# SAVITRIBAI PHULE PUNE UNIVERSITY

## B.E. (Biotechnology) Structure and Syllabus for 2012 Course
## (W.e.f. Academic Year 2015-16)

**B.E. (Biotechnology) Structure and Syllabus for 2012 Course Term-I**
**(W.e.f. Academic Year 2015-16)**

| Subject Code | Subject | Teaching Scheme Hrs/Week | | | Examination Scheme (Marks) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Lect | Tut | Pr | Theory | | TW | Pr | Or | Total |
| | | | | | In Sem. | End Sem | | | | |
| 415461 | Bioprocess Equipment Design | 4 | - | 2 | 30 | 70 | -- | - | 50 | 150 |
| 415462 | Bioseparation II | 3 | - | 2 | 30 | 70 | - | 50 | | 150 |
| 415463 | Biochemical Engineering | 3 | - | 2 | 30 | 70 | -- | - | 50 | 150 |
| 415464 | Elective - I | 3 | - | 2 | 30 | 70 | 50 | - | -- | 150 |
| 415465 | Elective - II | 3 | - | - | 30 | 70 | -- | - | -- | 100 |
| 415466 | Project | - | 2 | - | --- | -- | 50 | -- | | 50 |
| **Total →** | | 16 | 02 | 08 | 150 | 350 | 100 | 50 | 100 | 750 |

| Elective I | Elective II |
|---|---|
| 1. Environmental Biotechnology | 1. Bioenergy and Renewable Resources |
| 2. Chemo informatics and Structural Biology | 2. Biomaterials |
| 3. Bio-therapeutics Technology | 3. Stem Cell Biology and Regenerative Medicine |

| Subject Code | Subject | Teaching Scheme Hrs/Week | | | Examination Scheme (Marks) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Lect | Tut | Pr | Theory | | TW | Pr | Or | Total |
| | | | | | In Sem. | End Sem | | | | |
| 415467 | Plant Engineering & Project Costing | 3 | - | 2 | 30 | 70 | -- | - | 50 | 150 |
| 415468 | Bioprocess Modeling & Simulation | 3 | - | 2 | 30 | 70 | - | -- | 50 | 150 |
| 415469 | Elective - III | 3 | - | 2 | 30 | 70 | 50 | - | | 150 |
| 415470 | Elective - IV | 3 | - | - | 30 | 70 | -- | - | -- | 100 |
| 415471 | Advanced Biotechnology Practices | | - | 2 | | | 50 | -- | -- | 50 |
| 415472 | Project | - | 6 | - | | | 100 | -- | 50 | 150 |
| **Total →** | | 12 | 02 | 08 | 120 | 280 | 200 | | 150 | 750 |

**B.E. (Biotechnology) Term-II**

| Elective III | Elective IV |
|---|---|
| 1. Food Biotechnology | 1. Management and Entrepreneurship |
| 2. Agricultural Biotechnology | 2. IPR, Bioethics and Regulations |
| 3. Genomics | 3. Industrial Organization and Management |

**B.E. BIOTECHNOLOGY**

**TERM I**

# BIOPROCESS EQUIPMENT DESIGN (415461)

**Teaching Scheme:**
**Theory: 4 hr/week**
**Drawing: 2 hr/week**

**Exam Scheme:**
**In Sem: 30 Marks**
**End Sem : 70 Marks**
**Oral: 50 Marks**

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**UNIT 1** **[7 Hrs]**
**Basic Principles of design**

Design Factors, Design procedure, Codes and Standards, Optimization, Design Loads, Combined Loading in Equipments, Concept of Stress and Strain, Theories of Failure.

**UNIT 2** **[8 Hrs]**
**Pressure Vessels and bioreactors**

Design of unfired pressure vessels: Types of pressure vessels, material of construction, selection of corrosion allowance and weld joint efficiency, purging of vessels, Selection and design of various types of heads.
Design principles of bioreactors, Geometric configuration, flanges, nozzles, gaskets, supports

**UNIT 3** **[8 Hrs]**
**Bioreactors and Reaction vessels:**

Accessories for bioreactors, Study of various types of agitators, aerators, air filters, stabilizers, power requirement.

**Reaction vessels -** Introduction, classification, heating systems, various types of jackets like plain, half coil, channel, and limpet oil. Study and design of internal coil of reaction vessels, Heat transfer coefficients in coils

**UNIT 4** **[8 Hrs]**
**Heat Exchange Equipments**

Introduction, types of heat exchangers, codes and standards for heat exchangers, Materials of construction, baffles and tie rods, tube joining methods, Design of shell and tube heat exchangers

**UNIT 5** **[7 Hrs]**
**Design of distillation column**

Design variables in distillation, design methods for binary systems, plate efficiency, approximate column sizing, plate contactors and plate hydraulic design - Plate design, weir dimensions, weep point, hole size, and Plate pressure drop.

**UNIT 6** **[8 Hrs]**
**Bioreactors**

Material for construction of bioreactors and selection criteria

Scale up of bioreactors, safety measures in bioreactors. Economic consideration for scale up

**Practical's (Minimum 6):**

Drawing of following preferably on (Minimum six Auto CAD)

1. Pressure vessel
2. Shell and tube heat exchanger
3. Basket Centrifuge
4. Distillation Column
5. Rotary Filter
6. Bioreactor

**Text Books:**


1. Process Equipment Design. S. D. Dawande, Dennet and Company.

2. Process Equipment Design, M. V. Joshi. McMillan India.

3. Plant Design and Economics for Chemical Engineers. M. Timmerhouse, McGraw Hill and Co.

4. Bioprocess Engineering-Systems, Equipment and Facilities" Edited by Bjorn K. Lydersen, Nancy A D'elia and Kim L. Nelson, A Wiley Interscience Publication.

5. Introduction to Chemical Equipment Design" by B.C. Bhattacharya, C.B.S. Publications.


**Reference Books:**


1. Process equipment design" by L.E. Brownell and E. Young, John Wiley, New York, 1963.

2. Chemical Engineering Vol. 6" by J.M. Coulson, J.F. Richardson, and R.K. Sinott, Pergamon Press.

3. Chemical Engineering volume 2" by J.M. Coulson, J.F. Richardson, and R.K. Sinott Pergamon Press.

4. Mixing theories and practices" by Uhl V.W. and Grey J.B. Academic Press, New York, 1967.

5. Mass Transfer Operations" by Treyball R.E., McGraw Hill, New York.

6. Chemical Process Equipment-Selection and design" Walas S.M., Butter worth Heinamer, McGraw Hill book company, New York.

7. Indian standards Institution" code for shell and tube heat exchangers, IS – 4503

8 Applied Process Design for Chemical and Petrochemical Plants" vol 1 and 2, Ludwig E.E., Gulf publishing co. publishing company,

# BIOSEPARATION II (415462)

**Teaching Scheme:**
**Theory: 3 hr/week**
**Practical: 2hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End Sem : 70 Marks**
**Practical: 50 Marks**

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**UNIT 1** **[6 Hrs]**

**Downstream Processing in Biotechnology**

Role and importance of downstream processing in biotechnological processes, Problems and requirements of bio-product purification, Characteristics of biological mixtures, Process design criteria for various classes of bio-products - high volume, low value products and low volume, high value products

**UNIT 2** **[8 Hrs]**

**Spectrophotometry**

Introduction, Beer-Lambert's law, Instrumentation ,Spectrofluorometry – Principle, Instrumentation, Applications, Case studies, Quantitative spectrophotometeric analysis, Basic principles of spectroscopy, Introduction to atomic absorption spectroscopy and NMR

**UNIT 3** **[8 Hrs]**

**Chromatography – Types and applications**

Principles, retention, procedures, materials and applications of – Gel permeation chromatography, Ion exchange chromatography, Chromatofocussing, affinity chromatography, Reversed phase and hydrophobic interaction chromatography

**UNIT 4** **[6 Hrs]**

**Chromatography – Types and applications**

Gas Chromatography, Liquid chromatography, Introduction to GC-MS and LC-MS, Instrumentation: Pumps, degasser, mixer, guard column, column and detectors, Chromatograms

**UNIT 5** **[8 Hrs]**

**Other separation techniques**

Zone refining, Molecular sieves, Adductive crystallization, Supercritical fluid extraction, Reactive extraction, Precipitation, Aqueous two phase systems, Introduction to SEP box and Hyphenated techniques.

**UNIT 6** **[6 Hrs]**

**Applications of Bio-separations – Case studies**

Health care products - Production of penicillin, peptide antibiotics

Food and Beverages – Beer, Citric acid

Bio-chemicals – Butanol

Specialty products – Microbial polysaccharides

**Practicals (Any 8):**

1. Verification of Beer Lambert's law
2. Determination of $\lambda_{max}$ for proteins
3. Determination of protein concentration in fermentation broth
4. Separation of casein protein from milk
5. Study of tangential flow filtration

6. To study gel filtration chromatography
7. Separation of compounds using column chromatography
8. Demonstration of Liquid chromatography (HPLC)
9. Demonstration on SEP BOX

**Text Books:**


1. Belter, P. A., Hu, W. S. and Cussler, E. L., "Bioseparation: Downstream processing for Biotechnology", Wiley, New York
2. Belter, P. A. and Cussler, E., "Bioseparations", Wiley, New York 1985
3. Siva Shankar, "Bioseparations", PHI publications


**Reference Books**:


1. McCabe, W. L., Smith, J. C. and Harriott, P., "Unit Operation of Chemical Engineering", McGraw Hill
2. Seader, J. D. and Henley, E. J., "Separation Process Principles", Wiley
3. Product Recovery in Bioprocess Technology", BIOTOL Series, VCH, 1990
4. Asenjo, J. M., "Separation processes in Biotechnology", Marcel Dekkere Inc., 1993
5. Biosepration Engineering: Principles, practice and economics", Wiley, Interscience
6. Wankat, P. C., "Rate controlled separations", Elsevier, 1990

## BIOCHEMICAL ENGINEERING (415463)

**Teaching Scheme:**
**Theory: 3hr/Week**
**Practical: 2hr/Week**

**Exam Scheme:**
**In Sem Exam : 30 Marks**
**End Sem Exam: 70 Marks**
**Oral: 50 Marks**

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**Unit I** **[6Hrs]**

**Fermentation Process Kinetics:**

Introduction to Growth Kinetics, Balanced growth kinetics, Transient growth kinetics, Structured Kinetic models, Product formation kinetics, Thermal death Kinetics of cells and spores.

**Unit II** **[8Hrs]**

**Fermenter design Operation I:**

CSTR, Modes of operation in stirred reactors: discontinuous batch operation, continuous operation, open and closed loop controlled reactors, semi continuous reactors, periodic fed batch cultivation, bubble column reactors, air lift tray bioreactors, hollow fiber configuration and application of bioreactors.

**Unit III** **[8Hrs]**

**Fermenter design Operation II:**

Detailed study of design and operation of different types of fermenters, auxiliary fittings, like sampling port, impeller design, agitated power requirement, measurement and control of dissolved oxygen, $CO_2$, temperature, pH and foam, effect of rheological properties and its importance in fermentation operation.

**Unit IV** **[8Hrs]**

**Aeration and agitation:**

Aeration and agitation, effect of shear, oxygen requirement of microorganisms, mass transfer theory, diffusional resistance to oxygen transfer, methods of measurement of mass transfer coefficients: $k_{La}$ measurement methods- sulphite oxidation methods and Gassing out, Type of impellers.

**Unit V** **[6Hrs]**

**Scale up of Fermenter Process:**

Introduction to scale up, Applications, rules of thumbs to scale up, dimensionless analysis, similarity principles, Environmental approach, regimen analysis.

**Unit VI** **[6Hrs]**

**Advanced Fermentation Techniques:**

Reactors for immobilized techniques, Animal and plant cell reactors, semi synthetic fermentation process: Case Study, Disposable fermenters- Case study.

**Practicals: (Any 8)**

1 Study of kinetics of cell growth of any one fermentation process

2. Study of kinetics of Product formation of any one fermentation process

3. Study of effect of Temperature on fermentation process

4. Study of effect of Ph on fermentation process

5. Fermentation and Production of Vitamins and Antibiotics

6. Beer Fermentation

7. Production of corn syrup using Bacterial Amylase

8. Study of enzyme immobilization by gel entrapment

9. Study of Laboratory fermenter (Study experiment)

**List of Books:**

**Text Books**

1. James E.Bailey, David F.ollis, Biochemical Engineering Fundamentals 2nd edition, , Tata McGraw Hill Edition

2. E.M.T. El-Manasi, C.F.A. Bryce, A.L.Demain, A.R.Allman, Fermentation Microbiology and Biotechnology 2nd Edition Taylor & Fransis

3. Michael L.shuler, Fikret Kargi, Bioprocess Engineering- Basic concepts 2nd edition, PHI Learning Pvt.Ltd.

4. Bioreactor Design and Product Yield- Biotol Series

**Reference Books:**

1. A. Rosevear, John F Kennedy, Joaquim M S Cabral, Adam Hilger, Immobilized Enzymes and Cells

2. S.N. Mokhopadhyay, Experimental Process Biotechnology Protocols, Viva Books Pvt. Ltd.

**B.E. BIOTECHNOLOGY**

**TERM II**

## PLANT ENGINEERING AND PROJECT COSTING (415467)

**Teaching Scheme:**
**Theory: 3 hr/week**
**Drawing: 2 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End Sem : 70 Marks**
**Oral: 50 Marks**

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**UNIT 1** **[7 Hrs]**

**Introduction**

Basic considerations in chemical plant design, project identification, preliminary techno-economic feasibility. Process flow Diagrams and symbols: Symbols of Process Equipments & their concepts, types of flow diagrams, Importance of Laboratory development pilot plant, scale up methods

**UNIT 2** **[7Hrs]**

**Detailed process design**

Basic engineering in process, thermodynamic and kinetic feasibility, capacity identification and selection, process specification, equipment specification material selection, plant safety operation and maintenance, Plant location and layout: Factors affecting site selection, factors affecting both planning and layouts, drawing of plant layout, plant elevation drawing and complete engineering flow sheet drawings

**UNIT 3** **[7 Hrs]**

**Piping Design & Layout**

Piping design, layout, and supports for piping insulations. Pipe fittings, types of valves, selection of valves, process control and instrumentation control system design. Pipe size estimation, water hammer design of pipelines, Isometric of piping, material selection for pipe and pipe fitting, expansion and contraction of piping,thermal insulation of piping, color code of pipeline, bill of material of piping.

**UNIT 4** **[7 Hrs]**

**Process utilities**

Process water, boiler feed water, water treatment, waste treatment and disposal, disposal, steam, oil heating system, chilling plant, compressed air and vacuum.

**UNIT 5** **[7 Hrs]**

**Cost estimation**

Factors involved in project cost estimation - Total capital investment, Fixed capital and working capital, types and methods for estimation of total capital investment, Estimation of equipment cost

**Project scheduling and Financial Management**

CPM/PERT techniques, project engineering, project planning, plant erection, testing and commissioning

**UNIT 6** **[7Hrs]**

**Profitability, alternative investments and replacement**

Methods for profitability evaluation,Evaluation of Break Even Point, % rate of return, Practical factors in alternative investment and replacement studies.

**Depreciation:**

**T**ypes and methods of determining depreciation, evaluation of depreciation methods.

**Practicals:**

Drawing of following preferably on Auto CAD (Minimum six)

1. Process Equipment Symbols
2. Process flow diagram
3. Piping and instrumentation diagram
4. Plant layouts and elevations
5. Piping GA drawing
6. Piping isometrics

**Text Books:**

1. Plant design and Economics for chemical engineers, peter M. S. Timmerhaus, K. D. McGraw Hill.
2. Project Engineering with CPM and PERT, Modes J. Philips, Rheinhold publishers.

**Reference Books:**

1. Systematic design of chemical process plants, Grossman, Biegler and Vesterberg.
2. Turton et al, “Analysis synthesis and design of chemical processes, Prentice-Hall.
3. Chemical Process Economics, Happel J. Jordon D.G. The Chemical Economy, Reaben B.G., Burstall M.L. Longman.

**BIOPROCESS MODELING AND SIMULATION (415468)**

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical: 2 hr/week**

**Exam Scheme:**
**In Sem: 30 Marks**
**End Sem: 70 Marks**
**Oral: 50 Marks**

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**UNIT 1** **[6 Hrs]**

Introduction to Modeling Introduction, definition of Modeling and simulation, Fundamental laws Continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics, Model building, application of mathematical modeling, scope of coverage

**UNIT 2** **[6 Hrs]**

Models based on Mass, component, energy and force balance: Batch reactors, PFR's, CSTR's, Gravity flow systems, Reactors in series, Concept of Heated tanks

**UNIT 3** **[6 Hrs]**

Classification of mathematical modeling Classification based on variation of independent variables, classification based on state of the processes, classification based on type of the processes, comparison between rigid and stochastic processes and introduction of boundary conditions

**UNIT 4** **[8Hrs]**

Modeling of fermentation Batch reactor, Fed batch reactor, Modeling a continuous culture: Chemostat, Chemostat with recycles, substrate limited growth in Chemostat, theory of fed-batch culture control, product inhibition and substrate utilization kinetics

**UNIT 5** **[8Hrs]**

Modeling of fermenters: Modeling of suspended growth reactors, activated sludge systems, theory on agitated and sparged bioreactor, tower-aerobic and anaerobic bioreactors

**UNIT 6** **[8Hrs]**

Mass Transfer Equipment: Reactor with mass transfer, Ideal binary distillation column, Multi-component Batch distillation, Two phase CSTR with heat Removal, Single component vaporizer

**Practicals:**

1. Evaluation of Molar volume and compressibility factor from Vander Waals equation.
2. Steady state material balance on a separation train and calculating molar flow rates and compositions of the train.
3. Calculation of terminal velocity of falling particles.
4. Reaction equilibrium for multiple gas phase reactions.
5. Material and energy balances for a batch reactor.
6. Evaluation of liquid composition in a batch distillation column.
7. Reaction equilibrium for multiple gas phase reactions using polymath.
8. Study of characteristics of multicomponent distillation column.
9. Study of multicomponent absorption column.

10. Steady stages tow stage extraction.

**Text Books:**


1. Luyben, W. L., “Process modeling simulation and control for chemical engineers”, McGraw Hill, 2nd Ed. 2. Bailey, J. and Ollis, D., “Biochemical engineering Fundamentals”, McGraw Hill Kogakusha Ltd. Tokyo
3. Balu, K. and Padmanabhan, K., “Modeling and analysis of Chemical Engineering processes”, IK International private limited, 2007


**Reference Books**:


1. Dunn, I. J., et al., “Biological engineering Principles, Applications and Simulation”, VCH, Weinheim
2. Bioprocess Engineering Principles, Pauline M. Doran, Publisher: Elsevier Science & Technology Books, $2^{nd}$ edition.

## ADVANCED BIOTECHNOLOGY PRACTICES (415471)

**Teaching Scheme:** **Exam Scheme:**
**Practical: 2 hr/week** **Term Work: 50 Marks**

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**Practicals :**

1. Bioassay for antibiotics :
   i. Screening of antibiotic producer.
   ii. Determination of MIC.
   iii. To determine the potency of an antibiotic by agar diffusion method.

2. Aqueous two phase extraction :
   i. To isolate the given protein by ARPS
   ii. To find the partition coefficient of the protein.

3. Media design and inoculum preparation :
   i. To study media preparation of solid state fermentation system
   ii. To study inoculum preparation process of solid state fermentation system.

4. Solid state fermentation – I
   To study the biomolecule production using solid state fermentation with emphasis on upstream processing.

5. Solid state fermentation – II
   To study downstream processing of biomolecules produced in solid fermentation.

6. Downstream processing using steam distillation/column distillation.
   To study production of ethanol in submerged liquid fermentation (SMF) & downstream processing using distillation.

7. Fermentation efficiency and yield analysis:
   To study the fermentation efficiency of alcohol production to determine the yield.

8. Study of types of enzyme inhibition:
   To study the inhibition of enzyme by any one type (Competitive/non-competitive/uncompetitive).

9. HPLC demonstration.

**References:**

**1.**

# LIST OF ELECTIVE SUBJECTS FOR FINAL YEAR BIOTECHNOLOGY

## Semester I

### Elective I

1. Environmental Biotechnology
2. Chemoinformatics and Structural Biology
3. Bio-therapeutics Technology

### Elective II

1. Bioenergy and Renewable Resources
2. Biomaterials
3. Stem Cell Biology and Regenerative Medicine

## Semester II

### Elective III

4. Food Biotechnology
5. Agricultural Biotechnology
6. Genomics

### Elective IV

4. Management and Entrepreneurship
5. IPR, Bioethics and Regulations
6. Industrial Organization and Management

## ELECTIVE I: ENVIRONMENTAL BIOTECHNOLOGY (415464)

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical: 2 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End Sem : 70 Marks**
**Term work: 50 Marks**

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**UNIT 1** **[8 Hrs]**

**Introduction to water and waste water management**

Domestic and industrial wastewater, types, sources and effects of water pollutants, Waste water characteristics–DO, BOD, COD, TOC, total suspended solids, colour and odour, bacteriological quality, oxygen deficit, determination of BOD constants, heavy metals, Water quality standards: ICMR, WHO, MPCB and CPCB, Principles of primary treatment and secondary treatment, process design and basic operating principles of activated sludge (suspended growth) process, sludge treatment and disposal,

**UNIT 2** **[8 Hrs]**

**Methods of waste water treatment**

Aerobic & Anaerobic systems - Trickling filters and their biological principle, different T.F media and their characteristics; rotating biological contactors(RBC); aerated lagoons their principle, advantages and disadvantages; oxidation ditches their principle, advantages and disadvantages; Fluidized bed reactor (FBR), packed bed reactors air- sparged reactors; UASB, photo catalytic reactors, wet-air oxidation

**UNIT 3** **[6 Hrs]**

**Industrial waste waters**

Introduction, Pollution Control: Governing bodies, Policies and Amendments, disposal standards; Treatment of industrial effluents: neutralization, proportioning, effluent sampling and characterization, treatment strategies and disposal standards for different industries: paper and pulp, sugar, distillery, textile, tannery

**UNIT 4** **[8 Hrs]**

**Air Pollution- Sources, Effects and Measurement**

Definition, sources of air pollutants, Effects of air pollutants on human health, plants, animals, materials, Sampling and measurement of air pollutants, Air pollution control standards: WHO, MPCB, CPCB, Air Pollution Control Methods and Equipment, Particulate pollution: cleaning methods, collection efficiency, particulate collection systems, Basic design and operating principles of settling chamber, cyclone separator, fabric filter, electrostatic precipitator, Operating principles of spray tower, centrifugal scrubber, venturi scrubber, Selection of particulate collector, Gaseous pollution: Principles of control by absorption, adsorption, combustion or catalytic oxidation, removal of SOx, NOx. $CO_2$ sequestration by algae

**UNIT 5** **[8 Hrs]**

**Hazardous and Solid Waste Management**

Xenobiotic compounds, recalcitrance; Hazardous Waste Management, Sources & Classification, physicochemical properties, Hazardous Waste Control & Treatment; Concept of Waste minimization: benefits and technologies to hazardous waste reduction; Hazardous Waste Management & Handling rules, Hospital Waste Management, Solid Waste Management Plan: Sanitary land filling, Recycling, Composting, Incineration, Biotechnology application to hazardous waste management - Biodegradation and Biological detoxification; examples of cyanide and phenols

**UNIT 6** **[8 Hrs]**

**Bioremediation**

Constraints and priorities of Bioremediation; Biostimulation and Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation, Bioremediation Case studies: Oil pollution – treatment with micro-organisms, Recovery of metals from waste water and sludge, Xenobiotics – degradative capabilities of microorganisms with reference to toxicology, pesticides, herbicides, polyaromatic hydrocarbons; Solid phase bioremediation – land farming, prepared beds, soil piles; Phytoremediation, Composting – Anaerobic and aerobic, Bioventing & Biosparging; Wormicomposting, Wetland Management, Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors Membrane based waste water treatment processes

**Practical (any 8):**

1. To study microbial flora of waste water
2. Determination of potability of water by MPN Test
3. Characterization of coliforms
4. To study quality of air
5. To study BOD
6. To study COD
7. Conductivity measurement of water
8. Effect of treatment method on coliform/ microbial content
9. To study TDS

**Text books:**

1. Wastewater Engineering: Treatment and Disposal, Second edition, Metcalf and Eddy, Inc Tata McGraw-Hill publishing Company, New Delhi, 1987
2. Wastewater Engineering: Treatment and Disposal fourth edition,Metcalf and Eddy, Inc McGraw-Hill Companies, 2002
3. Environmental engineering – Peavy, Rowe – Mc Graw Hill Publications.

**Reference books:**


1. Waste water treatment for pollution control **,** Soli J. Arciwala**,** Tata McGraw-Hill Publications, New Delhi
2. Manual Sewerage and Sewage Treatment – Public Health Department, Govt. of India.
3. Sewage disposal and treatment – Dr. Modi , Standard Publications, NewDelhi.
4. Wastewater Treatment – M. N. Rao and A. K. Dutta, Oxford and IBH Publlishing Co Pvt Ltd, New Delhi, 1987
5. Environmental Pollution Control Engineering, First edition, C.S. Rao, New Age International (P) Ltd., 1991
6. Wastewater Engineering, second edition, B.C.Punmia, Ashok Kr Jain– Laxmi Publications (P) Ltd, New Delhi, India, 1998
7. Fundamentals of Environmental biology, S. Arora Kalyani Publishers, New Delhi, 2008

## ELECTIVE I - CHEMOINFORMATICS & STRUCTURAL BIOLOGY (415464)

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical : 2 hr/week**

**Exam Scheme:**
**In Sem: 30 Marks**
**End Sem: 70 Marks**
**Term work: 50 Mark**

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**UNIT 1** **[8 Hrs]**

Macromolecular Structure as Protein - Primary, Secondary, Supersecondary, Tertiary and Quaternary structure Nucleic acid–DNA and RNA, Carbohydrates, 3D Viral structures,
Protein–protein interactions, protein–DNA interactions, DNA binding proteins, Different forces involved in the interactions

**UNIT 2** **[8 Hrs]**

Methods to study 3D structure - Principles of crystallography, Principles of protein folding and methods to study protein folding, Mass spectrometry and computational approaches in structural biology

**UNIT 3** **[8 Hrs]**

Introduction to cheminformatics, History and evolution of cheminformatics, Use of cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation

**UNIT4** **[8 Hrs]**

Chemical Database Design, Basic database theory, Types of database system, Relational model, Object based model, Structure databases, Reaction databases, Chemical abstracts file, Crystallographic databases, Inorganic Crystal Structure Database (ICSD), Cambridge Structural Database (CSD)

**UNIT 5** **[8 Hrs]**

Structure representation systems, 2D and 3D structures, General introduction to chemical structure-hybridization, tetrahedron geometry etc, Wiswesser Line Notation and Applications

ROSDAL and Applications, the SMILES coding and Applications, Reaction transformations notation like SMIRKS

**UNIT 6** **[8 Hrs]**

Characterization of chemicals by Class & by Pharmacophore, application in HTS Analysis as Introduction to pharmocophore, Identification of pharmacophore features Building pharmacophore hypothesis, Searching databases using pharmocophores,

Introduction to Quantitative Structure Activity Relationship

**Practicals:**

1. DrugBank: Search and retrieval of data from databases.
2. PubChem: Search and retrieval of data from databases.
3. SMILES: Importance of storing chemical in the form of notations and to study molecular representation using SMILES.
4. Swiss PDB Viewer: Study of Homology Modeling using Swiss PDB Viewer.
5. Chemsketch: 2D Structure Generation using ChemSketch
6. CORINA and CONCORD: Importance of 3D structure and methods available for 3D structure generation- CORINA and CONCORD.

7. HEX:  Study of Molecular Docking using HEX.
8. ISIS Base: A brief introduction to database (ISIS Base) with special emphasis on the storage of chemical in the database format.

**Textbooks:**

1. Introduction to Protein Structure by Branden, Carl & Tooze, John, Garland Publishing, 1991.
2. Chemoinformatics by Johann Gasteiger and Thomas Engel, 2004.
3. An introduction to Chemoinformatics by Andrew R. Leach and Valerie J. Gillet, Kluwer Academic Publisher, 2003.

**Reference books:**

1. Chemometrics and Chemoinformatics by Barry K. Lavine, ACS Symposium series 894.
2. Molecular Modeling: Basic Principles and application by Hans Dieter and Didier Rognan. Wiley VeH Gmbh and Co. KGA, 2003.

## ELECTIVE I: BIO-THERAPEUTICS TECHNOLOGY (415464)

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical: 2 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**
**Term work: 50 Marks**

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**UNIT 1** **[8 hrs]**

**Introduction to Biotherapeutics development**

1. Overview of the pharmaceutical and biopharmaceutical industry
2. Definition of the terms: traditional pharmaceutical product, 'biologic' and 'biopharmaceutical',
3. Biopharmaceuticals - current status and future.
4. Overview of biopharmaceutical products now approved for use,
5. Overview of the drug development process;
6. Pre-clinical studies – safety, efficacy, in-vitro, in-vivo

**UNIT 2** **[8 hrs]**

**Various systems used for production of Biotherapeutics: Recombinant Proteins**

1. Developing a recombinant therapeutic protein
2. Cloning in expression vector
3. Choices of vectors for Bacterial cells, Transfection methods for Bacterial cells
4. Choices of vectors for insect cell lines, Transfection methods insect cell lines
5. Choices of vectors for Mammalian cell lines, Transfection methods Mammalian cell lines,
6. Examples of recombinant proteins
7. Production of EPO, hGH, Factor VIII

**UNIT 3** **[8 hrs]**

**Various systems used for production of Biotherapeutics: Recombinant Proteins**

1. Hybridoma technique,
2. Monoclonal antibodies,
3. Vaccines,
4. Identification of potential biopharmaceutical products, generation of suitable recombinant expression systems,
5. Production and characterization of recombinant proteins
6. Recombinant production in bacterial/animal cells,
7. Transgenic Plants sources of recombinant biopharmaceuticals
8. Transgenic animals as potential sources of recombinant biopharmaceuticals

**UNIT 4** **[8 hrs]**

**The biopharmaceutical manufacturing process**

1. The manufacturing process; master and working cell banking systems,
2. Clean rooms design and flow of operations
3. Decontamination and sanitation and Generation of water for pharmaceutical / biopharmaceutical processing, WFI, CDS
4. Product flow through the facility and associated documentation, The QA function,
5. Range and significance of biopharmaceutical product impurities like microorganisms, viruses, contaminant proteins,DNA and pyrogens
6. The range of QC tests carried out on typical biopharmaceutical products.
7. Biopharmaceutical validation, Principles of validation, validation of chromatographic systems used in biopharmaceutical manufacture

**UNIT 5** **[8 hrs]**

**Formulation and drug delivery system of Biotherapeutics and Biopharmaceuticals**

1. Formulation Introduction, Types of formulation:
2. Oral, Topical, Parentral,
3. Slow release,
4. Degradation Routes, Physical Stability Issues and Chemical Stability Issues,
5. Understanding the Routes of Chemical Instability, and Modeling for Streamlining
6. Accelerated stability, real time stability, agents aiding increase in stability,
7. Advanced drug Delivery Systems: Liposomes, PEGyaltion, microparticles and
8. Nanoparticles, biodegradable drug delivery system (hydrogel based)

**UNIT 6** **[8 hrs]**

**Biopharmaceutical regulation**

1. Regulatory requirements for Biotech product development,
2. Hierarchal structure in Indian biotechnology,
3. Biosafety, Current GMP, Role of DCGI,
4. National& International guidelines,
5. Toxicity,
6. Clinical trials, studies, clinical research
7. Clinical data management,
8. IPR, patents, trademarks, trade secrets,
9. Export, Import of product, Rules & Regulations for start up companies

**Practicals** (any 8)**:**

1. Seperation of protein of interest

2. Stability study of proteins at 37□C, check integrity using SDS PAGE.

3. Stability study of proteins at 55□C, check integrity using using SDS PAGE

4. Stability study of proteins at 65□C, check integrity using using SDS PAGE

5. Study of effect of temperature on efficacy of lysozyme: enzyme assay

6. Formulations: Tablet disintegration time

8. Preparation of herbal extract/protein extract

9. HPLC: demonstration practical

**Text Books**

1. Elmer, G. W., Farland, L. V. and Surawicz, C. M., “Biotherapeutic Agents and Infectious iseases”, Humana Press Inc., Totowa, NJ, USA, 1999

2. Grewal, I. S., “Emerging Protein Biotherapeutics”

**Reference Books**

1. Hillery, A. M., Lloyd, A. W. and Swarbrick, J., “Drug Delivery and Targeting: For Pharmacists and Pharmaceutical Scientists”

2. Walsh, G., “Biopharmaceuticals: Biochemistry and Biotechnology”, 2nd Edition, Blackwell, USA

## ELECTIVE II - BIOENERGY AND RENEWABLE RESOURCES (415465)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**

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**UNIT 1** **[6 Hrs]**

**Energy resources and their utilization**

Indian and global energy sources, Energy demand, Energy exploited, Energy planning, Energy parameters (energy intensity, energy-GDP elasticity), Environmental impacts of the conventional and renewable sources, Renewable Energy**:** Introduction to various sources of energy, Solar thermal, Photovoltaic, Water power, Wind energy, Biomass, Ocean thermal, Tidal and wave energy, Geothermal energy, Hydrogen energy systems, Fuel cells, Decentralized and dispersed generation

**UNIT 2** **[6Hrs]**

**Wind and Geothermal energy**

Wind energy, Characteristics of wind: Effect of density, Frequency variances, Angle of attack, Wind velocity, Principles of wind turbine: operation, siting and control, Process of electricity generation and supply to the grid - wind energy farms, Types of wind machines and their characteristics, Horizontal and Vertical axis wind mills, Elementary design principles, Coefficient of performance of a wind mill rotor, Aerodynamic considerations in wind mill design, Selection of a wind mill, Availability of wind energy in India

Geothermal: Uses of geothermal energy and the geothermal power plants, Mechanisms for deep geothermal heat extraction and power generation, Dry-steam Flash-steam and Binary-cycle, Shallow geothermal and heat-pumps, Wave and Tidal

**UNIT 3** **[8Hrs]**

**Solar energy and Photovoltaic**

Need of solar energy in the world and India, Basics of converting sunlight into electricity, Technologies of producing solar fuels, solar energy collectors, System components, Grid connection and applications, Solar thermal: Technologies and applications of solar thermal energy - Power production and heating applications, Solar heating and solar cooling, Concentrated solar power (CPV and CSP) for utility-scale applications, Domestic and industrial

**UNIT 4** **[8Hrs]**

**Biodiesel**

Definition, advantages of biodiesel, properties of biodiesel, feedstocks - jatropha, Karanja, Neem, plantation, Transesterification, process issues, homogeneous and heterogeneous catalysis, biodiesel from microalgae, algae cultivation, types of photobioreactor, Indian perspective

**UNIT 5** **[8Hrs]**

**Alcohol fuels**

Feedstock for alcohol fuels, common methods for alcohol production, ethanol production from lignocellulosic materials, pretreatment-dilute acid, hot water, steam explosion, Ammonia; enzymatic hydrolysis, detoxification, fermentation, butanol fermentation, challenges in ethanol and butanol production, case studies, concept of biorefinery

**UNIT 6** **[6Hrs]**

**Gaseous fuels**

Biomethanization, microbiological aspects of biogas production, biogas anaerobic fermentation & process, raw materials, factors affecting biodigestion, classification of biogas plants, methods for maintaining biogas production, problem in biogas plants, thermal processes, case study on biogas production, introduction to hydrogen as a fuel

**Textbooks:**

Renewable Energy Resources: Basic Principles and Applications, G N Tiwari and M Ghosal Narosa Publishing House, India, 2004

1. Non-Conventional energy Source, Rai G.D Khanna Publishers, New Delhi, 2004
2. Bansal Keemann, Meliss," Renewable energy sources and conversion technology", Tata Mc Graw Hill.
3. Renewable energy resources and emerging technologies, Kothari D.P, Prentice Hall of India Pvt. Ltd., 2008

**Reference books:**

1. Renewable Energy Resources 2nd Ed. - John Twidell and Tony Weir, New York, 2006
2. Solar Energy - Principles of Thermal Collection and Storage, S.P. Sukhatme and J. K. Nayak, third edition, Tata McGraw Hill Publishing Company Ltd, 2008
3. Solar Power Engineering / B.S Magal Frank Kreith & J.F Kreith.
4. Principles of Solar Energy, D. Yogi Goswami, Frank Kreith and Jan F. Kreider, second edition, CRC press, 2000
5. Non-Conventional Energy Systems, K M Mital, A H Wheeler Publishing Co Ltd , 1999
6. Renewable Energy Technologies, Ramesh R & Kumar K U, Narosa Publishing House, New Delhi, 2004
7. Progress in Biomass and Bioenergy Research, S. F. Warnmer, (Ed), Nova Publishers, 2006
8. Bioenergy: Realizing the Potential, S. Silveira, (Ed), Elsevier Science, 2005
9. Non-Conventional Energy, Ashok V Desai, New Age International (P) Ltd, New Delhi, 2003
10. The Biomass Assessment Handbook: Bioenergy for a Sustainable Environment**,** Rosillo-Calle, P. D. Groot, S. Hemstock, J. Woods, Earthscan Publisher, 2006.
11. Biomass and Bioenergy: New Research, M. D. Brenes, (Ed), Nova Publishers, 2006

## ELECTIVE II – BIOMATERIALS (415465)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**

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**UNIT I** **[9 Hrs]**

General properties of materials, Classes of materials used in medicine: Metals, Polymers, Hydrogels, Bioresorbable and Biodegradable Materials, Ceramics, Natural materials, composites thin films, grafts, Coatings medical fibers and Biological functional materials, Smart materials, Pyrolytic Carbon for long-term medical Implants, textured and Porous materials, non-fouling surfaces.

**UNIT 2** **[9 Hrs]**

Biopolymers: Classification (nucleic acid, protein, polysaccharide), Manufacturing, chemistry and applications of polysaccharide such as dextran, xanthan, gellan, pullalane, chitin, chitosan, etc., structural characterization using protein sequencing by Edman degradation, mass spectrometer, optical tweezer (or atomic force microscopy)

**UNIT 3** **[9 Hrs]**

Fermentative production of polyesters with special emphasis on polyhydroxyalkanoates, and biodegradable polymers such as polylactic acid, polyglycolide and polycaprolactone, lactoyllactic acid, Structure, physical and chemical properties including production of the above polymers

**UNIT 4** **[9 Hrs]**

Application of biocatalyst such as enzymes and microorganisms in biotransformation process, development of polymer precursors using Biotransformation processes Precursors: aromatic hydrocarbons, biological formation of specialty hydroxylated monomers, L-homophenylalanine production using membrane bioreactor.

**UNIT 5** **[9 Hrs]**

Types of bioadhesive, nano biomaterial, composite biomaterial, Evaluation of biocompatibility according to United States Pharmacopoeia, Biodegradable plastic, design, synthesis, characterization and application of nanomterials to biological and biomedical problems, Characterize, predict, and control the biological properties of nanobiomaterials

**UNIT 6** **[9 Hrs]**

Applications of materials in medicine, Dentistry and Biology: Cardiovascular medical devices, Nonthrombogenic treatments and Strategies, Dental implantation adhesive and Sealants, Ophthalmologic applications-intraocular lens implants, Orthopedic biomaterials, Artificial organs and tissues.

**Text Books:**

1. Biomaterials Science: An Introduction to Materials in Medicine Buddy D. Ratner, Frederick J. Schoen, Allan S. Hoffman, Jack E. Lemons

2. Hench L L Ethridgc E.C. Biomaterials, an interfacial approach, Academic press 1982

**Reference Books:**

1. Bronzino J D, The biomedical engineering handbook CRC Press

## ELECTIVE II - STEM CELL BIOLOGY AND REGENERATIVE MEDICINE (415465)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**

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**UNIT 1** **[8 Hrs]**

History and introduction to stem cell biology and regenerative medicine. Terms: stem cell, progenitor cells, precursor cells, transit amplifying cells. General properties of stem cells. Terms: Totipotent, pluripotent, multipotent, unipotent stem cells. Differentiation and transdifferentiation. Stem cell niche, growth and differentiation factors.

**UNIT 2** **[8 Hrs]**

Techniques used in stem cell biology. Lineage – tracing technique, gene knock-out and knock-in studies, inducible gene expression or repression, transfection, DNA sequencing, Chromatin immunoprecipitation, fluorescent-activated cell sorting, confocal microscopy. Other techniques.

**UNIT 3** **[8 Hrs]**

Stem cell types: embryonic stem cells, somatic cell nuclear transfer, induced pluripotent stem cells, neural stem cells, hematopoietic stem cells, pancreatic stem cells. Isolation and culture of the above stem cell types.

**UNIT 4** **[8 Hrs]**

Guidelines for stem cells research and therapy in India: introduction, general mechanisms, aim and scope, categorization of research on stem cells, clinical application of umbilical cord blood stem cells, criteria on use of placental / fetal stem cells for research, approval of procurement. Banking or distribution of hESCs. International collaboration and patent issues.

**UNIT 5** **[8 Hrs]**

Degenerative diseases: discussion of degenerative diseases including Parkinson disease, diabetes, burn, retinal replacement therapy, cardiomyopathies, etc.

**UNIT 6** **[8 Hrs]**

Understanding of cell replacement and regeneration. Application of stem cells in degenerative medicine. Cells and tissue engineering. Application of different stem cell types for different degenerative diseases including gene therapy.

**Reference Books:**


1. Methods in Molecular Biology: Basic Cell Culture Protocols. Editors: Cheryl D. Helgason and Cindy L. Miller
2. Stem Cells Handbook. Editor: Stewart Sell. Humana Press.
3. Human Embryonic Stem Cells: An Introduction to the Science and Therapeutic Potential. Ann Kiessling and Scott C. Anderson. Jones and Bartlett Publishers
4. Human Embryonic Stem Cells. Editors: Arlene Chiu, Mahendra S. Rao Humana Press

5. Stem Cells and the Future of Regenerative Medicine. Committee on the Biological and Biomedical Applications of Stem Cell Research, Board on Life Sciences, National Research Council, Board on Neuroscience and Behavioral Health, Institute of Medicine. National Academies Press.
6. Stem Cell Biology. Editors: Daniel R. Marshak, Richard L. Gardner and David Gottlieb. Cold Spring Harbor Laboratory Press.
7. Essentials of Stem Cell Biology. Edited by Ian Wilmut. Elsevier publication.
8. Essentials of Stem Cell Biology. By Robert Paul Lanza. Elsevier Academic Press.
9. Stem Cells for Dummies. By Lawrence S. B. Goldstein, Meg Schnider. Wiley Publication.
10. Insight: Stem Cell Biology". Nature. 2006; 441:1059-1102.
11. Insight: Regenerative Medicine". Nature. 2008; 453:301-352.

## ELECTIVE III - FOOD BIOTECHNOLOGY (415467)

**Teaching Scheme:**
**Theory: 3 hr/week**
**Practical: 2hr/week**

**Exam Scheme:**
**In Sem Exam: 30 Marks**
**End Sem Exam: 70 Marks**
**Term Work: 50Marks**

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**UNIT 1** **[6 Hrs]**

**Introduction to Food Biotechnology and Spoilage of Food**

Biotechnology in relation to the food industry, classes of industrially important food, Characteristics of food - Nutritional value and sensory characteristics, spoilage of food – Mechanisms and types of spoilage, Intrinsic and extrinsic factors affecting spoilage: water activity, pH, temperature, redox potential etc., major spoilage micro organisms and their growth conditions, effect on food

**UNIT 2** **[9 Hrs]**

**Introduction to Food Processing**

Preliminary processing methods – need and types, Raw material preparation: Cleaning, sorting, grading, peeling etc Principles and methods of food preservation – Low temperature techniques: Refrigeration, Freezing and freeze drying, High temperature techniques: Blanching, HTST pasteurization, canning, UHT treatment, dehydration, drying, extrusion cooking, Irradiation techniques: UV light, microwave processing, gamma rays, hydrostatic pressure cooking, use of additives, modified atmosphere packaging and storage

**UNIT 3** **[7 Hrs]**

**Design of Food Preservation Equipments**

General engineering aspects and processing methods, types of equipments and their design: Refrigerator, freezer, dryer, thermal death kinetics of micro organisms, calculation of pasteurization time, time and temperature calculation for HTST sterilization

**UNIT 4** **[8 Hrs]**

**Microbial and Fermentation Biotechnology**

Technologies used for microbial production of food ingredients, Biotechnology of microbial polysaccharides in food, Microbial biotechnology of food flavor production, microbial production of oils and fats, food applications of algae, Process developments in solid state fermentation for food applications, solid state bio- processing for functional food ingredients, Fermentation biotechnology of traditional foods of the Indian subcontinent

**UNIT 5** **[6 Hrs]**

**Role of Enzymes in Food Processing**

Classes of industrially important enzymes in food industry, Role of enzymes in bakery industry, cereal and beverage industry, meat processing, beer mashing and chill-proofing, production and application of pectinases, proteases etc.

**UNIT 6** **[8 Hrs]**

**Processes for the treatment of food processing waste**

Classification and characterization of food industrial waste: solid, liquid and hazardous wastes, Waste disposal methods- physical, chemical and biological, Treatment methods of solid wastes, Treatment methods for liquid wastes from food industry, activated sludge and anaerobic processes for treatment of food processing wastes

**Practicals: (Any 8):**

1.SPC count of bacteria in Foods (e.g. Chuteny, souce etc.)

2.SPC count of Fungi in Foods

3.MPN test of food for E.coli (e.g. Pedha)

4.MBRT test of Milk.

5.Study of fats and oilsa) Iodine Value

b) Peroxide Value

6.Qualitative analysis of

a) Glucose

b) Fructose

c) Starch

d) Proteins

7.To study effect of pasteurization on Milk

8.Analysis of milk for total solid content.

9.Industrial Visit.

**Text Books:**

1. Shetty, K., Paliyath, G., Pometto, A. and Levin, R. E., “Food Biotechnology”, Taylor and Francis

2. Frazier, “Food Microbiology”

3. Fellows, P. , Ellis, H., “Food Processing Technology Principles and Practice”, Wiley, New York

**Reference books:**

1.Johnson-Green, Perry, “Introduction to Food Biotechnology”

2.Roger, A., Gordan, B. and John, T., “Food Biotechnology”, 1989

3.George, J. B., “Basic Food Microbiology”, CBS Publishers Distributors, 1987

4. James, M .J., “Modern Food Microbiology”, CBS Publishers & Distributors, 19875

5. Lindsay and Willis, “Biotechnology, Challenges for the flavor and food Industries”, Elsevier Applied Science, 1988

6. Desrosier, “Technology of food preservation”, CBS Publishers

7. Jay, “Modern Food Microbiology”, CBS Publishers, 1987

8. Reed, G., “Prescott and Dunn’s Microbiology”, CBS Publishers, 1987

## ELECTIVE III - AGRICULTURAL BIOTECHNOLOGY (415469)

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical: 2 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**
**Term work: 50 Marks**

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**UNIT 1** **[8 Hrs]**

**Introduction to Agricultural biotechnology**

Novel features of plant growth and development, Biodiversity, Conventional methods of crop improvement, Objectives of plant breeding, Types of breeding, Genetic variation and manipulation of variability, Breeding of selected crops-important cereals, pulses, oilseeds, fibre, sugar and cash crops, Plant Biodiversity, Classical deliberate interbreeding, Intraspecific hybridization, Methods of breeding self-pollinated crops and cross- pollinated crops, Methods of breeding asexually propagated crops, self incompatibility and male sterility in crop breeding, mutation breeding, Ploidy breeding, Innovative breeding methods, Hybrid varieties

**UNIT 2** **[8 Hrs]**

**Plant tissue culture and its application**

Principles of plant micropropagation, The totipotency concept, Role & composition of Plant tissue culture media, Micropropagation pathways, Callus induction & culture, organogenesis and embryogenesis, Meristem tip culture, Haploid production, Hardening of plants, Techniques of anther, embryo and ovule culture, Protoplast isolation, Somatic hybridization, Cybrids, Somaclones, Artificial seed Technology(synthetic seed), Embryo rescue Cell line selection using selection pressure, Production of secondary metabolites, Cryopreservation and germplasm storage

**UNIT 3** **[8 Hrs]**

**Plant molecular biology**

Organelle DNA, Satellite-and repetitive DNAs, DNA repair, Regulation of gene expression, Recombinant DNA technology-cloning vectors, restriction enzymes, gene cloning, Methods of gene transfer in plants, Achievements and recent developments of genetic engineering in agriculture, Development of transgenies for biotic & abiotic stress tolerance, Ribozfore Technology, Ti plasmid-based transformation, Agrobacterium biology, crown gall and hairy root disease, Ti and Ri plasmids, T-DNA genes, borders, overdrive, chromosomal and Ti plasmid virulence genes and their functions, vir gene induction, mechanism of T-DNA transfer, Ti pasmid vectors, vir helper plasmid, super virulence and monocot transformation, binary vector, Transgene silencing, Strategies to avoid transgene silencing, Direct transformation of protoplasts using PEG, electroporation, Transformation by particle bombardment, Assembly of particle gun, Microprojectile preparation and bombardment, Chloroplast transformation by particle bombardment.

**UNIT 4** **[8 Hrs]**

**Advanced technology for crop improvement**

Genetic engineering of crops, Commercial status of transgenic plants, Herbicide resistance, glyphosate, sulfonyl urea, phosphinothricin, atrazine, Pest resistance, B.t. toxin, synthetic B.t. toxin, Bt brinjal, Bt cotton, Protease inhibitor, GNA and other lectins, α-amylase inhibitor, nematode resistance, Genetic engineering for male sterility-Barnase-Barstar, Delay of fruit ripening, polygalacturanase, ACC synthase, ACC oxidase, Improved seed storage proteins, Improving and altering the composition

of starch and plant oils, Golden rice for β-carotene accumulation, Production of antibodies and pharmaceuticals in plants, Biofertilizers, Gene flow in plants – Development of mapping population – Molecular marker aided breeding-RFLP maps, Linkage analysis, RAPD markers, microsatellites, SCAR (Sequence Characterized Amplified Region), SSCP(Single strand Conformational Polymorphism), AFLP,QTL, map based cloning , Molecular marker assisted selection(MAS), Mapping genes on specific chromosomes, Gene pyramiding, Transcript mapping techniques

**UNIT5** **[8 Hrs]**

**Ethics and Biosafety**

Ethical issues in biotechnology, Biosafety and Risk assessment of GMOs, Public perception. IPR and Trade related aspects, Methods for producing transgenic plants and animals, Important genes of agronomic interest, Current trends in finding useful genes, GMO Act 2004. Traceability, Legislative aspects.Introduction, Historical Backround, Introduction to Biological Safety Cabinets, Primary Containment for Biohazards, Biosafety Levels, Biosafety Levels of Specific Microorganisms, Recommended Biosafety Levels for Infectious Agents and Infected Animals, 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

**UNIT6** **[8 Hrs]**

**Animal lifestock breeding**

Importance of livestock in agriculture, relationship between plant and animal husbandry, animal breeding, breeds of indigenous and exotic cattle, buffaloes, goats, sheep, pigs and poultries and their potential for milk, egg, meat and wool production, classification of feed and fodder, major contagious diseases affecting cattle and drought animals, poultries and pigs, Sericulture and its applications

**Practicals (Any 8) :**

1. Isolation of plant DNA
2. RE digestion of Plant DNA
3. Leaf disc method
4. RAPD or RFLP: PCR
5. RAPD/RFLP: agarose gel and scoring bands
6. Study of seed storage proteins
7. PTC facility and set up
8. Preparation of media for PTC
9. Somatic embryogenesis
10. Induction of callus
11. Suspension culture
12. Development of somatic embryos
13. Germination of embryos
14. Visit to PTC facility
15. Biofertilizers

**Text books**


1. Keshavachandran.R and K V Peter. 2008 .Plant Biotechnology: Tissue culture and Genetransfer. Orient and Longman, (Universal Press) Chennai.
2. Gresshoff, Peter M. (Ed). Plant biotechnology and development. 1992.
3. Jones, MGK & Lindsey, K. "Plant Biotechnology" in Molecular biology and biotechnology, Walker, JM & Gingold, EB (Eds). 2000.
4. Kumar H D, Agricultural Biotechnology, India ,2005


**Reference books:**


1. Esau's Plant Anatomy, Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function, and Development, 3rd Edition, John Wiley & Sons, 2006.
2. R.H.Smith, Plant Tissue Culture: Techniques and Experiments, Academic Press, San Diego. 1992.
3. M. J. Chrispeels and D.F. Sadava (eds), Plants, Genes and Crop Biotechnology, 2nd Edition, Jones and Barlett Press, 2003
4. J.H. Hammond, P. Mcgarvey, and V. Yusibov (eds), Plant Biotechnology, Springer Verlag, Heidelberg. 2000
5. BAREACT, Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., 2007
6. Kankanala C., Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd., 2007
7. Encyclopedia of ethics, legal and policy issues in biotechnology. 2000
8. Rodney B. Harrington, Animal Breeding: An Introduction, October 1995
9. Newman, S, Rothschild, MF (2002). Intellectual Property Rights in Animal Breeding and Genetics. Wallingford, Oxon, UK CABI Pub. ISBN 0-85199-641-8.

## ELECTIVE III – GENOMICS (45469)

**Teaching Scheme:**
**Theory : 3 hr/week**
**Practical: 2 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End Sem : 70 Marks**
**Term work: 50 Marks**

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**UNIT 1** **[7 Hrs]**
**Introduction to genomics**

Genome organization, C value paradox, repetitive DNA, gene families, structural genomics, human genome project, human genome project database

**UNIT 2** **[8 Hrs]**
**Genome analysis**

Sequencing strategies for whole genome analysis, Sequencing methods, capillary electrophoresis, Next Gen sequencing methods, Comparative genomics, genome annotation, YAC, BAC libraries

**UNIT 3** **[8 Hrs]**
**Functional genomics**

Global analysis of gene expression, Transcriptomics and microarray, Microarray-Types, Analysis, Applications, RNA interference, siRNA, miRNA

**UNIT 4** **[8 Hrs]**
**Epigenetics**

Epigenetics: Regulation of Organization & Gene Expression, Epigenetic Mechanisms, Methylation, Acetylation, Histone modifications, DNA methylation, model organisms for epigenetic studies, methods-CHIP on CHIP assays, CpG islands microarrays, Epigenetics and diseases

**UNIT 5** **[7 Hrs]**
**Pharmacogenomics**

Introduction to Pharmacogenomics, Variation in drug response, ADME, Drug Metabolizing enzymes and genes, Slow metabolizers, Extensive metabolizers, Case studies in Pharmacogenomics, Traditional medicine based Pharmacogenomics, Toxicogenomics

**UNIT 6** **[8 Hrs]**
**Nutritional genomics**

Overview of nutrigenomics, diet gene interactions. Diet, genes and diseases, Nutrigenomics and metabolic diseases, personalized nutrition

**Practicals: (Any 8)**

1. Isolation of DNA from blood or plant source or animal tissue
2. Agarose gel electrophoresis
3. Designing primers

4. Genotyping
5. PCR-RFLP
6. DNA polymorphism in DMES
7. RNA isolation
8. RNA gel electrophoresis
9. Demonstration of sequencing

**Text Books:**

1. Genes IX by Benjamin Lewin
2. L.Alberghina and H. Westerhoff, ed (2005). *Systems Biology: Definitions and Perspectives*. Topics in Current Genetics. 13. Springer Verlag. ISBN 978-3540229681
3. Discovering Genomics, Proteomics and Bioinformatics (2nd Edition) by A. Malcolm Campbell and Laurie J. Heyer (Mar 12, 2006)

**Reference books:**

1. Pharmacogenomics in Drug Discovery and Development, Series: Methods in Molecular Biology, Vol. 448, Yan, Qing (Ed.), 2008, XIII, 487 p. 62 illus.ISBN: 978-1-58829-887-4.
2. Creighton TE, Proteins, Freeman WH, Second Ed, 1993.
3. Branden C, Tooze R, " Introduction of protein structure ", Garland, 1993
4. Denis Noble (2006). The Music of Life: Biology beyond the genome. Oxford University Press. ISBN 978-0199295739. p21
5. Hiroaki Kitano, ed (2001). Foundations of Systems Biology. MIT Press. ISBN 0-262-11266-3.
6. Proteomics Today: Protein Assessment and Biomarkers Using Mass Spectrometry, 2D Electrophoresis,and Microarray Technology (Wiley - Interscience Series on Mass Spectrometry)

**References:**


1. DeBusk RM, Fogarty, CP, Ordovas JM, Kornman KS. Nutritional genomics in practice: where do we begin?. J Am Diet Assoc. 2005; 105:589-98. http://web.udl.es/usuaris/e4650869/Morella06/BB/Debusk_Nutrigenomics%20in%20practice.pdf
2. Fenech M, El-Sohemy A, Cahill L, Ferguson LR, French TA, Tai ES, Milner J, Koh WP, Xie L, Zucker M, Buckley M,Cosgrove L, Lockett T, Fung KY, Head R. Nutrigenetics and nutrigenomics: viewpoints on the current status and applications in nutrition research and practice. J Sci Food Agric. 2011; 4:69-89. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3121546/
3. Lucock M. Is folic acid the ultimate functional food component for disease prevention?. BMJ. 2004; 328:211-14. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC318492/
4. Ye K, Gu Z. Recent advances in understanding the role of nutrition in human genome evolution. Adv Nutr. 2011; 2:486-96. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3226386/

5. Minihane AM, Jofre-Monseny L, Olano-Martin E, Rimback G. ApoE genotype, cardiovascular risk and responsiveness to dietary fat manipulation. Proc Nutr Soc. 2007; 66:183-97. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=1002044
6. Corella D, Ordovás JM. Interactions between dietary *n-3* fatty acids and genetic variants and risk of disease. Br J Nutr. 2012; 107 Suppl 2:S271-83. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=8586755
7. Deckelbaum RJ, Worgall TS, Seo T. n-3 Fatty acids and gene expression**.** AJCN. 2006; 83:1520s-1525s. http://ajcn.nutrition.org/content/83/6/S1520.long
Phillips CM. Nutrigenetics and Metabolic Disease: Current Status and Implications for Personalised Nutrition. Nutrients. 2013; 5:32-57. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3571637/
8. Tsatsoulis A, Mantzaris MD, Bellou S, Andrikoula M. Metabolism. 2013; 62:622-633. An_evolutionary_perspective/file/72e7e529470b6de2f4.pdf&sa=X&scisig=AAGBfm1HUVNKbUhnEX4bN3V5eUS3unZwWQ&oi=scholarr
9. Herder C, Roden M. Genetics of type 2 diabetes: pathophysiologic and clinical relevance. Eur J Clin Invest. 2011; 41:679-92. http://onlinelibrary.wiley.com/doi/10.1111/j.1365-2362.2010.02454.x/abstract
10. Kaput J, Noble J, Hatipoglu B, Kohrs K, Dawson K, Bartholomew A. Application of nutrigenomic concepts to Type 2 diabetes mellitus. Nutr Metab Cardiovasc Dis. 2007; 17:89-103. http://www.nmcd-journal.com/article/S0939-4753(06)00255-9/fulltext
11. Reszka E, Wasowicz W, Gromadzinska J. Genetic polymorphism of xenobiotic metabolising enzymes, diet and cancer susceptibility. Br J Nutr. 2006; 96:609-19. http://journals.cambridge.org/download.php?file=%2FBJN%2FBJN96_04%2FS0007114506002704a.pdf&code=1a1a7b8dd35bc3d814e1b68b258da7cd
12. Ross SA Evidence for the relationship between diet and cancer. Exp Oncol. 2010; 32:137-42. http://exp-oncology.com.ua/wp-content/uploads/magazine/857.pdf?upload=
13. Mattick JS, Taft RJ, Faulkner GJ. A global view of genomic information- moving beyond the gene and the master regulator. Trends Genet. 2009; 26(1):21-8. http://classes.biology.ucsd.edu/bisp194-2.WI12/documents/MattickEtAl2009_000.pdf
14. McKay JA, Mathers JC. Diet induced epigenetic changes and their implications for health. Acta Physiol. 2011; 202:103-118. http://www.grochbiology.org/flyepigeneticsdiet.pdf
15. Nicoletto SF, Rinaldi A. In the womb's shadow. EMBO reports. 2011; 12:30-34. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3024135/ Gibney MJ, Gibney ER. Diet, genes and disease: implications for nutrition policy. Proc Nutr Soc. 2004; 63:491-500. http://journals.cambridge.org/download.php?file=%2FPNS%2FPNS63_03%2FS0029665104000679a.pdf&code=0e487c9580cd0ea9b38b329bcd41b762
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3550857/

## ELECTIVE IV – MANAGEMENT AND ENTERPRENEURSHIP (415470)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End Sem: 70 Marks**

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**UNIT 1** **[8 Hrs]**

**Management**

Introduction – Meaning – Concept and features of Management, Scope and functional areas of management – Management as a science, art or profession – Management and administration – Roles of management, Levels of management, development of management thought – early management approaches – modern management approaches. Decision making – importance of planning – steps in planning

**UNIT 2** **[7 Hrs]**

**Organizing and Staffing**

Nature and purpose of organization, principles of Organizations – Types of organization - Departmentation –Committees Centralization vs. Decentralization of authority and responsibility, span of Control, MBO, and MBE (Meaning only) Nature and importance of Staffing – process of selection and recruitment (in brief)

**UNIT 3** **[7 Hrs]**

**Directing & Controlling**

Meaning and nature of directing – Leadership styles and motivation theories, communication – Meaning and importance – Coordination, meaning and importance and Techniques of Co – ordination

**UNIT 4** **[8 Hrs]**

**Entrepreneur**

Meaning of Entrepreneur, Evolution of the Concept, Functions of an Entrepreneur, Types of Entrepreneur, Intrapreneur – an emerging Class, Development of Entrepreneurship steps in entrepreneurial process, Role of entrepreneurs in Economic Development: Entrepreneurship in India, Challenges to woman and achievements of woman Entrepreneurs, Identification of Business Opportunities

**UNIT 5** **[9 Hrs]**

**Small Scale Industry**

Meaning, Nature of Support; Objectives, Definition, Characteristics, Need and rationale: Objectives: Scope, role of SSI in Economic Development, Advantages of SSI, Steps to start in SSI – Government policy towards SSI, Functions, Types of Help, Ancillary Industry and Tiny Industry (Definition only)

**UNIT 6** **[7 Hrs]**

**Preparation Of Project**

Meaning of Project, Project Identification, Project Selection, Project Report, Need and Significance of Report, Contents, formulation, Guidelines by Planning Commission for Project report, Network Analysis, Errors of Project Report, and Project Appraisal

**Text Books:**


1. Principles of Management – P.C. Tripathi, P.N. Reddy; Tata McGraw Hill, 2nd Edition.
2. Dynamics of Entrepreneurial Development & Management – Vasant Desai–Himalaya Publishing House
3. Entrepreneurship Development – Small Business Enterprises – Poornima M Charantimath – Pearson Education –2006, 2nd Edition.


**Reference Books:**


1. Management Fundamentals - Concepts, Application, Skill Development – 1st Edition , Robert Lusier – Thomson ,
2. Innovation and Entrepreneurship- Peter F. Drucker, Harpercollins Publication
3. Management – Stephen Robbins – Pearson Education / PHI -17th Edition, 2003.
4. Management and Entrepreneurship – N.V.R. Naidu & T. Kirshna Rao, I.K. International, New Delhi – 2008.
5. Essentials of Management – Harold Koontz-TMGH-2010, 2 nd Edition

## ELECTIVE IV – ETHICS, IPR AND REGULATIONS (415470)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**

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**UNIT 1** **[8 Hrs]**

Ethics, definition, ICMR guidelines for ethics in biomedical research, consent form, composition of ethics committee, Ethics at workplace, various scenarios, defining the moral standards of right and wrong, morals and laws, an organizational perspective, legal vs ethical, ethics in business, ethics and profits.

**UNIT 2** **[8 Hrs]**

Bioethics, Case studies: ethics in life sciences, ethics in medicine, ethics in biotechnology, recombinant DNA, ethics in food biotechnology, agricultural biotechnology, environmental ethics, animal ethics, discuss moral righteous of an action, procedure or policy, moral wrongness of the action

**UNIT 3** **[8 Hrs]**

Patent, objects of patent law, benefits of patenting, remedies against infringement, requirements of patentability, rights of patentee, patent application procedure, patenting in biotechnology, patent search, patents from an international perspective, study of patents

**UNIT 4** **[8 Hrs]**

Domain name and trademark, purpose of trademark, requirements for registration for a trademark, copyright, assignment and transfer of copyright, copyright infringement, registration and piracy

**UNIT 5**

Regulatory requirements for Biotech. product development, Hierarchal structure in Indian biotechnology, Current GMP, Role of DCGI, National& International guidelines

**UNIT 6** **[8Hrs]**

Quality Assurance, Quality control requirement for Biotech product, Toxicity, clinical trials, studies, clinical research & clinical data management, Export, Import of product, Rules & Regulations for start up companies

**Text Books:**


1. Erbisch, F. H. and Maredia, K. M., “Intellectual property rights in agricultural biotechnology”
2. Jonathan Morris, “The ethics of biotechnology”


**Reference Books:**


1. K. C. Shippey, “A short course in international intellectual property rights”

## ELECTIVE IV – INDUSTRIAL ORGANIZATION AND MANAGEMENT (415470)

**Teaching Scheme:**
**Theory : 3 hr/week**

**Exam Scheme:**
**In Sem : 30 Marks**
**End sem : 70 Marks**

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**UNIT 1** **[8 Hrs]**
**Management Science**

Management, its growth, concepts of administration and management of organization, Definition of management, functions, authority and responsibility, Unity of command and direction, Decision making in management by objectives

Business Organization: Different forms of organization, their formation and working, Different organization structure- line organization, functional organization, line and staff organization

**UNIT 2** **[8 Hrs]**
**Personnel Management**

Manpower planning, sources of recruitment, selection and training of staff, Job evaluation, merit rating, performance appraisal, wage administration and system, of wage payment, incentive, motivations, industrial fatigue, Trade unions – industrial relations

**UNIT 3** **[8 Hrs]**
**Purchase and stores management**

Concepts of quotation, tenders and comparative statement, inspection and quality control, Inventory, carrying cost and fixed cost of inventory, examples of cost of Inventory, Stores management, functions of storekeeper, methods of inventory : LIFO, FIFO

**UNIT 4** **[8 Hrs]**
**Marketing management**
Concepts of selling, marketing, definition of marketing, market research and of pricing, penetration, pricing, skimming pricing, distribution of product, advertising and promotion

**UNIT 5** **[8 Hrs]**
**Export and import management**

Concepts of international trade, duties, antidumping duty, cost involved in exporting a product, pricing of export product, Government aids for export promotion, export houses, export promotion counsel, MODVAT, patent and patent rights,

Quality Management: TQM, quality circles, ISO systems

**UNIT 6** **[8 Hrs]**
**Management Laws**

Concepts of contract act, offer, and acceptance, types of contracts, Void contract, concept of guarantee and warranty, Introduction of MRTP and FERA

**Text Books:**

1. Industrial Engineering and Management- Shama and Banga S.C., Khanna Publishers,
2. Industrial Engineering and Management O.P.Khanna Khanna Publishers.
3. Principles of Management-Tripathy & Reddy,Third Edn.,Tata McGraw Hill Publishers

**Reference Books:**

1. Organizational Behaviour, Fred Luthans, Tenth Edn. Tata McGraw Hill Publications.
2. Business Law & Including Company Law, S.S.Gulshan, G.K.Kapoor, Fourteenth Edn.,New Age International Ltd.
3. Marketing Management V.S.Ramaswamy & S.Namakumari,MacMillan India Ltd
4. Financial Management, PV.Kulkarni, B.G.Satyaprasad, Thirteenth Edn. Himalaya Publishers Ltd.
5. Production & Operations Management, Everett Adam & R.J.Ebert., Fifth Edn., Pearson Publication.
6. Managerial Economics, Peterson, Lewis and Jain, Fifteenth Edn.,Perarson Publishers.
7. Quantitative Techniques, L.C.Jhamb, Sixteenth Edn.,Everest Publishing House.
8. Dynamics of Industrial Relationns, Mamoria,Mamoria & Gankar,Fifteenth Edn., Himalaya Publishing House.
9. Personal Management & Industrial Relations, R.S.Davar, Tenth Edn.,Vikas Publishing House.
10. Industrial & Labour Laws, S.P.Jain & K.Jain., Thirteenth Edn, Dhanpat Rai Publishers.

## ADVANCED BIOTECHNOLOGY PRACTICES (415471)

**Teaching Scheme:** **Exam Scheme:**
**Practical : 2 hr/week** **Term Work: 50 Marks**

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**List of Experiments:**

1. Bioassay for antibiotics :
   - I. Screening of antibiotic producer.
   - II. Determination of MIC.
   - III. To determine the potency of an antibiotic by agar diffusion method.

2. Aqueous two phase extraction :
   - I. To isolate the given protein by ARPS
   - II. To find the partition coefficient of the protein.

3. Media design and inoculum preparation :
   - I. To study media preparation of solid state fermentation system
   - II. To study inoculum preparation process of solid state fermentation system.

4. Solid state fermentation – I
   To study the biomolecule production using solid state fermentation with emphasis on upstream processing.

5. Solid state fermentation – II
   To study downstream processing of biomolecules produced in solid fermentation.

6. Downstream processing using steam distillation/column distillation.
   To study production of ethanol in submerged liquid fermentation (SMF) & downstream processing using distillation.

7. Fermentation efficiency and yield analysis:
   To study the fermentation efficiency of alcohol production to determine the yield.

8. Study of types of enzyme inhibition:
   To study the inhibition of enzyme by any one type (Competitive/non-competitive/uncompetitive).

9. HPLC demonstration.

**Reference Books:**


1. Laboratory Microbiology 2nd Edition, L. Jack Bradshaw
2. An Introduction to Practical Biotechnology, 1st Edition 2006, S. Harishe
3. Experimental Biotechnology, Practical manual Series, Sunita Dutta

4. Basic Biotechnology, 3rd Edition,Colin Ratledge, Cambridge university Press