PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

I. To prepare students to excel in research and to succeed in Biopharmaceutical technology profession through global, rigorous post graduate education.

II. To provide students with a solid foundation in statistical, scientific and engineering fundamentals required to solve biopharmaceutical related problems.

III. To train students with good scientific and technical knowledge so as to comprehend, analyze, design, and create novel products and solutions for the health related problems.

IV. To inculcate students in scientific & professional ethics, scientific communication skills, teamwork skills, multidisciplinary approach, and an ability to address health related problems to broader social context.

V. To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful Scientific and professional career.

PROGRAMME OUTCOMES (POs):

On successful completion of the programme,

1. Graduates will demonstrate knowledge of statistics, science and technology.
2. Graduates will demonstrate an ability to identify, formulate and solve health related issues.
3. Graduates will demonstrate an ability to design and conduct experiments, analyze and interpret data.
4. Graduates will demonstrate an ability to design an experiment, component or process as per needs and specifications.
5. Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.
6. Graduates will demonstrate skills to employ modern technology, software and equipment to analyze problems.
7. Graduates will demonstrate knowledge of professional and ethical responsibilities.
8. Graduates will be able to exhibit scientific communication effectively in both verbal and written form.
9. Graduates will show the understanding of impact of pharmaceutical technology on the society and also will be aware of contemporary issues.
10. Graduates will develop confidence for self education and ability for life-long learning.
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| Project work (Phase – I) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Drug discovery Laboratory | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
| Pre-clinical Laboratory | ✔ | ✔ | ✔ | ✔ | ✔ |

**SEMESTER - IV**

| Project Work (Phase – II) | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ | ✔ |
# ANNA UNIVERSITY:: CHENNAI 600 025
# AFFILIATED INSTITUTIONS
# M. TECH. BIOPHARMACEUTICAL TECHNOLOGY
# REGULATIONS – 2017
# CHOICE BASED CREDIT SYSTEM
# I TO IV SEMESTERS CURRICULUM AND SYLLABUS

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# SEMESTER IV

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**TOTAL CREDITS: 73**

# SEMESTER I, PROFESSIONAL ELECTIVES I

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### Employability Enhancement Courses (EEC)

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OBJECTIVES:

- This course is designed to provide a solid foundation on topics in statistics that can be useful for the biotechnologists to conduct research on different types of data arising in public health and clinical studies. It is framed to address the issues in biotechnology using the concepts on probability, correlation, regression, sampling, estimation theory, testing of hypothesis and design an analysis of experiments.

UNIT I  RANDOM VARIABLE AND PROBABILITY DISTRIBUTION  12


UNIT II  CORRELATION AND REGRESSION  12


UNIT III  SAMPLING DISTRIBUTION AND ESTIMATION THEORY  12

Random sampling – Sample mean and variance – Standard error – Estimator: Unbiasedness – Maximum likelihood estimation – Method of moments – Curve fitting by the method of least squares – Fitting curves of the form \( y = ax + b \), \( y = ax^2 + bx + c \), \( y = ab^x \) and \( y = ax^b \) - Multiple regression lines.

UNIT IV  TESTING OF HYPOTHESIS  12

Sampling distributions – Type I and Type II errors – Tests based on Normal, t, \( \chi^2 \) and F distributions for testing of mean, difference between two means, proportions, difference between two proportions, variance, ratio of two variances – Independence of attributes (r x c contingency table) - Goodness of fit.

UNIT V  DESIGN OF EXPERIMENTS  12

Completely random design –Randomized complete block design– Analysis of variance : One - way and two - way classifications – Latin square design - 2\(^2\) factorial design.

TOTAL :  60 PERIODS

OUTCOMES:

After completing this course, students should demonstrate competency in the following topics:

- Basic probability axioms and rules and the moments of discrete and continuous random variables.
• Distributions and their properties
• Least squares, correlation, regression, consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.
• Sampling and use statistical tests in testing hypotheses on data.
• List the guidelines for designing experiments, recognize the key historical figures in Design of Experiments, conduct statistical tests and analyze the results.

The students should have the ability to use the appropriate and relevant, fundamental and applied mathematical and statistical knowledge, methodologies and modern computational tools.

REFERENCES:

BO5102 DRUG DOSAGE FORMS AND DESIGN L T P C
3 0 0 3

OBJECTIVES:
• To enable students to acquire theoretical knowledge in pharmaceutical dosage forms and understanding the theoretical principles with application oriented problems.

UNIT I INTRODUCTION TO DOSAGE FORMS AND PREFORMULATION 9
Definitions and Classification of Dosage forms, Pharmacokinetics/Pharmacodynamics parameters for Dosage form development. Physical properties of drugs - physical form, polymorphism, particle size, shape, density, wetting, dielectric constant, solubility, dissolution, organoleptic property and their effect on formulation, stability and bioavailability. Study of chemical properties of drugs like hydrolysis, oxidation, reduction, racemization, polymerization, etc. and their influence on formulation and stability of products. Stabilization and stability testing protocol for various pharmaceutical products.

UNIT II SOLID DOSAGE FORMS 11
Importance of base absorption, manufacturing, quality control, stability and storage of capsule dosage forms.

UNIT III  LIQUID AND PARENTRAL DOSAGE FORMS  11

UNIT IV  SEMI SOLID AND AEROSOL DOSAGE FORM  5

UNIT V  PACKAGING TECHNIQUES  9
Packaging biopharmaceutical dosage design & delivery: Primary and secondary packaging materials. Desirable features and a detailed study of different types of pharmaceutical containers and closures (glass, plastics and rubber), including their merits and demerits; selection and evaluation of pharmaceutical packaging materials

TOTAL: 45 PERIODS

OUTCOME:
- The students would have learnt various dosage forms of drugs, technological advancements to improve formulations at the completion of course.

REFERENCES:
OBJECTIVES

- To introduce the students about biogenerics and biosimilars and their characterization using analytical methods and presumptions of therapeutic equivalence along with case studies.

UNIT I BIOGENERICS INTRODUCTION

Definition: Generics and its advantages; Biogenetics and Biosimilars; Why biosimilars are not (bio) generics?; The advent of Biosimilars; The role of patents in the drug industry; Protein-based biopharmaceuticals; Manufacturing processes; Global market; International Non-proprietary Names (INN) nomenclature system biosimilars regulation (EU position, US pathways, Government initiatives)

UNIT II BIOSIMILARS AND ITS SCENARIO

Approved follow-on proteins/Biosimilars; Characteristics of high selling peptides and proteins.; Products with expired patents; Challenging originator's patents; Target products for FOB (follow-on biologicals)/Biosimilars development peptides; Recombinant non-glycosylated proteins; Recombinant glycosylated proteins; Industries dealing with biogenerics and its market value; World scenario; Indian scenario.

UNIT III CHARACTERIZATION OF BIOSIMILARS

Approaches to the characterization of biosimilars; Problems in characterizing biologics (Types of biologic, Peptides, Non-glycosylated proteins, Glycosylated proteins, Monoclonal antibodies); Equivalence issues; Post-translational modifications; Effect of micro heterogeneity; Pharmacokinetics; Pharmacodynamics; and Clinical efficacy; Analytical methods for the characterization of biosimilars (Chromatography, Protein sequencing, Massspectrometry, UV absorption, Circular dichroism, X-ray techniques, Nuclear magneticresonance, Electrophoresis, Western blotting, Bioassays, ELISA, Immunoprecipitation and other procedures)

UNIT IV IMMUNOGENECITY OF BIOPHARMACEUTICALS

Immunogenicity of biopharmaceuticals: Immunogenicity; Factors contributing to immunogenicity (product-related factors, host-related factors), Consequence of immunogenicity to biopharmaceuticals; Measurement of immunogenicity

UNIT V STABILITY ANALYSIS AND CASE STUDIES OF BIOLOGICS


TOTAL: 45 PERIODS
OUTCOME

- The subject will give exposure of fundamental knowledge in biogenerics, biosimilar and biopharmaceuticals for students to make their career in pharmaceutical industries.

REFERENCES


BO5104 GENE MANIPULATION TECHNOLOGY L T P C
3 0 0 3

OBJECTIVE

- This subject will give conceptual knowledge in the Cloning & Expression of genes; Construction of DNA libraries & Sequencing; PCR & mutagenesis; Gene transfer & Gene therapy to students.

UNIT I CLONING AND EXPRESSION OF GENES


UNIT II CONSTRUCTION OF DNA LIBRARIES


UNIT III DNA SEQUENCING

DNA sequencing – Importance, Chemical & Enzymatic methods, Pyrosequencing, Automated sequence, Genome sequencing methods – top down approach, bottom up approach.

UNIT IV PCR AND MUTAGENESIS

PCR – Principle and applications. Different types of PCR – Hot start PCR, Touchdown PCR, Multiplex PCR, Inverse PCR, Nested PCR, AFLP-PCR, Allele specific PCR, Assembly PCR, Asymmetric PCR, LATE-PCR, Colony PCR, in-situ PCR, Long P CR. Real-time PCR –
SYBRGreen assay, Taqman Probes, Molecular beacons. Mutagenesis and chimeric protein engineering by PCR, RACE, Kuntel’s method of mutagenesis.

UNIT V GENE TRANSFER & GENE THERAPY 8
Introduction of foreign genes into animal cells – Importance DNA Microinjection, Retroviral vectors, Transfection of Embryonic stem cells, recombination. Transgenic plants – Importance Ti Plasmid, Cointegrate and Binary vectors. Overview of Gene therapy

OUTCOME
• Students will learn advanced molecular methods to help them design and execute complex molecular Biology experiments.

REFERENCES

BO5111 FORMULATION AND ANALYTICAL TECHNIQUES IN BIOPHARMACEUTICAL TECHNOLOGY L T P C 0 0 6 3

OBJECTIVES
• This course will provide hands on experience on different forms of drug formulation and the analytical methods available for evaluation of pharmaceuticals.

PART I: FORMULATION EXPERIMENTS
1. Preparation of solid dosage forms (Eg. Granules, Tablets, Capsules)
2. Preparation of liquid dosage forms (Eg. True Solutions, mixtures, Elixers)
3. Preparation of biphasic dosage forms (Eg. Emulsion, Suspension)
4. Preparation of semisolid dosage forms (Eg. Ointments, Creams, Gels, lotions)
5. Preparation of Parenteral and ophthalmic formulations
6. Preparation of specialized dosage forms (Eg. Suppositories, Patches)

PART – II: ANALYTICAL METHODS FOR EVALUATION OF PHARMACEUTICALS BASEDON PHARMACOPOEIAS
1. Evaluation of solid dosage forms (Hardness, dissolution etc)
2. Evaluation of liquid dosage forms (Stability tests, pH, odour etc)
3. Evaluation of biphasic dosage forms (Stability tests etc)
4. Evaluation of semisolid dosage forms (pH, spreadability, viscosity etc)
5. Evaluation of Parenteral formulations and evaluation (Microbial Tests etc)
6. Evaluation of specialized dosage forms (Melting tests etc)
7. Preparation of pharmaceutical buffers, physiological buffers and determination of buffer capacity.

**EQUIPMENTS REQUIRED**
1. Granulator
2. Punching machine
3. Capsule filler
4. Disintegration, dissolution and friability testing apparatus
5. pH meter, physical balances

**TOTAL: 90 PERIODS**

**OUTCOME**
- Hands on experience to make the students competent in drug formulation to take up challenging industry career.

**REFERENCE**

**BO5201 PHARMACOKINETICS AND PHARMACODYNAMICS**

**OBJECTIVES**
- This subject will enable the students to understand the essential principles of pharmacokinetics and pharmacodynamics required for the development of therapeutic agents.

**UNIT I FUNDAMENTALS ON DRUG ABSORPTION AND DISTRIBUTION**
Definitions, various routes of administration with advantages/disadvantages, bioavailability concepts in drug absorption and distribution, theories of drug dissolution, drug partition hypothesis, permeability and distribution of drugs, perfusion rate and volume of distribution, protein binding of drugs, kinetics of drug binding, various factors that affect drug absorption and distribution, drug interactions in the level of drug absorption and distribution.
UNIT II  FUNDAMENTALS ON DRUG METABOLISM AND EXCRETION  9
Biotransformation of drugs, pathways and enzymes of drug metabolism, Phase I and Phase II, drugs excretion – renal and non-renal routes, various factors that affect drug metabolism and excretion, prodrugs, drug interactions in the level of drug metabolism and excretion, bioavailability concepts in drug metabolism and excretion.

UNIT III  PHARMACOKINETIC INVESTIGATION AND EVALUATION  9
Concept of therapeutic concentration, time-profile, rates and various order of reactions (first, zero, mixed), Michaelis-Menton kinetics, differential equations for a simple pharmacokinetic models, compartment models (one, two, multi, open models), definition and calculation of parameters such as drug half-life, of Drugs, Volume of Distribution, and bioavailability(AUC) and their application to compartment models and kinetics of IV Bolus administration, comparison between bioavailability and bioequivalence.

UNIT IV  PHARMACODYNAMIC FUNDAMENTALS  10

UNIT V  APPLICATION OF PK/PD PRINCIPLES IN DOSAGE FORM DEVELOPMENT  8
Regimens for dosage form design, concentration response relationships, individualization therapeutics, controlled release formulations and novel drug delivery (oral, parenteral, transdermal, ophthalmic and intrauterine) systems, bioavailability testing of novel release formulations.

TOTAL : 45 PERIODS

OUTCOME
• On the completion of the course the students are expected to have understood and learnt the fundamentals of drug PK/PD that will enable them for research and application in dosage form development.

REFERENCES
OBJECTIVES

• To enable students to acquire knowledge in drug regulatory affairs in India and at International level.

UNIT I INTRODUCTION TO DRUGS & COSMETICS ACT 8
Definitions, Forms, Licenses; Schedules, New Schedule M, Schedule Y

UNIT II PHARMACOPOEIA 6
Descriptions & Monographs; Standards & Specifications; Testing of Drugs; Various Countries Pharmacopoeias; Indian, British, U.S, European, Japanese

UNIT III cGMPs & REGULATORY RECORDS-SITE MASTER FILE, DRUG MASTER FILE, DRUG DOSSIERS 10
cGMP concepts – Development, Manufacturing Record, Analytical & Process Validation, Equipment & utility Qualification and Calibration, Personnel procedures; Regulatory bodies & requirements - Indian FDA, WHO GMP; U.S. FDA, U.K. MCA, Australian TGA, Japanese PMDA. Drug dossier contents - CTD (CMC section) & data.

UNIT IV CLINICAL STUDIES- PRECLINICAL, PHASE I,II,III,IV 6
Schedule-Y, pre-clinical study requirements, clinical trial phases, types of trials, bioethics & stakeholders, Bioavailability & Bio equivalence studies.

UNIT V SAFETY AND ENVIRONMENTAL CONTROL 15
Patent act- Patent, Trade Mark Registration, I.P.R; Safety & Environmental control; Project (Regulatory factors).

TOTAL : 45 PERIODS

OUTCOME

• After completion of the course, students would have learnt the principles of drug regulatory affairs and latest information on drug research, manufacturing, sales and distribution.

REFERENCES

5. Indian Pharmacopoeia, 2014.
OBJECTIVES

- To enhance theoretical knowledge in the function of immune system in humans and to understand the applications of immunology and drug response.

UNIT I INTRODUCTION TO PHARMACOLOGY AND IMMUNOLOGY 9
Principles of basic and clinical pharmacokinetics and pharmacodynamics. Adverse drug reactions. Drug interactions, Innate and adaptive immunity, Immunogenicity; Antigenicity; Physiology of immune response, Immunity to virus, bacteria, fungi, Immune cell and organ classification, Relationships between immune and neurohumoral regulations, influence of stress, nutrition and environment on immunity.

UNIT II INTRODUCTION TO VACCINOLOGY 9
Classification, active immunization, vaccines technology, perspective vaccines, means of passive immunization, antibodies in therapy, antibody engineering, monoclonal antibodies, immunoconjugates - specific drug targeting, immunotoxins.

UNIT III IMMUNOTHERAPEUTICS 9
Cytokines classification, pathways of activation, Therapeutic use of cytokines, immunomodulators classification, thymic hormones and synthetic immunostimulators; complement pathways diagnostics, development of immunodiagnostics, ELISA, Flow cytometry, ELISPOT, immunoradiology, Basic immunotoxicology - principles of testing of immunomodulating and immunotoxicological properties of drugs and xenobiotics.

UNIT IV TRANSPLANTATION THERAPEUTICS 9
Laws of transplantation, host vs Graft and Graft vs Host reactions; HLA Classification immunosuppressants, drugs for immunosuppressive therapy: corticosteroids, Antimetabolites and calcineurine inhibitors, Clinical aspects of antiallergic, immunosuppressive, immune stimulating and substitutive therapy.

UNIT V IMMUNOLOGY OF ALLERGY 9
Classification of hypersensitivity reactions, Classification of allergens, therapy and prevention of allergic diseases and drug hypersensitivity. Classification of antihistamines, anti-rheumatoid drugs.

TOTAL: 45 PERIODS

OUTCOME
On completion of the course, students will be able to
• Understand advanced knowledge in pharmacology of drugs acting on the immune system, their classification, therapeutic use and mechanism of treatment.
• Understand various disease states, life style diseases and identification of novel therapeutic targets related to the diseases.
• Correlate the relationship between immune therapeutics with other drugs and their role in modulation of body’s own natural defenses.

REFERENCES

BO5204 FERMENTATION TECHNOLOGY

OBJECTIVE
• The subject provides knowledge involving basic principle of fermentation process, microbial kinetics and recombinant protein production along with case studies, to help the students understand fermentation processes involved in Pharmaceutical Industries.

UNIT I INTRODUCTION TO BIOREACTOR DESIGN & CONSTRUCTION
9
General requirements of fermentation processes, Basic design and construction of CSTR, bioreactor design of agitator/agitator motor, power consumption in aerated bioreactor, design of sparger, mixing time estimation, oxygen mass transfer capability in bioreactor, Removal of Heat in bioreactor, Main parameters to be monitored and controlled in fermentation processes.

UNIT II MICROBIAL KINETICS AND DESIGN OF VARIOUS CULTIVATION PROCESSES
9
Simple unstructured kinetic models for microbial growth of bacterial, fungal, animal and plantsystems, kinetics of substrate utilization, biomass growth and product formation in continuous cultures, batch and fed batch cultures, total cell retention cultivation, inhibition on cell growth and product formation.
UNIT III  MODELING OF RECOMBINANT CULTIVATION ANIMAL AND PLANT CELL CULTIVATION SYSTEMS FOR THE THERAPEUTIC PROTEINS

Structured models of metabolism and growth, models of gene expression and regulation, a generalized model of plasmid replication, Genetic instability, predicting host-vector interactions and genetically instability. Process considerations for utilizing genetically engineered strains. Media, aeration in cell culture systems, Bioreactors for plant/animal suspension culture, cell immobilization and organized tissue, bioreactor considerations for animal/plant cell culture for production of pharmaceuticals, Therapeutic proteins and Monoclonal antibodies.

UNIT IV  DOWNSTREAM PROCESSING AND SEPARATION TECHNIQUES

Characteristics of biological materials: pretreatment methods; Separation of cell mass: centrifugation, clarification and filtration; Different methods of cell disruption; Advantages; Disadvantages; Liquid shear method and solid shear method; Different concentration methods: evaporation, distillation, crystallization, evaporation, SCFE, solvent extraction, phase separation, drying etc., whole broth extraction, protein precipitation; extraction; adsorption; Modern techniques: Electrophoresis; Chromatographic methods; Ultrafiltration; Reverse osmosis; Cross flow filtration; Microfiltration; Isoelectric focusing; Affinity based separations.

UNIT V  CASE STUDIES IN FERMENTATION DERIVED PRODUCTS

Case studies on Production of penicillin, recombinant Insulin. Case studies should deal with strain improvement, medium design, reactor design & process optimization etc.

TOTAL : 45 PERIODS

OUTCOME

- This course work will provide essential knowledge for the students to make their career in bioprocess Industries.

REFERENCES

OBJECTIVES

- The student will undergo hands on experience on animal handing and various aspects of advanced immunological techniques like Competitive ELISA, Immunoprecipitations, flow cytometry assays and in vitro immunoassays training.

EXPERIMENTS

1. Selection and Handling of animals, Preparation of antigens, Immunization and methods of bleeding, Serum separation, Storage.
2. Antibody titre by ELISA method (Direct ELISA )
3. Competitive ELISA – Quantification of antigens
4. Cytokine analysis by Elispot test
5. Immunoprecipitation / Immunelectrophoresis
6. Isolation and purification of IgG from serum
7. SDS -PAGE, Immunoblotting, Dot blot assays
8. Demonstration of agglutination inhibition by latex beads (Pregnancy test)
9. Direct Agglutination – Widal test Salmonella detection
10. Separation of mononuclear cells by Ficoll-Hypaque
11. Separation and culturing of splenocytes and demonstration of T cell proliferation
12. Lymphoproliferation by mitogen/antigen and Thymidine uptake assay
13. Demonstration of cell viability by MTT assay
14. Flow cytometry, identification of T cells and their subsets
15. Evaluation of monoclonal antibodies for diagnostic and therapeutic applications
16. Demonstration of Immunodiagnostics using commercial kits (Rapid Dot Blot and Strip Test)

TOTAL: 90 PERIODS

Required Equipments:

- Microscopes, restainer (mouse, rat, rabbit), purification columns, microplate reader, UV spectrometer, PAGE apparatus, Western blot apparatus (dry/semi-dry/wet), Flow cytometer, centrifuge, Haemocytometer, required kits, strains & consumables

OUTCOME

The student will be able to
- Acquire various practical skills in modern immunological techniques
- Understand diagnostic tools for various diseases using immunological techniques.
- Impart their acquired knowledge in academic and industrial research.

REFERENCES


BO5311 DRUG DISCOVERY LABORATORY L T P C
0 0 6 3

OBJECTIVES
- To enable the students to enhance their hands-on experience in learning techniques towards discovery of new drugs and utilize this knowledge for industrial needs.

SYNTHETIC METHODS FOR DRUG DISCOVERY
1. Synthesis of selected drugs involving two or more steps of synthesis and study of spectral analysis of drug synthesized (Paracetamol, Aspirin, Fluorscein, acetanilide, etc.).
2. Determination of pharmacopoeia standards for the synthesized drugs.
3. Determination of QSAR parameters for drugs (partition co-efficient, dissociation constant, molar refractivity, etc.)

DISCOVERY OF DRUGS FROM NATURAL PRODUCTS
1. Extraction Techniques: Cold maceration, Hot Percolation and Soxhalation.
2. Evaluation of extraction Efficiency by yield calculation and TLC.
3. Fractionation : Solvent-solvent
4. Evaluation of fractionation efficiency by TLC fingerprinting.
5. Column chromatography and flash column chromatography.
6. Extraction and determination of alkaloids (caffeine acid from tea leaves).
7. To evaluate the antioxidant potential of herbal extracts using DPPH freeRadicals scavenging assay.
8. To evaluate the cytotoxic effect of herbal extracts using MTT assay.
9. To evaluate the nitric oxide (NO) modulatory effect of herbal extracts using Griess method.
10. Biotransformation study

TOTAL : 90 PERIODS

Required Equipments:
Soxhlet apparatus, rotary flash evaporator, Hot air oven, sonicator, mortar and pestle, TLC chamber, Fume hood, purification columns, micro-plate reader, UV spectrometer, centrifuge, required strains & consumables

OUTCOME
- The Students will be able to absorb the principles and practical approach of modern drug discovery including synthetic methods and natural products for drug discovery as per industry standards.
REFERENCES
5. Recent advances in Phytochemistry Vol. I & IV – Scilicet, Runnecles.

BO5312 PRE-CLINICAL LABORATORY L T P C
0 0 6 3

OBJECTIVES
• The student will go hands on training and get exposure on preclinical studies and its applications.

EXPERIMENTS
2. Experiments on permeation studies.
4. Experiments on in-vitro genotoxicity studies using PCR.
5. Experiments on PK/PD studies.

TOTAL : 90 PERIODS

For a batch of 10 students the following are needed:
1. Dissolution testing apparatus - 2 (PK/PD studies)
2. Disintegration testing apparatus - 2 (PK/PD studies)
3. CO2 incubator for in-vitro growing of cultures for toxicity studies
4. Inverted microscope for cytotoxicity studies
5. Biosafety hoods for handling cultures
6. spectrophotometer for assays
7. PCR machine - 2
8. Ussing Chamber for permeation studies - 2
9. Consumables - cell culture plates, micro-titre plates, membranes, reagents

OUTCOME
• Upon successful completion of this course the student able to conduct preclinical studies on given products.

REFERENCES

BO5313 PROJECT WORK – PHASE I

OBJECTIVES
- To provide research training in areas of Biopharmaceutical Technology and to stimulate the students to undertake research in this area.

OUTCOME
- Students would have developed expertise one or two techniques pertaining to research in biopharmaceutical technology and would be able to perform literature survey and make a comprehensive report presentation in a specified area.

BO5411 PROJECT WORK – PHASE II

OBJECTIVES
- To provide research training in specific areas of Biopharmaceutical Technology and to develop their skills for academic and industrial research.

OUTCOME
- The students will be trained to undertake cutting edge research in the area of Biopharmaceutical Technology.

BO5001 GENOMICS AND PROTEOMICS

OBJECTIVES
- The course intends to provide advanced theoretical knowledge on the organization and function of genomes, functional genomics analyses, and advanced methods and approaches in proteomics.

UNIT I STRUCTURE OF GENOMES, MAPPING AND SEQUENCING
Organization and structure of genomes in prokaryotes, eukaryotes, and organelles (chloroplast, mitochondrion); Genome mapping methods (genetic and physical); RAPD, RFLP, SNP
analyses; Fluorescence In-Situ Hybridization (FISH) techniques; Advances in gene finding and functional prediction; Chain termination and chemical degradation sequencing methods.

UNIT II  LARGE SCALE GENOMICS/ FUNCTIONAL GENOMICS ANALYSES  9
Genome-wide association (GWA) analysis; Comparative Genomic Hybridization (CGH); Massively parallel Signature Sequencing (MPSS); Whole genome shot-gun sequencing and its applications. Introduction of Next Generation Sequencing (NGS).

UNIT III  TRANSCRIPTOMICS ANALYSES  9
Gene expression analysis by cDNA and oligonucleotide arrays; Micro array experimental analysis and data analysis. Methylome analysis using microarray; Chip-on-Chip analysis. Bioinformatic analysis of large-scale microarray data for comparative transcriptomics.

UNIT IV  SEPARATION AND PROCESSING OF PROTEINS FOR PROTEOMICS  9
Over-view of strategies used for the identification and analysis of proteins; Protein extraction from biological samples (Mammalian Tissues, Yeast, Bacteria, and Plant Tissues); 2-DE of proteins for proteome analysis; Liquid chromatography separations in proteomics (Affinity, Ion Exchange, Reversed-phase, and size exclusion); Enzymatic cleavage of proteins. Analysis of complex protein mixtures using Nano-liquid chromatography (Nano-LC) coupled to Mass-spectrometry analysis.

UNIT V  MASS SPECTROMETRY AND COMPARATIVE PROTEOMICS  9
Common ionization methods for peptide/protein analysis; Introduction to Mass spectrometers; MALDI-TOF and LC-MS analyses; Comparative proteomics based on global in-vitro and in-vivo labeling of proteins/peptides followed by Mass-spectrometry. Analysis of posttranslational modification (PTM) of proteins; Characterization of protein interactions using yeast two-hybrid system and Protein microarrays; Proteomics informatics and analysis of protein functions.

OUTCOME
• The students will acquire in-depth knowledge on the methods and approaches in genomics and proteomics areas which help them to carry out cutting edge academic and industrial research.

TOTAL: 45 PERIODS

REFERENCES

BO5002 HUMAN PHYSIOLOGY AND DRUG METABOLISM  L T P C
                                                        3 0 0 3

OBJECTIVES
- To provide fundamental knowledge of human physiology, drug metabolism and biotransformation of drug in human body.

UNIT I FOUNDATIONS OF PHYSIOLOGY AND OVERALL PHYSIOLOGY CONCEPTS  12
ANS, CNS, Cardiovascular system, Gastrointestinal system, Muscle and skeletal system, excretory system

UNIT II GROWTH AND METABOLISM  12

UNIT III DRUG ABSORPTION AND METABOLISM  8
Factors influencing enzyme induction and inhibition; Extraction of drugs; Biliary and fecal excretion; Factors effecting drug metabolism; Drug metabolism in fetus and new born

UNIT IV BIOTRANSFORMATION CONCEPTS  6
Biotransformation of drugs; Enzymes responsible for bio-transformations; Microsomal and non-microsomal, mechanisms.

UNIT V MODEL IN DRUG METABOLISM  7
Models to study drug metabolism; Dose effect relationships; Adverse drug reactions and drug interactions; Toxic reactions; Allergic reactions; Idiosyncrasy; Acute poisoning and its treatment.

TOTAL: 45 PERIODS

OUTCOME
- This course work will provide basic understanding of human physiology and drug metabolism which will enable the student to understand how the body functions and the physiological mechanisms that operate to maintain homeostasis.

REFERENCES

Mcgraw Hill, 1992

BO5003 BIOCONJUGATE TECHNOLOGY AND APPLICATIONS L T P C
3 0 0 3

OBJECTIVES
• The course will provide advanced theoretical knowledge on Bio conjugate technologies in Biopharmaceutical Applications

UNIT I FUNCTIONAL TARGETS 9

UNIT II CHEMISTRY OF ACTIVE GROUPS 9
Amine reactive chemical reactions – Thiol reactive chemical reactions – carboxylate reactive chemical reactions – hydroxyl reactive chemical reactions – aldehyde and ketone reactive chemical reactions – Photo-reactive chemical reactions.

UNIT III BIOCONJUGATE REAGENTS 9

UNIT IV ENZYME AND NUCLEIC ACID MODIFICATION AND CONJUGATION 9
Properties of common enzymes – Activated enzymes for conjugation – biotinylated enzymes – chemical modification of nucleic acids – biotin labeling of DNA- enzyme conjugation to DNA – Fluorescent of DNA.

UNIT V BIOCONJUGATE APLICATIONS 9

TOTAL : 45 PERIODS

OUTCOME
• The students will acquire knowledge in advanced methods to carry out cutting edge academic and industrial research.
OBJECTIVES

- To enhance theoretical knowledge of students in the chemistry of natural products and to explore this knowledge for practical applications

UNIT I  CARBOHYDRATES AND RELATED COMPOUNDS

Sugars and sugar-containing drugs polysaccharides and polysaccharide-containing drugs, cellulose gums and mucilages, pectin

UNIT II  GLYCOSIDES AND TANNINS

Biosynthesis of glycosides, Phenol and alcohol glycosides, anthraquinone glycosides, cyanophore glycosides, saponin glycosides, cardiac glycosides, isothiocyanate flavonollactone glycosides tannins volatile oils, resins and resin combinations.

UNIT III  ALKALOIDS AND ALICYCLIC COMPOUNDS

Pyridine and piperidine alkaloids, Tropane alkaloids, Quinolinealkaoids, isoquinolinealkaloids, Indole alkaloids, Imidazole alkaloids, Steroidal alkaloids, Alkaloidal amines purinebases. Terpenes, camphor, menthol, carotenes

UNIT IV  VITAMINS, PURINES, FLAVONOIDS

Chemistry, medicinal and pharmaceutical uses of vitamin A, D, E, K, B1, B2, B6, B12 and Folicacid. Chemistry and structural elucidation of uric acid, interrelation between caffeine, theophylline and theobromine. Classification and application of flavanoids (hespiridineetc)

UNIT V  MOLECULES FROM NATURAL SOURCES

Classification of Drug molecules of Plant/marine/microbial and animal sources-cytotoxic/anti-neoplastic agents, cardio vascular drugs -antimicrobial substances – anti-inflammatory and anti-spasmodic agents

TOTAL : 45 PERIODS

OUTCOME

- At end of the course work students will appreciate the importance of natural compounds as novel drugentity for the development of newer drugs.
REFERENCES

BO5005 MOLECULAR MEDICINE AND MECHANISM

OBJECTIVES
- The objective of the course is to understand the molecular mechanism of the disease and advanced understanding of drug interactions.

UNIT I INTRODUCTION TO MOLECULAR MEDICINE

UNIT II CARDIOLOGY
Molecular Cardiology – Congenital Heart Disease – Inherited Cardiomyopathies – Coronary Atherosclerosis – Endothelium – Derived Nitric Oxide and Control of Vascular Tone – Hypertension – Cardiac Arrhythmias – Cardiovascular Gene Therapy.

UNIT III PULMONOLOGY
Asthma – Cystic Fibrosis – Pulmonary Emphysema – Surfactant Deficiency – Lung Cancer: The Role of Tumor Suppressor Genes – Strategies for controlling the diseases.

UNIT IV ENDOCRINOLOGY

UNIT V NEPHROLOGY

TOTAL: 45 PERIODS
OUTCOME

- Students will be trained to understand the applications of mechanism of molecular diseases.

REFERENCES


BO5006 CLINICAL TRIALS AND BIOETHICS L T P C

3 0 0 3

OBJECTIVES

- The course will provide Fundamental ethical to advanced clinical trial management including drug development and trial planning; Project management in clinical trials; Consent and data protection; Quality assurance and governance.

UNIT I INTRODUCTION TO CLINICAL TRIALS

Fundamentals of clinical trials; Basic statistics for clinical trials; Clinical trials in practice; Reporting and reviewing clinical trials; Legislation and good clinical practice - overview of the European directives and legislation governing clinical trials in the 21st century; International perspectives; Principles of the International Committee on Harmonisation (ICH)-GCP.

UNIT II REGULATIONS OF CLINICAL TRIALS

Drug development and trial planning - pre-study requirements for clinical trials; Regulatory approvals for clinical trials; Consort statement; Trial responsibilities and protocols - roles and responsibilities of investigators, sponsors and others; Requirements of clinical trials protocols; Legislative requirements for investigational medicinal products.

UNIT III MANAGEMENT AND ETHICS OF CLINICAL TRIALS

Project management in clinical trials - principles of project management; Application in clinical trial management; Risk assessment; Research ethics and Bioethics - Principles of research ethics; Ethical issues in clinical trials; Use of humans in Scientific Experiment; Ethical committee system including a historical overview; the informed consent; Introduction to ethical codes and conduct; Introduction to animal ethics; Animal rights and use of animals in the advancement of medical technology; Introduction to laws and regulation regarding use of animals in research.
UNIT IV INFORMED CONSENT
Consent and data protection - the principles of informed consent; Consent processes; Data protection; Legislation and its application; Data management – Introduction to trial master files and essential documents; Data management.

UNIT V QUALITY CONTROL AND GUIDELINES
Quality assurance and governance - quality control in clinical trials; Monitoring and audit; Inspections; Pharmacovigilance; Research governance; Trial closure and pitfalls-trial closure; Reporting and legal requirements; Common pitfalls in clinical trial management.

TOTAL: 45 PERIODS

OUTCOME
- The students will acquire knowledge in all aspect of clinical trials, management and ethical standards required to conduct clinical trials.

REFERENCES
1. Lee, Chi-Jen et al, “Clinical Trials or Drugs and Biopharmaceuticals.” CRC / Taylor &Francis, 2011.

BO5007 BIOCATALYSTS AND ENZYME TECHNOLOGY

OBJECTIVES
- The course intends to give advanced knowledge about Biocatalysts, Enzyme kinetics, immobilization and enzymatic biotransformation of drugs

UNIT I BASICS OF ENZYMES AS BIOCATALYSIS
Introduction to enzymes, Classification, Sources, Mechanism of enzyme action. Strategies of purification of enzymes, criteria of purity, molecular weight determination and characterization of enzymes, Enzymes of biological importance - Acetylcholinesterase, angiotensin converting enzyme (ACE), ACE Inhibitors, HMG CoA reductase inhibitors, pseudocholinesterase, 5'-nucleotidase (5NT), glucose-6-phosphatedehydrogenase (GPD), Kisoforms, immune reactive trypsinogen (IRT) and chymotrypsin; amylaselopeptinases.

UNIT II KINETICS OF ENZYME ACTION
UNIT III IMMOBILIZED ENZYMES
Techniques of enzyme immobilization; kinetics of immobilized enzymes, effect of solute, partition & diffusion on the kinetics of immobilized enzymes, design and configuration of immobilized enzyme reactors; applications of immobilized enzyme technology, Economic argument for immobilization.

UNIT IV ENZYMES IN FUNCTIONAL GROUP TRANSFORMATION
Functional group interconversion using enzymes (hydrolysis reactions, oxidation/reduction reactions, C-C bond formations), Retrosynthetic biocatalysis, Chemoenzymatic synthesis of natural products. Industrial process using enzymes for production of drugs, fine chemicals and chiral intermediates.

UNIT V ENZYMATIC TRANSFORMATION
Reaction engineering for enzyme-catalyzed biotransformations. Catalytic antibodies. Biocatalysts from extreme Thermophilic and Hyperthermophilic microorganisms (extremozymes). The design and construction of novel enzymes, artificial enzymes, Biotransformation of drugs (hydroxylation of Steroids), Host Guest Complexation chemistry, enzyme design using steroid templates, enzymes for production of drugs, fine chemicals and chiral intermediates.

TOTAL: 45 PERIODS

OUTCOME
- The students will acquire knowledge in all aspect of Biocatalysis, enzyme kinetics and immobilization.
- The enzymatic transformation will give theoretical idea about drug biotransformation.

REFERENCES
2. Blanch, H.W., Clark, D.S. Biochemical Engineering, Marcel Dekker, 1997

BO5008 PROTEIN ENGINEERING AND INDUSTRIAL APPLICATIONS

OBJECTIVES
- To provide advanced knowledge of proteins and their structure function relationship, essential for future pharmaceutical technology.
UNIT I   INTRODUCTION 6
Amino acids, primary structure of proteins, amino acid composition, industrial significance, primary structure determination by chemical methods including automated sequencing and by gene sequencing, significance of primary structure determination, peptide synthesis, secondary structure and super secondary structures

UNIT II   PROTEIN ARCHITECTURE 6
Tertiary structure of proteins, types of proteins, domains, quaternary structure, protein complexes, protein-protein interactions

UNIT III   STRUCTURE-FUNCTION RELATIONSHIP 15
DNA-binding proteins: prokaryotic transcription factors, Helix-turn-Helix motif in DNA binding, Trp repressor, Eucaryotic transcription factors, Zn fingers, helix-turn helix motifs in homeodomain, Leucine zippers
Membrane proteins: General characteristics, Transmembrane segments, prediction, bacteriorhodopsin and Photosynthetic reaction center
Immunoglobulins: IgG Light chain and heavy chain architecture, Abzymes and Enzymes: Serine proteases, understanding catalytic design by engineering trypsin, chymotrypsin and elastase, substrate assisted catalysis other commercial applications.

UNIT IV   PROTEIN ENGINEERING METHODS 9
Protein engineering methods, amino acid side chain reactions, chemical modification of proteins, site-directed mutagenesis, posttranslational modifications and engineering.

UNIT V   INDUSTRIAL APPLICATIONS OF PROTEIN ENGINEERING 9
Examples of industrial protein engineering applications Engineering of serine proteases, engineering of antibodies, engineering of proteins for thermal stability, engineering of proteins for preventing aggregation, His-tagged proteins in purification, engineering proteins for secretion, de novo protein synthesis.

TOTAL: 45 PERIODS

OUTCOME
- On completion of the course, students will learn the functional characteristics of various types of proteins and engineering of proteins for production of new protein pharmaceutics.

REFERENCES

BO5009 MICROBIAL TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES
- To provide fundamental knowledge of pharmaceutical microbiology and microorganisms associated with the manufacture of pharmaceuticals

UNIT I BIOLOGY OF MICROORGANISMS

UNIT II INFECTIOUS DISEASES

UNIT III ANTIBIOTICS AND OTHER ANTIMICROBIAL AGENTS

UNIT IV MICROBIAL ASPECTS OF PHARMACEUTICAL PROCESSING
Ecology of microorganisms as it affects the pharmaceutical industry - Microbial spoilage and preservation of pharmaceutical products - Contamination of non-sterile pharmaceuticals in hospitals and community Environments - Principles and practice of sterilization - Sterilization control and sterility assurance - Sterile pharmaceutical products - Factory and hospital hygiene and good manufacturing practice
UNIT V  BIOCATALYST TECHNOLOGY

Advantages and disadvantages of biocatalysis over chemical catalysis; Different types of biocatalysis: Microbial, enzymatic and immobilized system of biocatalysis; Current industrial biocatalysis; Biocatalysis with different enzymes: Lipase, amidase/ aminopeptidase, Acylase, Hydantoinase, lyases, Oxidoreductase, Nitrilase, Epoxide hydrolase, Hydroxylase, Aldolases, Decarboxylase;

TOTAL : 45 PERIODS

OUTCOME
- The students would have learnt various aspects of pharmaceutical microbiology include the research and development of anti-infective agents, the use of microorganisms to detect mutagenic and carcinogenic activity in prospective drugs, and the use of microorganisms in the manufacture of pharmaceutical products

REFERENCES

BO5010  PHARMACOLOGY  L T P C
3 0 0 3

OBJECTIVES
- The objective of the course is to provide advanced knowledge in detail on the pharmacology of drugs and toxicology.

UNIT I  INTRODUCTION TO PHARMACOLOGY

UNIT II  DRUGS ACTING ON THE HAEMOPOIETIC SYSTEM AND CARDIOVASCULAR SYSTEM
Haematinics, Anticoagulants, vitamin K and haemostatic agents, Fibrinolytic and anti-platelet drugs, Blood plasma volume expanders. Histamine, 5-hydroxytryptamine, Prostaglandins and
their antagonists, cardiac glycosides and other drugs for congestive heart failure, antiarrythmatic, antianginal, anti-ischemic, and anti hypertensive drugs.

UNIT III PHARMACOLOGY OF DRUGS ACTING ON GASTROINTESTINAL TRACT AND ENDOCRINE SYSTEM 9
Antacids, anti-secretory and anti-ulcer drugs; Laxatives and Anti-diarrhoeal drugs; Appetite stimulants and suppressants; Emetics and anti-emetics; Hypothalamic and pituitary hormones, Thyroid hormones and anti-thyroid drugs, Parathormone, Calcitonin and Vitamin D, Insulin, Oral hypoglycemic agents and glucagon. ACTH and corticosteroids, Androgens and anabolic steroids, Estrogens, progesterone and oral contraceptives, Drugs acting on the uterus;

UNIT IV CHEMOTHERAPY 9
General principles of chemotherapy; Sulfonamides; Antibiotics – Penicillins, Cephalosporins, Chloramphenicol, macrolides, Quinolones, fluoroquinolones and other antibiotics; Chemotherapy of tuberculosis, leprosy, fungal diseases, viral diseases, urinary tract infections and sexually transmitted diseases; Chemotherapy of malignancy and immune suppressive agents.

UNIT V MOLECULAR PHARMACOLOGY AND PRINCIPLES OF TOXICOLOGY 9
Classification of neurotransmitters and receptors, mechanism of action, receptor activation and signal transduction with special reference to CNS, Definition of poison, general principles of treatment of poisoning, Heavy metals and heavy metal antagonists, OECD guidelines for testing acute, sub-acute, and chronic toxicity, genotoxicity, carcinogenicity, teratogenicity and mutagenicity of drugs and chemicals.

TOTAL : 45 PERIODS

OUTCOME
After the completion of course, the student will able to
1. Identify typical examples of drugs which are used to restore physiological functions.
2. Understand the systemic effect of drug action on human body.
3. Recognize the fundamental principles used in pharmacology and toxicology of drugs for academic and industrial research.

REFERENCES
OBJECTIVES

- The course intends to give advanced theoretical knowledge on Microarrays, Next Generation DNA sequencing and Protein profiling.

UNIT I MICRO ARRAYS IN GENOMICS
Designing and producing microarrays; types of microarrays; cDNA microarray technology; Oligonucleotide arrays; Sample preparation, labeling, hybridization, generation of microarray data. Transcriptomics using cDNA and oligonucleotide arrays.

UNIT II NEXT GENERATION SEQUENCING TECHNOLOGIES
Overview of Next Generation Sequencing (NGS) technologies; Principles of NGS by Roche/454, Illumina, Life Technologies, Pacific Biosciences, Ion Torrent technologies; Applications of NGS to disease diagnosis and personalized medicine.

UNIT III PROTEIN MICRO ARRAYS AND YEAST TWO-HYBRID SYSTEM
Types of protein arrays; Protein microarray fabrication; Experimental analysis of proteins arrays. Data acquisition and processing; Applications of protein microarray types. Principles and methods in yeast two-hybrid system, Advances in yeast two hybrid system and its applications.

UNIT IV TWO-DIMENSIONAL GELELECTRO PHORESIS OF PROTEINS
Sample preparation, First-dimension IEF with IPG; Second dimensional separation of proteins; Image analysis of 2-DE gels; DIGE, Protein expression profiling and comparative proteomics of complex proteomes using 2-DE.

UNIT V MASS-SPECTROMETRY IN BIOLOGICALS
Basics of Mass-spectrometry (MS) and bimolecular analysis; Common ionization methods for peptide/protein analysis; Principles of Time of Flight (TOF), Ion Trap (IT), and Orbitrap mass analyzers; Mass spectrometry based proteomics: MALDI-TOF, Nano-LC-MS; Gas-chromatography coupled to Mass spectrometry; Mass-spectrometry analysis of Post-Translational Modifications of proteins.

OUTCOME:

- The students will acquire knowledge in advanced molecular methods to carry out academic and industrial research

REFERENCES

BO5012 METABOLIC ENGINEERING L T P C
3 0 0 3

OBJECTIVES
- To familiarize the student with quantitative approaches for analyzing cellular metabolism and the use of theoretical and experimental tools that can give insights into the structure and regulation of metabolic networks. A central aspect of the course is to identify the optimal strategy for introducing directed genetic changes in the microorganisms with the aim of obtaining better production strains. Case studies will be taken up on metabolically-engineered products and processes in various expression systems.

UNIT I METABOLIC FLUX ANALYSIS
Introduction to metabolic engineering, comprehensive models of cellular reactions with stoichiometry and reaction rates; metabolic flux analysis of exactly/over/under determined systems. Shadowprice, sensitivity analysis.

UNIT II TOOLS FOR EXPERIMENTALLY DETERMINING FLUX THROUGH PATHWAY
Monitoring and measuring the metabolome, Methods for the experimental determination of metabolic fluxes by isotope labeling metabolic fluxes using various separation-analytical techniques. GC-MS for metabolic flux analysis, genome wide technologies: DNA/phenotypic microarrays and proteomics.

UNIT III CONSTRAINT BASED GENOMIC SCALE METABOLIC MODEL
Development of Genomic scale metabolic model, Insilico Cells: studying genotype-phenotype relationships using constraint-based models, case studies in E.coli, S.cerevisiae metabolic network reconstruction methods, optimization of metabolic network, Identification of targets for metabolic engineering; software and databases for genome scale modeling.

UNIT IV METABOLIC CONTROL ANALYSIS AND KINETIC MODELING
Fundamental of Metabolic Control Analysis, control coefficients and the summation theorems, Determination of flux control coefficients. Multi-substrate enzyme kinetics, engineering multifunctional enzyme systems for optimal conversion, and a multi scale approach for the predictive modeling of metabolic regulation.
UNIT V CASE STUDIES IN METABOLIC ENGINEERING

Metabolic engineering examples for bio-fuel, bio-plastic and green chemical synthesis. Study of genome scale model in various system for the production of green chemicals using software tools. Validation of the model with experimental parameters.

TOTAL: 45 PERIODS

OUTCOME

- This course work will provide essential knowledge for the students to make their career in bioprocess Industries.

REFERENCES


BO5013 PHARMACOGENOMICS

OBJECTIVES

- The course intends to provide knowledge about Pharmacogenomics and drug design using genomic applications for drug action and toxicity.

UNIT I INTRODUCTION TO PHARMACOGENOMICS

Pharmacogenetics-The roots of pharmacogenomics, Genetic drug response profiles, the effect of drugs on Gene expression, pharmacogenomics in drug discovery and drug development.

UNIT II THE HUMAN GENOME

Expressed sequence Tags (EST) and computational biology, Microbial genomics, computational analysis of whole genomes, Genomic differences that affect the outcome of host pathogen interactions: future of whole genome-based pharmacological science.
UNIT III ASSOCIATION STUDIES IN PHARMACOGENOMICS
Viability and ADR in drug response: contribution of genetic factor, Multiple inherited genetic factors influence the outcome of drug treatments, Plasma binding proteins, Drug targets.

UNIT IV GENOMICS APPLICATIONS FOR DRUG ACTION AND TOXICITY
Genomics, Proteomics; applications in pharmaceutical industry, Understanding biology and diseases; Target identification and validation, Drug candidate identification and optimization.

UNIT V PHARMACOGENOMICS AND DRUG DESIGN
The need of protein structure information, protein structure and variation in drug targets-the scale of problem, Mutation of drug targets leading to change in the ligand binding pocket.

TOTAL : 45 PERIODS

OUTCOME
• At the completion of course, the student would have learnt advanced pharmacogenomics enabling him for cutting edge academic and industrial research.

REFERENCE

BO5014 CONVENTIONAL AND RATIONAL DRUG DISCOVERY STRATEGIES

OBJECTIVES
• This subject will expose the students to various principles and methodologies involved in the drug discovery and validation process.

UNIT I FUNDAMENTALS ON RATIONAL DRUG DESIGN
Various approaches in drug discovery process – conventional versus rational, drug targets, lead identification; Principles of ligand chemistry – lead optimization, pharmacophores, bio-isosteres, principles of ligand chemistry such as configuration, conformation, chirality, isosteric replacement; Parameters of ligand design such as –Physiochemical, geometric, conformational, topological, partitional, steric, stereochemical and electronic properties of drug molecules;
UNIT II IN-SILICO AND SIMULATION METHODOLOGIES IN DRUG DISCOVERY 9
Introduction to molecular docking (including methods and scoring functions), denovo pharmacophore elucidation/ drug design for structurally well-defined receptor targets from case studies (Eg. HIV protease inhibition, ACE inhibition); Principles of macromolecule-ligand docking, docking algorithms, AUTODOCK; Molecular dynamic simulations, relative energy, energy minimization methods, ligand binding free energy calculations (both simulation and empirical methods), intermolecular interactions, forces related to drug binding, force-field calculation including solvation, role of solubility in drug binding and pKa, Poisson-Boltzmann Surface Area (PBSA), AMBER,GROMOS and GROMACS.

UNIT III COMBINATORIAL AND SYNTHETIC PEPTIDE LIBRARIES 9
Combinatorial Chemistry in drug development, Biopolymers as natural libraries, Selection and evolution of expression genetic libraries, Combinatorial assembly of antibody genes, Molecular solutions to Combinatorial problems, Solid-Phase peptide synthesis, Peptide on pins, Other iterative disconvolution strategies, Examples of Split/Couple/Mix Peptide Libraries, Positional Scanning,. Polystyrenes, Grafted supports, Coupling strategies, linkers, Supported Solution and Phase Synthesis, analytical methods for solid-phase

UNIT IV HIGH THROUGHPUT SCREENING IN DRUG DISCOVERY 9
Classification of HTS: Protein based biochemical screens, methods of analytical biochemistry used in HTS (photometry, purification, electrophoresis, kinetic assay, radioisotopes, immunoassay,HTS FACS based assays). Assay design for HTS and statistical treatment of the results for decision.

UNIT V GENETIC BASED TOOLS IN DRUG DISCOVERY PROCESS 9
Basic of gene silencing, transgenic worms in drug screening; designing siRNAs, Types of RNAi Screens – Loss of Function screens (LOF), Synthetic Lethal screen, Mini-clonogenic RNAi screen; optimizing, and implementing high-throughput siRNA genomic screening for the discovery of survival genes and novel drug targets, siRNA HTS Screening for identification of targeted pathways in biological systems.

TOTAL : 45 PERIODS

OUTCOME
• On the completion of the course the students will learn various conventional and advanced methods employed in newdrug discovery process that will enable them for academic and industry research in future.

REFERENCES
3. GROMOS And GROMACS Manuals , 2014.

BO5015  NANOBIOTECHNOLOGY  L T P C

3 0 0 3

OBJECTIVES

- The ‘Nanobiotechnology’ course aims to provide fundamental concepts of nanotechnology and advanced knowledge on the application of nanotechnology to biological sciences including nanomedicine.

UNIT I  NANOSCALE AND NANOBIOTECHNOLOGY  9

Introduction to Nanoscience and Nanotechnology; Milestones in Nanotechnology; Overview of Nanobiotechnology and Nanoscale processes; Physicochemical properties of materials in Nanoscales.

UNIT II  FABRICATION AND CHARACTERIZATION OF NANOMATERIALS  9

Types of Nanomaterials (Quantum dots, Nanoparticles, Nanocrystals, Dendrimers, Bucky balls, Nanotubes); Gas, liquid, and solid –phase synthesis of nanomaterials; Lithography techniques (Photolithography, Dip-pen and Electron beam lithography); Thin film deposition; Electrospinning. Bio-synthesis of nanomaterials.

UNIT III  PROPERTIES AND MEASUREMENT OF NANOMATERIALS  9

Optical Properties: Absorption, Fluorescence, and Resonance; Methods for the measurement of nanomaterials; Microscopy measurements: SEM, TEM, AFM and STM. Confocal and TIRF imaging.

UNIT IV  NANOBIOLOGY AND BIOCONJUGATION OF NANOMATERIALS  9

Properties of DNA and motor proteins; Lessons from nature on making Nano devices; Reactive groups on biomolecules (DNA & Proteins); Surface modification and conjugation to nanomaterials. Fabrication and application of DNA nanowires; Nano fluidics to solve biological problems.

UNIT V  NANO DRUG DELIVERY AND NANOMEDICINE  9

Properties of Nano carriers; drug delivery systems used in nanomedicine; Enhanced Permeability and Retention effect; Blood-brain barrier; Active and passive targeting of diseased cells; Health and environmental impacts of nanotechnology.
OUTCOMES
- The students would have learned the physicochemical properties of nanomaterials; the unique changes that happen at nanoscale; nanoscale view of the natural biomolecular processes; synthesis, modification, and characterization of nanomaterials; and application of Nanomaterials to biological problems including nanomedicine

REFERENCES

BO5016 RESEARCH AND RESEARCH METHODOLOGY IN BIOTECNOLOGY L T P C 3 0 0 3

OBJECTIVES
- The course will provide knowledge about the objectives to perform research and for interpretation of data from experimental results and presenting technical publications.

UNIT I RESEARCH AND ITS METHODOLOGIES (WITH EXAMPLES) 9
Objectives of research; research process – observation, analysis, inference, hypothesis, axiom, theory, experimentation; Types of research (basic, applied, qualitative, quantitative, analytical etc); Features of translational research, the concept of laboratory to market (bench to public) and Industrial R&D.

UNIT II RESEARCH IN BIOTECHNOLOGY – AN OVERVIEW 9
Biological systems and their characteristics that influence the type and outcome of Research; Exploratory and product-oriented research in various fields of biotechnology (health, agri, food, industrial etc). Types of expertise and facilities required; Interdisciplinary nature of biotech research; Sources of literature for biotech research

UNIT III EXPERIMENTAL RESEARCH: BASIC CONCEPTS IN DESIGN AND METHODOLOGY 9
Precision, accuracy, sensitivity and specificity; major experimental variables, biochemical measurements, types of measurements, enzymes and enzymatic analysis, antibodies and
immunoassays, instrumental methods, bioinformatics and computation, experimental planning –
general guidelines.

UNIT IV  RESULTS AND ANALYSIS  9
Importance and scientific methodology in recording results, importance of negative results,
different ways of recording, industrial requirement, artifacts versus true results, types of
analysis (analytical, objective, subjective) and cross verification, correlation with
published results, discussion, outcome as new idea, hypothesis, concept, theory, model etc.

UNIT V  SCIENTIFIC AND TECHNICAL PUBLICATION  9
Different types of scientific and technical publications in the area of biotechnology, and their
specifications, Ways to protect intellectual property – Patents, technical writing skills, definition
and importance of impact factor and citation index; Assignment in technical writing

OUTCOME
- After the completion of course, students will able to design, conduct, and interpret
  research outcomes for academic and industrial research needs.

REFERENCES
1. "Biochemical Calculations: How to Solve Mathematical Problems in General
2. "Essentials of Research Design and Methodology" Geoffrey R. Marczyk, David
4. S Janarthanan, “Practical Biotechnology: Methods and Protocols” Orient Blackswan
   2007

BO5017  ADVANCE ANALYTICAL TECHNIQUES FOR BIOLOGIST  L T P C
3 0 0 3

OBJECTIVE
- To enable students to acquire knowledge in various advanced analytical techniques
  used in the screening of pharmaceutical agents.

UNIT I  UV-VISIBLE SPECTROSCOPY  9
Brief introduction of spectroscopy, EMR and principle of absorptions by molecule. The
absorption law – Beer’s and Lambert’s law, limitations and chromospheres concept, Theory of
electronic transition theory, choice of solvent and solvent effects, modern instrumentation –
design and working principle. Applications of UV-Visible spectroscopy (various qualitative and
quantitative methods), Woodward – Fischer rules for calculating absorption maximum.

UNIT II  IR SPECTROSCOPY AND THERMAL METHODS OF ANALYSIS  9
Infrared radiation, theory of IR absorption by a molecule, vibrational frequency and factors
influencing vibrational frequency, rotational degrees of freedoms, transmission/absorption
modes, types of bands, instrumentation and sampling techniques, interpretation of spectra, applications in pharmaceuticals. FT-IR-theory and applications, Attenuated Total Reflectance (ATR). Instrumentation and applications of thermal methods - Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), Differential Thermal Analysis (DTA) and Thermo Mechanical Analysis (TMA).

UNIT III NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY 9
Basic theory of NMR/PMR, excitation/emission process and instrumentation. solvents, reference compound, scale of measurement, shielding/deshielding; chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling and shift reagents, proton exchange reactions, FT-NMR, 2D-NMR, NMDR, NOE, NOESY, COSY and applications in pharmaceuticals, spectral interpretations, C13 NMR, Natural abundance, C13-NMR, its role in structural applications.

UNIT IV MASS SPECTROMETRY 9
Basic principles, instrumentation and ionization methods; precursor ion/product ion production and fragmentation pattern; atmospheric pressure ionization (API), Chemical ionization (CI), Field Ionization (FI), Fast Atom Bombardment (FAB), Matrix assisted laser desorption ionization (MALDI), Time of Flight (TOF), hybridization with other techniques, and interpretation of mass spectrum and applications in pharmaceuticals.

UNIT V CHROMATOGRAPHIC METHODS 9
Classification of chromatographic methods on mechanism of separation: High Performance Liquid Chromatography: Principle, instrumentation, solvents, packing materials and applications in pharmaceuticals; Gas Chromatography: principle, theory, column operations, instrumentation, derivatisation methods and applications in pharmaceuticals; HPTLC and Super Critical Fluid Chromatography (SFC): Theory, instrumentation, elution techniques and pharmaceutical applications; Principles, classifications, instrumentation, moving boundary electrophoresis, Zone Electrophoresis (ZE), Iso-electric focusing (IEF) and applications.

TOTAL: 45 PERIODS

OUTCOME
• The student would have learnt various advanced analytical techniques for identification, separation, purification and quantification of pharmaceutical agents from various biological sources.

REFERENCES
BO5018 HERBAL DRUG DEVELOPMENT AND STANDARDIZATION

OBJECTIVE

- To enable students to acquire theoretical knowledge in herbal drug development and understanding the theoretical principles of standardization.

UNIT I GENERAL METHODS OF PROCESSING OF HERBS

Definition, sources, identification and authentication of herbs - Different methods of processing of herbs like collection, harvesting and garbling - packing and storage conditions - Methods of drying – Natural and artificial drying methods, with their merits and demerits.

UNIT II EXTRACTION METHODS

Principles of extraction and selection of suitable extraction method - Different methods of extraction including maceration, percolation, hot continuous extraction, pilot-scale extraction and supercritical fluid extraction with their merits and demerits - Purification and recovery of solvents.

UNIT III STANDARDIZATION OF HERBAL RAW MATERIALS AND EXTRACTS

Standardization of herbal raw materials, including pharmacognostical, physical, chemical and biological methods with examples - Standardization of herbal extracts, physical, chemical and spectral analysis - Qualitative and Quantitative estimation of active principles from standardized extracts by HPTLC - Biological standardization - Pharmacological screening of herbal extracts and Microbiological evaluation of herbal extracts - Toxicity studies of herbal extracts.

UNIT IV ISOLATION AND ESTIMATION OF PHYTOCONSTITUENTS

Different methods for isolation and estimation of phytoconstituents from the following drugs (with special emphasis on HPLC and HPTLC): Hypericin / Hyperforin from Hypericum species - Forskoline from Coleus forskoli - Catechins from Green tea - L-hydroxy citric acid from Garcinia combogia - L-Dopa from Mucuna pruriens. Andrographolides from Andrographis paniculata -
Alicin from Garlic - Piperine from Piper nigrum / Piper longum - Bacosides from Bacopa monnieri - Berberine from Berberis aristata etc.

UNIT V HERBAL DRUG FORMULATION AND QUALITY CONTROL

TOTAL: 45 PERIODS

OUTCOME
- The students would have learnt various herbal formulation, processing and standardization of herbal extracts and estimation of phytoconstituents.

REFERENCES

BO5019 ADVANCED CANCER BIOLOGY

OBJECTIVES
- To develop fundamental concepts of cancer identification, etiology and epidemiology. To know the signaling pathways and their relation to cancer. To understand the cellular and molecular basis of current strategies for cancer prevention and treatment.

UNIT I INTRODUCTION TO CANCER BIOLOGY
Regulation of cell cycle; mutations that cause changes in signal molecules; Apoptosis and caspases; Cancer Epidemiology; Chemical and Radiation Carcinogenesis.

UNIT II MOLECULAR ASPECTS OF CANCER
Signal targets and cancer; activation of kinases; Oncogenes; detection of oncogenes; retroviruses and oncogenes; Oncogenes/proto oncogene activity; Tumor Suppressor Genes; Growth factors related to transformation.

UNIT III METASTASIS & ANGIOGENESIS
Three step theory of invasion; basement membrane disruption; metastatic cascade; Angiogenesis; Tumor Progression and Metastasis; Cell Proliferation and Cell Death.
UNIT IV CANCER MANAGEMENT
Different forms of therapy- chemotherapy; radiation therapy; immunotherapy- engineered monoclonal antibodies and vaccines; use of signal targets towards therapy of cancer; Gene therapy; pharmacology of Anti-neoplastic agents.

UNIT V CANCER MARKERS AND ITS DETECTION
Diagnostic Tests; Detection using biochemical assays; tumor markers; ideal markers; risk markers; diagnostic markers; prediction of aggressiveness of cancer; molecular tools for early diagnosis of cancer; Hormones and cancer; Immune system and cancer.

OUTCOME
• To understand the cellular mechanisms and cell cycle and acquire knowledge on molecular aspects of Cancer

REFERENCES:

BO5020 ENTREPRENEURSHIP AND INTELLECTUAL PROPERTY RIGHTS LT P C
3 0 0 3

OBJECTIVE
• To enable students to acquire knowledge in Entrepreneurship and IPR and understanding the rules and regulations.

UNIT I ENTREPRENEURSHIP
Definition, functions and kinds of entrepreneurs, intrapreneur-entrepreneurship and economic development, entrepreneurial competencies-traits, developing competencies, project identification, selection and financing. Project report- content and significance, Planning Commission’s guidelines for formulating project reports-methods of project appraisals.

UNIT II INTRODUCTION TO INTELLECTUAL PROPERTY
Types of Intellectual property (IP): Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of GMOs IPas a factor in R&D; IPs of relevance to Biotechnology Agreements and Treaties History of GATT & TRIPS Agreement; Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty; PCT; Indian Patent Act 1970 & recent amendments Case Studies
UNIT III  BASICS OF PATENTS AND CONCEPT OF PRIOR ART  8
Introduction to Patents; Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; Specifications: Provisional and complete; Forms and fees Invention in context of “prior art”; Patent databases; Searching International Databases; Country-wise patent searches (USPTO, esp@cenet(EPO), PATENTScope(WIPO), IPO, etc.)

UNIT IV  PATENTING PROCEDURES  7
National & PCT filing procedure; Time frame and cost; Status of the patent applications filed; Precautions while patenting – disclosure/non-disclosure; Financial assistance for patenting - introduction to existing schemes Patent licensing and agreement Patent infringement meaning, scope, litigation, case studies

UNIT V  BIOENTREPRENEURSHIP AND BIOSAFETY  10
Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of National Regulations and relevant International Agreements including Cartegana Protocol.

TOTAL : 45 PERIODS

OUTCOME
- The students would have learnt various law, rules and regulations in IPR, Patent, procedure and student became a Entrepreneur.

REFERENCES
5. Solution Pvt. Ltd., 2007

BO5091  TISSUE ENGINEERING AND REGENERATIVE MEDICINE  L T P C
3 0 0 3

OBJECTIVES
- The course intends to give advanced theoretical knowledge on tissue engineering, Stemcells and its biological applications

UNIT I  INTRODUCTION  9
Introduction to tissue engineering: Basic definition; current scope of development; use in therapeutic, cells as therapeutic agents, cell numbers and growth rates, measurement of cell
characteristics morphology, number viability, motility and functions. Measurement of tissue characteristics, appearance, cellular component, ECM component, mechanical measurements and physical properties.

UNIT II TISSUE ARCHITECTURE 9
Tissue types and Tissue components, Tissue repair, Basic wound healing events, Applications of growth factors: Role of VEGF. Angiogenesis, Basic properties, Cell-Matrix & Cell-Cell Interactions, Control of cell migration in tissue engineering.

UNIT III BIOMATERIALS 9
Biomaterials: Properties of Biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of Biomaterials, biological and synthetic materials, Biopolymers, Applications of biomaterials, Modifications of Biomaterials, Role of Nanotechnology.

UNIT IV BASIC BIOLOGY OF STEM CELLS 9
Stem Cells : Introduction, Types & sources of stem cell with characteristics: hematopoietic differentiation pathway, Potency and plasticity of stem cells, sources, embryonic stemcells, hematopoietic and mesenchymal stem cells, Stem Cell markers, FACS analysis, Differentiation, Stem cell systems- Liver, neuronal stem cells, cancer stem cells, induced pluripotent stem cells.

UNIT V CLINICAL APPLICATIONS 9

TOTAL: 45 PERIODS

OUTCOME
- The students will acquire knowledge in advanced methods to carry out cutting edge academic and industrial research.

REFERENCES

BO5021 NOVEL DRUG DELIVERY SYSTEM L T P C
3 0 0 3

OBJECTIVE
- The course intends to give advanced knowledge about various Novel drug delivery systems

UNIT I SUSTAINED RELEASE DRUG DELIVERY SYSTEMS (SRDDS)
Introduction - rationale of SRDDS - advantages and disadvantages of SRDDS - factors influencing the design and performances of SRDDS - physicochemical properties of a drug influencing design and performance - biological factors influencing design and performance of SRDDS - routes of drug administration of SRDDS - micro encapsulation - different micro-encapsulation processes, - advantages - disadvantages and applications - polymers used in SRDDS – classification and applications in formulation - system design for rate–controlled drug delivery - feedback - regulated drug delivery systems, in vitro and in vivo evaluation of controlled released drug delivery

UNIT II PARENTERAL CONTROLLED RELEASE DRUG DELIVERY SYSTEMS
Approaches for injectable controlled release formulations - development of injectable controlled release formulations - long-acting penicillin preparations - long-acting Insulin preparations - long-acting steroid preparations and long-acting contraceptive preparations - approaches and applications of implantable drug delivery systems

UNIT III ORAL CONTROLLED RELEASE SYSTEMS
Design and development of oral controlled-release drug administration - dissolution controlled – diffusion-controlled - membrane permeation controlled - osmotic pressure controlled - gel diffusion-controlled - pH controlled - ion-exchange controlled delivery systems - prolongation of GI retention of oral drug delivery system

UNIT IV TRANSDERMAL AND MUCOADHESIVE DRUG DELIVERY SYSTEMS
UNIT V  OCULAR AND TARGETED DRUG DELIVERY SYSTEM

Preparation and evaluation of ocular controlled drug delivery systems - ophthalmic inserts and in-situ gels – targeted drug delivery systems – concepts - targeting of drugs through nanoparticles, liposome - resealed erythrocytes – microspheres - magnetic microspheres and monoclonal antibodies - brief study of colon targeting

TOTAL:45 PERIODS

OUTCOME
- The student will acquire knowledge about various Novel drug delivery systems and chemical, biophysical and biological factors that impact on targeted, sustained and controlled drug delivery systems

REFERENCES

BO5022  DOWNSTREAM PROCESSING

OBJECTIVE:
- To develop an understanding of concepts in efficient separation of biomolecules (proteins, peptides, oligosaccharides, DNA, etc) and particularly with relevance to pharmaceuticals

UNIT I  INTRODUCTION TO BIOSEPARATION
Fundamentals and concepts in bioseparation technology. Characterization and analysis of fermentation broth, Physical methods of structure determination of biomolecules, Guidelines to recombinant protein purification.

UNIT II  ISOLATION OF PRODUCTS
Extraction – theory and practice: Aqueous two phase extraction, supercritical fluid extraction. Precipitation techniques: salts, solvents, polymers (PEG). Membrane based separation – Microfiltration, Ultrafiltration, reverse osmosis, dialysis.

UNIT III  CHROMATOGRAPHY FOR BIOSEPARATION
Theory, practice and selection of media for – gel-filtration chromatography, Ion exchange chromatography, Hydrophobic interaction chromatography, reverse phase chromatography,
Affinity chromatography – Metal affinity chromatography, dye affinity chromatography, immunosorbert affinity chromatography & Expanded bed chromatography. Scale-up criteria for chromatography, calculation of no. of theoretical plates and design. Electrophoresis separation.

UNIT IV FINAL POLISHING AND CASE STUDIES 10
Freeze drying, lyophilization, spray drying and crystallization. Case studies on purification of: cephalosporin, aspartic acid, Recombinant Streptokinase, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase, Insulin. Case studies of product recovery economics.

UNIT V ADVANCED BIOSEPARATIONS 6
Recent trends in bioseparations, pervaporation, reverse miceller extraction, super critical fluid extraction spin base, magnetic separation and their application, case studies of product purification and recovery.

TOTAL: 45 PERIODS

OUTCOME:
- Students get skills to understand the various principles involved in protein purification. Understand the characterization of various bio-molecules. Understand the principles involved in various chromatography techniques

REFERENCE:

BIOMATERIALS

OBJECTIVES
- To know the classification of biomaterial, their bulk and surface properties and characterization to prepare the students to find a place in biomedical field. To learn the various biological responses to the materials and biomechanics. To have an exposure
on the clinical context of their use, manufacturing processes and testing, cost, sterilization, packaging and regulatory issues.

UNIT I  INTRODUCTION AND CLASSIFICATION  9
Introduction and classifications; Metals: different types, properties and interaction with the tissue, Polymers: classification and properties, Ceramics: Types, properties and interactions with the tissue, Composites: matrix and reinforcing agents/fillers and properties, Cell adhesion, host- tissue reactions. Tissue derived biomaterials: Structure and properties of collagen and collagen-rich tissues, Biotechnology of collagen, design of resorbable collagen-based medical implants soft.

UNIT II  BULK AND SURFACE CHARACTERIZATION  9
Bulk Characterization: XRD, FT-IR, SEM, energy dispersive X-ray (EDX), DSC, TGA, dielectric analysis (DEA); Surface analysis: XPS, SIMS, AES, surface enhances Raman spectroscopy (SERS), AFM/STM; Structural properties of tissues-bone, teeth and elastic tissues, Effects of sterilization on material properties.

UNIT III  TESTING  9
Biocompatibility: blood and tissue compatibility; degradation of biomaterials in biological environment, toxicity tests, sensitization, carcinogenicity, mutagenicity and special tests; In vitro and In vivo testing, implant associated infections, biocompatibility enhancement using carona discharge and plasma processes, surface coatings; Ethical considerations, good manufacturing practice, standards, Regulatory issues.

UNIT IV  TISSUE REPLACEMENT IMPLANTS WITH BIOMATERIALS  9
Tissue replacements, sutures, surgical tapes, adhesive, percutaneous and skin implants, maxillofacial augmentation, blood interfacing implants, hard tissue replacement implants, internal fracture fixation devices, Joint replacements.

UNIT V  ARTIFICIAL ORGANS WITH BIOMATERIALS  9
Artificial heart, prosthetic cardiac valves, limb prosthesis, externally powered limb prosthesis, Dental implants.

TOTAL: 45 PERIODS

OUTCOME
• To select biomaterial for organ replacement and temporary body implant Design, analytical, problem solving, technical judgment skills

REFERENCES: