomics: Glycoanalysis in proteomics, Proteomics as tool for plant genetics and plant breeding. Host Guest Complexation chemistry, enzyme design using steroid templates.

BIOMATERIALS

Overview of Biomaterials and implant regulatory issues. Review of Cell and Tissue Structure and their Functions. Functional Requirements of Biomaterials and Tissue Replacements. Synthetic Biomaterials: Metals, Polymers, Ceramics, Gels, Hybrids, Sterlization Technology. Foreign Body Response, Biocompatibility and Wound Healing. Constitutive Behavior: Linear and Non-linear elasticity, rubber elasticity. Constitutive Behavior: Viscoelasticity. Multiaxial loading, yield and failure criteria. Biomechanical Issues: Design for bending/flexure, fatigue, fracture. Tribological issues: Surfaces, Lubrication, Friction, and Wear. Orthopedic Biomaterials: Requisite properties, Materials selection, Issues of wear, Case Studies. Dental materials: Implants, Coatings, Mechanical fixation. Cardiovascular Biomaterials: Tissue properties of blood vessels, Treatments of atherosclerosis; Biomechanical design issues pertaining to stents, balloon angioplasty, and pacemakers. Soft Tissue Reconstruction; Natural and Synthetic. Wound healing. Tissue ingrowths: Stability; Biofixation, Foreign Body response, Soft implants. Case Studies. Tissue Engineering: Current issues and Future Directions

Polymers as biomaterials, microstructure, mechanical properties – effects of environment on elastic moduli, yield strength and fracture strengths, sterilization and disinfections of polymeric materials. Biocompatibility of polymers, polymers as biomaterials, heparin and heparin-like polysaccharides, proteoglycans, structure and biological activities of native sulfated glycosaminoglycans, chemically modified glycosaminoglycans, heparin like substances from nonglycosaminoglycan polysaccharides and microbial glycosaminoglycan, surface immobilized heparins.

Medical devices and biomaterials, high performance polyurethane elastomers, applications of polymers in medicine and surgery. Skin graft polymers, biodegradable polymers in drug delivery and drug carrier systems.

Properties of implant materials, metals and alloys, polymers, ceramics and composites, qualification of implant materials, goal of clinical trials, design and conclusion of clinical trials.

BIOMODELING & DRUG DESIGN

Scope and application of modeling in modern biology. Amino Acid Building Blocks, Rotameric Structures Protein Conformation Framework, Ramachandran Plots, Conformational Hierarchy, Structural motifs. Basic Building Blocks, Conformational Flexibility, Canonical DNA Forms, DNA Sequence Effects. Introduction to graphic representation, Representation of molecular structure: both small molecules and macromolecules Database of macromolecular structures. Usages of freely available visualization packages like VMD, Rasmol, Pymol, SpdbViewer , Chime, Cn3D. First principle methods for predicting protein structure, comparative modeling, threading, CASP, Protein folding theories. Different types of interactions and formulation of forcefield. Basic algorithm of QM, MM and MC and their utilities. Basic MD algorithm, Its limitation, treatment of long range forces. Systematic methods of exploring conformational space. Molecular modeling in drug discovery, molecular docking, quantitative structure-activity relationship

Generation of Rational Approaches in Drug Design, Molecular Modeling: The Second Generation, Conceptual Frame and Methodology of Molecular Modeling, The Field Currently Covered, Importance of the "Bioactive Conformation", Molecular Mimicry and Structural Similarities, Molecular Mimicry, Structural Similarities and Superimposition Techniques, Rational Drug Design and Chemical Intuition, An Important Key and the Role of the Molecular Model, Limitations of Chemical Intuition Major Milestones and Future Perspectives.

Constructing an Initial Model, Refining the Model, Manipulating the Model, Visualization. Structure Generation or Retrieval, Structure Visualization, Conformation Generation, Deriving Bioactive Conformations, Molecule Superposition and Alignment, Deriving the Pharmacophoric Pattern, Receptor Mapping, Estimating Biological Activities, Molecular Interactions: Docking, Calculation of Molecular Properties, Energy Calculations (no derivation), Examples of Small Molecular Modeling Work, Nicotinic Ligands, Sigma Ligands, Antimalarial Agents.

Introduction, Basic Concepts, Molecular Recognition by Receptor and Ligand Design, Active Conformation, Approaches to Discover New Functions, Approaches to the Cases with known and unknown receptor structure.

Program GREEN Grid: Three - Dimensional Description of Binding Site Environment and Energy Calculation, Automatic Docking Method, Three-Dimensional Database Search Approaches, Automated Structure Construction

Methods, Structure Construction Methods with known Three-Dimensional Structure of the Receptor, Structure Construction in the case of Unknown Receptor Structure. Scope and Limitations, Points for Consideration in Structure, Construction Methods, Handling of X-Ray Structures of Proteins, Future Perspectives, Types of programs available for molecular modeling- scope and limitations- interpretation of results.

The Drug Development Process, Introduction, The Discovery and Development Process, New Lead Discovery Strategies, Composition of Drug Discovery Teams, The Practice of Computer-Assisted Drug Discovery (CADD), Current Practice of CADD in the pharmaceutical Industry, Management Structures of CADD Groups, Contributions and Achievements of CADD Groups, Limitations of CADD Support , Inherent Limitations of CADD Support, State of Current Computational Models, Software and Hardware Constraints.

BIOREACTOR ENGINEERING & DESIGN

Fermentation Process – General requirements of fermentation Process; An overview of aerobic and anaerobic fermentation processes and their application in industry.

Basic design and construction of fermenters and its ancillaries; Material of construction, Vessel geometry, Bearing assemblies, Motor drives, Aseptic seals; Flow measuring devices, Valves, Agitator and Spurges Design, Sensor.

Medium requirements for fermentation processes – examples of simple and complex media; Design and usage of commercial media for industrial fermentations; Thermal death kinetics of microorganisms; Batch and continuous heat – sterilization of Liquid media; Filter sterilization of liquids.

Stoichiometry of Cell growth and Product formation – Elemental balances, available- electron balances, degrees of reduction; yield coefficients of biomass and product formation; maintenance of coefficients; oxygen consumption and heat evolution in aerobic cultures.

Phases of cell growth in batch culture; Simple unsaturated kinetic models for microbial growth; growth associated and non-growth associated product formation kinetics; Mono and Leudekng – piret models; Introduction to structured models for growth and product formation.

Mass transfer in heterogeneous biochemical reaction systems; Oxygen transfer in submerged fermentation processes; Oxygen uptake rates and determination of oxygen transfer coefficients (k_La); role of aeration and agitation in oxygen transfer. Heat transfer processes in biological systems.

Operational models of reactors, - Batch, continuous, Fed Batch, repetitive batch, recycle and continuous cultivation; Novel bioreactors; Stirred tank, Air lift & Loop reactors, Packed bed and Hollow fiber membrane bioreactors, Bioreactors for waste treatment processes; Scale-up of bioreactors, SSF bioreactors.

BIOSENSORS: DESIGN & APPLICATIONS

Overview of biosensors, History, concepts and applications. Bioinstrumentation and bio-electronic devices, Fundamental elements of biosensor devices and designs. Molecular recognition: Enzymes, Antibodies and DNA. Modification of bio-recognition molecules for selectivity and sensitivity. Kinetics and thermodynamics of bio-recognition reactions. Applications of Biosensor-based instruments to the bioprocess industry. Target analysis, various recognition, signals, and device types.

Considerations, calibration, dynamic Range, signal to noise, sensitivity, selectivity, interference. Fundamentals of surfaces and interfaces, Electrochemistry for biosensors, Principles of potentiometry and potentiometric biosensors; amperometry and amperometric biosensors; Voltammetry: principles and techniques; Bio-electrochemistry and direct biosensors, Electrical and Electrochemical Impedance: Principles and Applications. Conductimetric and Impedimetric Biosensors.

Enzyme sensors, affinity sensors: antibodies, oligo-nucleotides, measuring binding in affinity sensors, SPR, quartz crystal microbalance, FRET, Membrane protein sensors: ion channels, receptors, whole cell sensors – bacteria, yeast, mammalian cells, non-biological and bio-mimicry: molecularly imprinted polymers, non-biological organic molecules, electro-chemiluminescence, pH sensors, artificial receptors

Immobilization: adsorption, encapsulation - (hydro-gel, sol-gel glass, etc.), covalent attachment, diffusion issues

Optical Biosensor, Microlithography for biosensors, FETS and Bio-FETS, MEMS and Bio-MEMS. Lab-on-a-chip: TAS and m-TAS devices, Sensors based on Fiber Optic, Surface Plasmon Resonance (SPR) biosensors, Surface Characterization of Hybrid Bilayer Membrane Sensors, Quartz Crystal Nanogravimetry (QCN) biosensors, quantum dots, magnetic beads, PEBBLE sensors, Coupled mass transport and kinetics of enzyme-catalyzed and molecular binding reactions, Biosensor Arrays and Chemometrics, Multi-element array biosensors: electronic nose and electronic tongue, Signal Processing and Data Fusion for Biosensors

Measuring complex samples, multi-analyte detection, continuous measurements, reagent less biosensors, implantable sensors, biocompatibility issues.

Applications of biosensors in Agriculture, food safety, food processing: state of the field, market potential, unique design criteria and needs. Biomedical sensors:

Microfabricated Sensors and the Commercial Development Of the i-Stat Point-Of-Care system, Noninvasive Biosensors in Clinical Analysis. Applications of Biosensor-based instruments; Blood chemistry sensors, sensors for Genetic testing, Physical sensors, Electrical sensors: Electrocardiographs Electroencephalograph etc., Electrosurgical equipments. Applications of biosensors in Bio-security, environmental : state of the field, market potential, unique design criteria and needs, current sensors in use.

FOOD BIOTECHNOLOGY

History of Microorganisms in food. The Role and Significance of Microorganisms, Primary Sources of Microorganisms found in Foods, Types of Microorganisms in Foods.
Synopsis of Common Food-borne bacteria, Synopsis of Genera of Molds Common to Foods, Synopsis of Genera of Yeasts Common to Foods.

Culture, Microscopic, and Sampling Methods, Conventional; SPC, Membrane Filters, Microscope colony Counts, Agar Droplets, Dry Films, Most probable Numbers (MPN), Dye-reduction, Roll Tubes, Direct Microscopic Count (DMC), Microbiological Examination of surfaces, Air Sampling, Enumeration and Detection of Food-borne Organisms.

Microbial Spoilage of Vegetables, Fruits, Fresh and Processed Meats, Poultry, and Seafood. Spoilage of Miscellaneous Foods, Food Preservation, Rheology of Food Production, Food Preservation Using Irradiation, Characteristics of Radiations of Interest in Food Preservation., Principles Underlying the Destruction of Microorganisms by Irradiation, Processing of Foods for Irradiation, Application of Radiation. Legal Status of Food Irradiation, Effect of Irradiation of Food constituents; Food Preservation with Low Temperatures, Food Preservation with High Temperatures, Preservation of Foods by Drying.

Characteristics of Food Industry. Food manufacturing & processing, common additives, bioorganic additives, spoilage, prevention of spoilage, storage and preservation through biotechnological means, food packaging. Factors influencing food product development, marketing, and promotional strategies. Food Industry: Nutrition value, basal metabolic rate, influences on nutritional status, dietary strategies for individuals, diet for specific groups, Market Place, ecologically sustainable production, risks and benefits of biotechnology to food industry.

CYTOGENETICS AND PLANT BREEDING

Ultra structure of prokaryotic and eukaryotic cell, differences in plant and animal cells, cell differentiation in plant and animal cells. Special types of cells: muscle, nerve, and gland cells, types of blood cells and their function. Cellular organelles: Structure and function – Cell wall, Plasma membrane, Endoplasmic reticulum, Golgi complex, Mitochondria, Chloroplast, nucleus, Ribosome, Peroxisomes and Vacuoles

Cell cycle. Morphology of chromosomes, Molecular structure of chromosomes, Nucleosome – solenoid models; chromosome banding, chemical constitution of chromosomes, Eu and heterochromatin, cell cycle; Cell division: cell differentiation, cell death, mitosis, meiosis. Physical location of gene, chromosomal theory of inheritance.

Physical basis of heredity, genes as determinants of inherent properties of the species, genetic variation, demonstration of genetic segregation, genes & phenotypes, linkage of genes, recombination, genetic mapping, calculation of map distance, mapping genes by mitotic segregation and recombination, mapping by *in situ* hybridization, Chi-square test and probability.

Introduction to plant breeding: Historical concepts, strategy and objectives. Evolution of crop plants, plant genetic resources, agencies in plant breeding; self- and cross-pollinated crops, Gene recombination in plant breeding - Mendelian heredity, progeny test, testcross, backcross. Quantitative inheritance in plant breeding - Types of variations, qualitative and quantitative characters and their inheritance, types of gene action, heritability estimates, genetic advance, Hardy-Weinberg law. Inbreeding, parent selections and hybridization - Consequences of inbreeding, sources of germplasm and hybridization techniques, Doubled-haploid (DH) breeding – Induction of haploids, Backcross and multiline breeding – General features of backcross, recurrent and donor, parent, backcross procedure. Multiline – purpose and method of development, isolines. Use of modern techniques in plant breeding – Molecular markers, biotechnology.

PHARMACEUTICAL BIOTECHNOLOGY

Introduction to pharmaceutical biotechnology, Pharmaceutical Industry. Drug design, development and Economics, Fundamental principles and practical processes involved in preclinical and early proof-of-concept clinical development of a chemical or biological entity. Orphan drugs Provisions for and use of unlicensed medicines, Drug abuse and dependence, Prescription and Non-prescription drugs.

Evolution of Drug Metabolism As A Science, Phase I Metabolism (microsomal oxidation, hydroxylation, dealkylation) Phase II Metabolism (Drug conjugation pathway) CYP Families.Pharmacodynamics and Pharmacokinetics of protein based drugs. Physiologic Pharmacokinetic Model, Mean Residence Time and Statistical Moment Theory Molecular Mechanism of Drug Action

Basic concepts in toxicology, the mechanism of toxin action, The biotransformation of toxins, their inactivation and removal from the body, Reactive intermediates

Definitions, historical use and applications, composition, preparation, physicochemical considerations, short study of current biotech products , quality control, storage and stability of biotech products. Preformulation Testing, Concept of preformulation, and their parameters Tablets, compressed tablets, tablet granulation, Coatings, Pills , Parenteral preparations, Oral liquids, Ointments.

Advanced Sustained Release Drug Delivery System, Advanced drug Delivery Systems, Liposomes and Nanoparticles Drug Delivery System, Biodegradable Drug Delivery System, Hydrogel based Drug Delivery System

Vitamins Cold remedies Laxatives Analgesics, Non-steroidal contraceptives, External antiseptics, Antacids , Antibiotics, Biologicals , Validation Techniques for pharmaceutical industries Pilot Plant Scale-Up Techniques Analytical methods and tests for various drugs and Packaging techniques – Glass containers, plastic containers, film wrapper, bottle seals. Quality assurance and control.

Introduction to pharmaceutical chemistry, classification of drugs based on therapeutic actions using suitable examples. Antineoplastic agents, Immunomodulators, Heavy metals and heavy metal antagonists, Therapeutic gases. Free radical biology and antioxidants, Pharmacotherapy of migraine, Drug therapy in Alzheimer's disease and male sexual dysfuntion. Hormone replacement therapy.

BIOPROCESS CONTROL, AUTOMATION & OPTIMIZATION

Instrumentation, Introduction to flow, pressure, temperature and level measurements, methods of on-line and off-line measurements of cells, substrates and products, microbial caloriemetry, parameter estimation techniques for biochemical processes.

Process characteristics, I order system – examples, mercury in glass theromometer, level, lineraisation, composition, I order system in series, interacting and non-interacting systems. Second order system with under damping, derivation of transfer function for various systems, dead time response of I and II order overdamped and underdamped systems, to step, ramp, impulse (pulses) and sinusoidal changes.

Controllers and final control elements, controllers – discontinuous and continuous, two position floating, single and multiple feed, proportional speed floating (integral), Proportional + Reset (P+I); Proportional + Rate (P+D); Proportional + Reset + Rate controller (PID);

Actuators, positioners, valve body, value plugs, characteristics, final control elements. Block diagram of reduction block diagram for servo and regulator problems. Transient response of I and II order processes for set point changes and load changes with proportional, PI, PD, and PID controllers.

Introduction to frequency response, concepts of stability, Routh test for stability, stability criteria, root locus method, Bode plots and stability criterion, tuning of controllers.

Dynamics and control of bioreactors & sterilizers. On-line data analysis for measurement of important physico-chemical and biochemical parameters, methods of on-line and off-line biomass estimation, flow injection analysis for measurement of substrates, products and other metabolites, state and parameter estimation techniques for biochemical processes.

Optimization fundaments, Fibonacci and golden search algorithms. Polynomial approximation methods. Method based in the gradient of the function. Applications to Biochemical engineering problems. Methods of direct search: simplex algorithm. Methods based on the function gradient. Quasi-Newton methods. Applications to the Biochemical engineering problems. Problem design. Linear programming. Dual theory. Non-linear programming. Lagrange multipliers, penalty functions. Applications to the Biochemical engineering problems. Quadratic programming. Integer programming, Multi objective problems.

AGRICULTURAL BIOTECHNOLOGY

Applications of plant transformation technology for productivity and performance, disease resistance, genes and gene constructs used for viral resistance by coat protein mediated production, bacterial resistance by lysozyme gene and fungal resistance by chitinase and beta glucanase genes. Agrobacterium mediated tranformation. Crop improvement to resist adverse soil conditions. Salinity tolerance, drought resistance. Herbicide resistance in commercially important plants. Insecticide resistance through Bt-gene. Integrated pest management. current status of Bt crops in the world. Effect of transgenic crops on environment.

Introduction to plant cell culture. Explant selection, sterilization and inoculation; Various media preparations; MS, B5, SH PC L-2; Callus and cell suspension culture; plant regeneration: organogenesis. Somatic embryogenesis; somaclonal variation, its genetic basis and application in crop improvement. Role of tissue culture in rapid clonal propagation, production of pathogen - free plants and "synthetic seeds"; haploid production: advantages and methods. Protoplast technology.

Antisense RNA technology (ACC synthase gene and polygalacturonase) Delay of softening and ripening of fleshy fruits by antisense RNA for ACC synthase gene in tomato, banana. Use of antisense RNA technology for extending shelf life of fruits and flowers. Protection of cereals, millets and pulses following harvest using biotechnology. Biotechnology for fortification of agricultural products- Golden rice, transgenic sweet potatoes.

Importance of biofertlilizers in agriculture. (*Rhizobium, azatobacter, Mycorrhiza, Frankia* and Blue green algae) current practices and production of biofertilizers.

An overview of Legal and Socio-economic impact of Biotechnology. Biotechnology & hunger. Ethical issues associated with labeling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications.

MICROBIAL BIOTECHNOLOGY

Study of Prokaryotes & Eukaryotes, Classification and characteristics of Microorganisms, Bacterial nomenclature, Eukaryotic microorganisms-structure, reproduction (protozoa, yeast and filamentous fungi). Viruses- structure and replication.

Screening, Strain improvement, Scale up of fermentations, Inoculum preparations, Stock culture maintenance, Contamination problems in fermentation industry.

Production of single cell protein-Microorganisms and substrates used, techniques of production, nutritional value of SCP, economics of production, merits and demerits of SCP. Microbial insecticides-Candidates for developments for development into microbial insecticides, production of insecticides, evaluating potential hazards to man and environment, effectiveness, safety, economics, advantages and disadvantages. Production and applications of microbial polysaccharides-Xantham gum and Alginate.
Industrial production of: Microbial enzymes- glucose isomerase, cellulase, Microbial transformations of antibiotics and steroids. .Industrial production of distilled alcoholic beverages.

Bioremediation- Concept and principles, *in situ* and *ex situ* bioremediation, biosorption and accumulation of heavy metals, Biodegradation of hydrocarbons, crude oil degradation by bacteria, Methanotrophs, Genetic engineering of microbes for bioremediation. Sewage & Waster water treatment, Microbiological Degradation of xenobiotics.

Production of recombinant proteins- Insulin, Coagulation factors, FSH, Thrombolytic agents vaccines- Polio vaccines and chicken pox vaccines, vitamins, Antibiotics and therapeutic hormones.

ENVIRONMENTAL BIOTECHNOLOGY & BIODIVERSITY

Introduction to Ecology and Ecosystem. Concerns pertaining to Ecological damage. Environmental Pollution; Types; Water, Soil, Air, Noise and Thermal pollutions, their sources and effects. Ecological effects of pollutants on living and non-living systems. Environmental impact analysis. Soil erosion and sediment control. Acid rain: sources and solutions.

Types, Anaerobic treatment of wastes - Attached growth and other biological treatment process, Trickling filter. Biological treatment of recalcitrant compounds other biological processes, Lagoons, Bioremediation, Biological treatment of solid wastes and gases.

Biodegradation, Biodegradation of xenobiotic compounds, organisms involved in degradation of chlorinated hydrocarbons, substituted simple aromatic compounds, polyaromatic hydrocarbons, pesticides, surfactants and microbial treatment of oil pollution. Bioremediation and biorestoration of contaminated lands.

Environmental policies and regulations, Waste minimization, Plan of minimization of wastes Conservation of water and energy, Fugitive loss, Environmental Management Systems, Environmental Auditing, Other tools for environmental management, Environmental Impact Assessment, Programs of municipal pollution control, Risk evaluation and decision analysis. Sustainable development.

Status of biodiversity in India and the world, forest, water, soil, Food and agriculture resources, Functions of ecosystem, Major ecosystems, Energy and its flow in Ecosystem, Biogeochemical cycles and other nutrient cycles. Renewable and non-renewable resources. Conservation of Biodiversity: Role of Biotechnology in conservation of biodiversity. *Exsitu* and *insitu* conservation. Conservation programs.

PLANT DESIGN & ECONOMICS

Technical feasibility survey, process development, flow diagrams, equipment design and specifications.

Marketability of the product, availability of technology, raw materials, equipment, human resources, land and utilities, site characteristics, waste disposal, govt. regulations and other legal restrictions, community factors and other factors affecting investment and production costs.

Fixed capital investments including land, building, equipment and utilities, installation costs, (including equipment, instrumentation, piping, electrical installation and other utilities), working capital investments

Direct Production costs (including raw materials, human resources, maintenance and repair, operating supplies, power and other utilities, royalities, etc.), fixed charges (including depreciation, taxes, insurance, rental costs etc.).

Administration, safety and other auxiliary services, payroll overheads, warehouse and storage facilities etc.

Return on original investment, interest rate of return, accounting for uncertainty and variations and future developments.

Linear and dynamic programming, optimization strategies.

MEDICAL BIOTECHNOLOGY

Initial Differences Among Xenopus Blastomeres Arise from the Spatial Segregation, Inductive Interactions Generate New Types of Cells in a Progressively More Detailed Pattern, A Simple Morphogen Gradient Can Organize a Complex Pattern of Cell Responses, Cells Can React Differently to a Signal According to the Time When They Receive It: The Role of an Intracellular Clock, In Mammals the Protected Uterine Environment permits an Unusual Style of Early Development, All the Cells of the Very Early Mammalian Embryo Have the Same Developmental Potential, Mammalian Embryonic Stem Cells Show How Environmental Cues Can Control the Pace as well as the Pathway of Development, Summary.

Stem Cells Can Divide Without Limit and Give Rise to Differentiated Progeny, Epidermal Stem Cells Lie in the Basal Layer, Differentiating Epidermal Cells Synthesize a Sequence of Different Keratins as They Mature, Epidermal Stem Cells Are a Subset of Basal Cells, Basal Cell Proliferation Is Regulated According to the Thickness of the Epidermis, Secretory Cells in the Epidermis Are Secluded in Glands That Have Their Own Population Kinetics , Summary.

New Skeletal Muscle Cells Form by the Fusion of Myoblasts, Muscle Cells Can Vary Their Properties by Changing the Protein Isoforms That They Contain, Some Myoblasts Persist as Quiescent Stem Cells in the Adult, Summary.

The Connective-Tissue Cell Family Fibroblasts Change Their Character in Response to Signals in the Extracellular Matrix, The Extracellular Matrix May Influence Connective-Tissue Cell Differentiation by Affecting Cell Shape and Attachment, Different Signaling Molecules Act Sequentially to Regulate Production of Fact Cells, Bone Is Continually Remodeled by the Cells Within It, Osteoblasts Secrete Bone Matrix, While Osteoclasts Erode It, During Development, Cartilage Is Eroded by Osteoclasts to Make Way for Bone, The Structure of the Body Is Stabilized by Its Connective-Tissue Framework and by the Selective Cohesion of Cells, Summary.

Hemopoietic Stem Cell Disorders : Classification and manifestations Hemopoietic Stem Cell Disorders : A plastic Hemopoietic Stem Cell Disorders : Myleo dysplastic Myleo proliplastic Clinical applications of Colony Stems Complications of Germs therapy Replacement Therapy and Marrow Transplantation. Immunological principles, Preservation and Clinical use of blood and blood components, hemapheresis procedures and varies to oxiplantation.

AGRICULTURE ECONOMICS AND MARKETING

Role of agriculture in Indian Economy; Features of Indian Agriculture; Backward agriculture-Unprogressive character, Causes of backwardness; Measures for agricultural development; Progress of agriculture-Various planned efforts; Elements of progress; Unsatisfactory features.

Mechanising Agriculture- Implements in use; For and against mechanization; Scope for mechanisation; Green Revolution- Meaning and features; Impact and progress; An evalution; Causes of limited spread; Extending the green revolution.

Importance and present state-Manifold significance; Highly unsatisfactory state; Evil consequences; Improvements and Progress; Cooperative marketing-Important role; Progress; Suggested Improvements; Government's Policy-important role; Various measures.

Trends and causes- Rising and fluctuating prices; Causes of rise and fluctuations; Stabilization and Price-policy-Determining the level of stable prices; Role and functions of price-policy; Buffer-stocks and Imports- Buffer-stock operations; Imports; role and problems; Government's policy- Objectives and instruments; Evaluation of government's policy; Suggested improvements.

Need for special Programmes-Low economic level; Inadequacies of planning; various Programmes-Employment programmes; Area development Programme; Programme of land reforms; People's participation; significant achievements; Serious shortcomings.

ENTREPRENEUR DEVELOPMENT IN BT

General introduction to biotech industry. Scope. Trends and key issues in biotechnology industry. Organization, financing, policy, trends, problems and issues in the healthcare, pharmaceutical, Agri and other biotech industries. Overview of cost, quality, access issues.

Management Concepts and Functions. Development of Management Theories. The Internal and External Environments of the Organisation. Social Responsibility and Ethics in Management. Managerial Decision Making. The planning process. The nature of Organisation Structure. Organisational Control. Contemporary issues in Management. Management in Future. Concepts, structures & functions characterizing contemporary Biotechnology industries in India and other industrialized nations – model case studies. Management, Need of Managements, Leadership, Communication Skills for Management; audience awareness, style, individual and group presentations, conflict resolution. Logistics Systems Management; Control of the movement of goods; coordination of supply and demand and creation and maximization of time and place utility. Negotiation Strategies.

Mobilization of Financial resources; Bank loans & Venture capitalism. Concepts and techniques of accounting for planning, control, and motivation. Factors influencing capital acquisition and allocation. Financial decision making; Decision making under uncertainty; positive and normative models; Current issues in financial management.

Industrial R&D and product development. Product development and project management in Agri, Pharma, Health and other biotech industries. Overview of issues and techniques involved in conducting & outcome of research. The multidisciplinary nature of outcomes research: research design and methods, data collection measurement instruments and clinical endpoints, quality of life issues, behavior change, and cost-effectiveness. Analysis Transition from R&D to business units. Product development, market learning and transition from R&D. Management of radical innovation technologies vs. stage gate approach in product development. Case studies.

Introduction to the theory, concepts, skills, and principles of marketing. Business environment. User-oriented analysis of marketing research process, including problem definition, design, data collection, data analysis, interpretation, and presentation. Applications of the theory, concepts, skills, and principles of public relations in marketing. Development of a marketing management focus, including market analysis, competitive analysis, and decisions in pricing, product, promotion, and distribution channels. Study of marketing of goods and services to

business, institutions, and government. Marketing strategy for health, pharmaceutical, and other biotechnology products.

Rights and responsibilities of business under the Indian Constitutional system. Basic standards, rules, principles and issues relating to the law of corporations; core issues affect the corporate governance of business; relationship between management, boards and shareholders. Business laws applied to Biotech industries

Regulatory issues in Biotech industries with special reference to clinical trial of pharma products and field trials of Agricultural products. Regulatory processes details. Intellectual property in biotech. Business. Models around intellectual property, licensing issues. Product development for commercial ventures. Bioethics and Current legal issues. Ethics of new technology.

BIOTECHNOLOGY AND IPR

Introduction, Concept of Property, Mar'x theory on Property, Constitutional aspects of Intellectual property. Basic principles of Patent laws: Historical background in UK, US and India. Basis for IP protection. Criteria for patentability: Novelty, Utility, and Inventive step, Non obviousness, Non patentable invention.

Paris convention (1883), Berne convention for protection of literary and artistic works (1886), Patent Corporation Treaty (PCT), Madrid agreement (1891) and protocols of relative agreement 1989). Rome convention (1961) on the protection of performances, producers of phonograms and Broadcasting organization, TRIPS agreement (1994), WIPO performance and phonograms Treaty (WPPT, 1996).

Objectives, Evolution of Biotechnology, Application of Biotechnology, Commercial potential of BT invention, R & D investments, Rationale and applications. Concept of Novelty and Inventive step in BT, Micro organisms and BT inventions, Moral issues in patenting BT invention. Substantiation of Patent laws & international agreements related to pharma, microbial, environmental, agricultural and informatics sectors via classical case studies.

Introduction, Justification for plant variety protection, International position, UPOV, 1961, 1978, 1991 guidelines, Plant variety protection in India. Justification for geographical indications, International position, Multi-lateral treaties, National level, Indian position.

Concept of Traditional knowledge, holders, Issues concerning traditional knowledge, Bioprospecting & Biopyracy – ways to tackle, Protectability of traditional knowledge under existing IP framework, need for sui-generis regime, Traditional knowledge on the International arena, Traditional knowledge at WTO and National level, Traditional knowledge digital library.

BIOETHICS & BIOSAFETY

Public acceptance issues for biotechnology: Case studies/experiences from developing and developed countries. Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries. The Cartagena protocol on biosafety. Biosafety management: Key to the environmentally responsible use of biotechnology. Ethical implications of biotechnological products and techniques. Social and ethical implications of biological weapons.

The legal and socioeconomic impacts of biotechnology, Public education of the processes of biotechnology involved in generating new forms of life for informed decision making – with case studies.

Biosafety regulations and national and international guidelines with regard to rDNA technology, transgenic science, GM crops, etc. Experimental protocol approvals, levels of containment. Guidelines for research in transgenic plants. Good manufacturing practice and Good lab practices (GMP and GLP).

Environmental aspects of biotech applications. Use of genetically modified organisms and their release in environment. Special procedures for rDNA based product production.

Intellectual property rights (IPR), WTO-GATT, TRIPS, International conventions patents and methods of applications of patents. Plant breeder's rights. Legal implications, Biodiversity and farmers rights. Examples of patents in biotechnology. Special application of patent laws in biotechnology. Licensing and cross licensing. Flavr Savr ^{Tm} Tomato as model case and case studies.

Beneficial applications and development of research focus to the need of the poor. Identification of directions for yield effect in agriculture, aquaculture etc. Ethics & Biosafety aspects in Bioremediation.

RESEARCH METHODOLOGY

What is research? – Reflection, Science & Research. Basic & Applied Research, Steps in Research, Literature Collection: Review of literature, review process and bibliography, research/discriminative reading, consulting source material, Research Objectives and hypothesis, Research method and materials, Research action, Data collection and analysis plan, Research budget and resources.

Introduction – identification of the research question, hypotheses, and justification for the topic
Literature review – updated version of the initial literature review developed for the research proposal; should review in detail at least four analytical works. Research Design – detailed discussion of the conceptualization and operationalization of variables. Data Gathering – thorough description of methods of data gathering and sources. Analytical Techniques – detailed discussion of data gathering and analytical methods, including explanation of their suitability of these techniques compared with others and any possible problems arising from the methods selected. Data Analysis and Presentation – application and execution of analytical techniques, and interpretations of findings.

Issues related to plagiarism, copyright laws, acknowledging the sources etc to be discussed with case studies. Format for manuscript writing, documentation, organization of reference material, bibliography, end note etc to be discussed with case studies.

COMPUTATIONAL BIOLOGY / BIOINFORMATICS

The nucleotide and protein sequence Databases: Introduction, Primary and Secondary Databases, Format Vs. Content, The Database, The Gene bank flat file - A dissection.
Introduction to Structures, PDB: Protein Data Bank, Molecular Modeling Database at NCBI, Structure file formats, visualizing structural information, Database structure viewers.
Introduction, The evolutionary basis of sequence alignment, the Modular Nature of proteins, Optional Alignment Methods, Substitution scores and Gap penalties, Statistical significance of Alignments, Database similarity searching, FASTA, BLAST, Low-Complexity Regions, Repetitive Elements. Practical Aspect of Multiple, Sequence Alignment - Progressive Alignment Methods, Motifs and Patterns. Hidden Markov Models (HMMs), and Threading methods.

Elements of phylogenetic Models, Phylogenetic Data Analysis: Alignment, Substitution Model Building, Tree Building, and Tree Evaluation, Building the Data Model (Alignment), Determining the Substitution Model, Tree - Building Methods, Searching for Trees, Rooting Trees, Evaluating Trees and Data, Phylogenetic software (PHYLIP), Phylogenetics on the web, some simple practical considerations.

Predictive Methods using Nucleotide sequences: Framework, Masking repetitive DNA, Database searches, Codon Bias Detection, Detecting Functional Sites in the DNA, Integrated Gene Parsing, finding RNA Geners, Future Prospectus. Predictive Methods using Protein sequences: Protein Identity based on composition, Physical properties Based on sequence, secondary structure and folding classes, specialized structures or features, tertiary structure. Related software.

Restriction mapping, DNA strider, MacVector and OMIGA, gene construction KIT, Vector NTI, Primer design for PCR Sequencing, Primer design programs and software.

Scope and application of modeling in modern biology. Amino Acid Building Blocks, Rotameric Structures Protein Conformation Framework, Ramachandran Plots, Conformational Hierarchy, Structural motifs. Basic Building Blocks, Conformational Flexibility, Canonical DNA Forms, DNA Sequence Effects. Introduction to graphic representation, Representation of molecular structure: both small molecules and macromolecules Database of macromolecular structures. Usages of freely available visualization packages like VMD, Rasmol, Pymol, SpdbViewer , Chime, Cn3D. First principle methods for predicting protein structure, comparative modeling, threading, CASP, Protein folding theories.

Different types of interactions and formulation of forcefield. Basic algorithm of QM, MM and MC and their utilities. Basic MD algorithm, Its limitation, treatment of long range forces. Systematic methods of exploring conformational space. Molecular modeling in drug discovery, molecular docking, quantitative structure-activity relationship and their utilities in insilico drug design.

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