AC 26/02/2015 Item no. 4.64

# UNIVERSITY OF MUMBAI

**Revised Syllabus**
Program – **Bachelor of Engineering**
Course – **Biotechnology Engineering**
(Final Year – Sem VII and VIII)

under
**Faculty of Technology**
(As per Credit Based Semester and Grading System from 2015-16)

## General Guidelines

### Tutorials

- The number of tutorial batches can be decided based on facilities available in the institution.
- Tutorials can be creative assignments in the form of models, charts, projects, etc.

### Term Work

- Term work will be an evaluation of the tutorial work done over the entire semester.
- It is suggested that each tutorial be graded immediately and an average be taken at the end.
- A minimum of ten, or as specified in syllabus, tutorials will form the basis for final evaluation.
- The total marks for term work(except project and seminar) will be awarded as follows:

  | | |
  |---|---|
  | Assignments etc. | 20 |
  | Attendance | 05 |

  Further, while calculating marks for attendance, the following guidelines shall be adhered to:

  | | |
  |---|---|
  | 75 % – 80%. | 03 |
  | 81% – 90% | 04 |
  | 91% onwards | 05 |

### Theory Examination

- In general all theory examinations will be of 3 hours duration.
- Question paper will comprise of total six questions, each of 20 Marks.
- Only four questions need to be solved.
- Question one will be compulsory and based on as much of the syllabus possible.

**Note:** In question paper, weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus as far as possible.

### Practical Examination

- A student becomes eligible for practical examination after completing a minimum of eight experiments out of ten experiments.

### Project & Seminar Guidelines

- Project Groups: Students can form groups with not more than 3(Three).
- The load for projects may be calculated as below,

  Sem VII: $\frac{1}{2}$ hr for teacher per group.

  Sem VIII: 1 hr for teacher per group.
- Maximum of four groups can be allotted to a faculty.

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.
- The load for seminar will be calculated as one hour per week irrespective of the number of students.
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, six hours are allotted in Project A, 8 hours in Project-B and three hours for Seminar.

# University of Mumbai

## Scheme for BE: Semester-VII

| Subject Code | Subject Name | Teaching Scheme | | | Credit Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| BTC701 | Bioseparation & Downstream Processing Technology-I | 04 | – | 01 | 04 | – | 01 | 05 |
| BTC702 | Bioprocess Modeling & Simulation | 04 | – | 01 | 04 | – | 01 | 05 |
| BTS703 | Seminar | – | – | 03 | – | – | 03 | 03 |
| BTE704 | Elective-II | 04 | – | 01 | 04 | – | 01 | 05 |
| BTP705 | Project-A | – | – | 06 | – | – | 03 | 03 |
| BTL706 | LAB VI | – | 04 | – | – | 02 | – | 02 |
| BTL707 | LAB VII | – | 04 | – | – | 02 | – | 02 |
| **Total** | | 12 | 08 | 12 | 12 | 04 | 09 | 25 |

### Examination Scheme

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory marks | | | | Term Work | Pract. | Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | | | | |
| | | Test 1 (A) | Test 2 (B) | Avg.of (A) & (B) | | | | | |
| BTC701 | Bioseparation & Downstream Processing Technology-I | 20 | 20 | 20 | 80 | 25 | – | – | 125 |
| BTC702 | Bioprocess Modeling & Simulation | 20 | 20 | 20 | 80 | 25 | – | – | 125 |
| BTS703 | Seminar | – | – | – | – | 50 | – | – | 50 |
| BTE704 | Elective – II | 20 | 20 | 20 | 80 | 25 | – | 25 | 150 |
| BTP705 | Project-A | – | – | – | – | 100 | – | 50 | 150 |
| BTL706 | LAB VI | – | – | – | – | – | 25 | – | 25 |
| BTL707 | LAB VII | – | – | – | – | – | 25 | – | 25 |
| | | | | **Total** | 60 | 240 | 225 | 50 | 75 | 650 |

## Elective Streams(BTE704)

| | | |
|---|---|---|
| **Sem.VII** | **Elective II** | • Food Biotechnology<br>• Pharmaceutical Technology<br>• Nanotechnology |

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTC701 | Bioseparation & Downstream Processing I | 4.0 | 1.0 | 5.0 |

## Prerequisites

- Basics of Bioprocesses and Unit Operations
- Basic knowledge of mass balance
- Concepts of molecular diffusion and diffusion coefficients

## Course Objectives

- To cover the fundamentals, and design concepts of various downstream purification steps (unit operations) involved in a biochemical process.

## Course Outcomes

- Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing.

## Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Introduction to Bioproducts and Bioseparation:**<br>Range and characteristics of bioproducts<br>Characteristics of Fermentation Broth<br>Selection of unit operation with due consideration of physical, chemical and biochemical aspect of biomolecules<br>Stages of Downstream Processing | 06 |
| 2 | **Product release and recovery processes:**<br>Fundamental principles of obtaining the product from cell cultures: intracellular vs. extracellular product<br>Cell disruption-Physical, Chemical and Enzymatic methods of cell disruption<br>Mechanical Cell disruption methods: High pressure Cell Homogenizer, Bead Mill, Sonication | 07 |
| 3 | **Primary Separation:**<br>Removal of insolubles and Biomass (and particulate debris) separation techniques<br>Flocculation and sedimentation<br>Centrifugation-Ultracentrifugation, Gradient centrifugation<br>Filtration: Theory of Filtration, Pretreatment of Fermentation Broth, Filter Media and Equipment, Conventional and Cross-flow Filtration, Continuous Filtration, Filter cake resistance, specific cake resistance, Washing and dewatering of filter cakes | 12 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 4 | **Gas Absorption:**<br>Solubility of gases in liquids, Effect of temperature and pressure on solubility, Ideal and Non-ideal solutions, Choice of solvent for gas absorption, absorption factor,stripping factor, minimum gas liq ratio, Single stage gas absorption- Cross Current, Co-current, Countercurrent, Multistage Counter current Operation.<br>Absorption with Chemical Reactions<br>Related problems | 10 |
| 5 | **Liquid-Liquid Extraction:**<br>Introduction to Liquid-Liquid Extraction, Choice of Solvent for Liquid-Liquid Extraction<br>Triangular coordinate system, Ternary Equilibria [Binodal Solubility Curve with effect of temperature and pressure on it], Single Stage Operation, Multistage Cross Current Operation, Multistage Counter Current Operation [with and without reflux]<br>Equipments for liquid-liquid extraction.<br>Kinetics and modeling of extraction cycles<br>Types of extraction processes: Reactive extraction, Aqueous two phase systems, Reverse micellar extraction, Liquid-liquid and solid-liquid extraction, Supercritical fluid Extraction.<br>Design of extraction equipment.<br>Different types of extractors and designing of extractors.<br>**Leaching:**<br>Representation of equilibria, single stage leaching, multistage cross current leaching, multistage counter current leaching, equipments for leaching. | 12 |
| 6 | **Precipitation:**<br>Protein Precipitation methods: Isoelectric precipitation, Salting out, Organic solvent addition, Non-ionic polymers, Polyelectrolyte Addition<br>Selective denaturation of unwanted proteins<br>Large scale precipitation<br>Applications | 05 |

## References


1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processed and unit operations, Prentice Hall , New Delhi 1997.
4. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press

5. B.Shivshankar, Bioseparations: Priniples and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012

6. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, ( 09-2007)

7. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.

8. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.

9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.

10. Scopes Ak, Protein Purification, IRL Press, 1993

11. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993

12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989

13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis

14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTC702 | Bioprocess Modelling and Simulation | 4.0 | 1.0 | 5.0 |

### Prerequisites

- Knowledge of Fundamental Laws of Physics
- Knowledge of basic Mathematics
- Knowledge of Reactors and its types
- Knowledge of production of various fermentation products

### Course Objectives

- To understand the mathematical models in Biochemical Engineering systems
- To learn about different apects of modelling in Bioprocess system
- To learn various techniques to solve and simulate various bioprocess models

### Course Outcomes

- Students will be able to formulate model for biochemical System.
- Students will be able to solve Biochemical models

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | Basic Modelling Principles: Introduction, definition of Modelling and simulation, different types of models, application of mathematical modelling, fundamental laws: continuity equation, energy equation, equation of motion, transport equation, equation of state, Phase and chemical equilibrium, chemical kinetics with examples | 10 |
| 2 | Mathematical Models for Biochemical Engineering Systems: Batch Reactor, CSTR isothermal with cooling/heating jacket or coil, Continuous Stirred Tank Bioreactor, Fed Batch reactor, Batch distillation | 10 |
| 3 | Numerical Methods:<br>Solution of linear algebraic equations by Cramer's rule, Gauss elimination, Gauss siedel iterative method<br>Solution of Non algebraic equations by Bisection method, Newton Raphson, Secant Method<br>Numerical integration: Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule, Euler's method, Runga Kutta method<br>Basic data analysis-curve fitting | 12 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 4 | Modelling approaches for Biological systems<br>Growth kinetic Models - structured and unstructured systems; Compartment models;<br>Deterministic and stochastic approaches for modelling structured systems<br>Thermal death kinetics models, Stochastic Model for thermal sterilization of medium | 10 |
| 5 | Modelling for activated sludge process,Model for anaerobic digestion, Model for lactic acid fermentation, antibiotic production, Ethanol fermentation | 10 |

## References


1. J.E. Bailey and D.F. Ollis, Biochemical Engg Fundamentals, 1986, McGraw Hill Book Company
2. Said S.E.H. Elnashaie, Parag Garhyan, Conservation Equations and Modeling of Chemical and Biochemical Processes, 2003, Marcel Dekker
3. B. Wayne Bequette, Process Dynamics: Modeling, Analysis and Simulation, 1998, Prentice Hall
4. Michael Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, Englewood Cliffs, NJ, 2002
5. Process Modelling, Simulation and Control for Chemical Engineers, by William Luyben, McGraw Hill, Second Edition.
6. Numerical Methods and Modelling for Chemical Engineers, Davis M.E. ,Wiley, New York 1984
7. Numerical Methods for Engineers, Santosh Kumar Gupta, Tata McGraw hill, 1995
8. Numerical Methods, M. K. Jain, S. R. K. Iyengar, and R. K. Jain Sixth Edition.New Age International Publishers, New Delhi, 2012
9. Introduction to Chemical Engineering Computing by Bruce A. FinlaysonWiley- International, 2005.

| Course Code | Course/ Subject Name | Credits |
|---|---|---|
| BTS703 | Seminar | 3.0 |

**Details**

- Seminar topics will be the consensus of the project guide and the students. Each student will work on a unique topic.
- Representation of seminar work can be in the form of presentation.
- Students shall present research articles which may or may not be related to the topic of their project.

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE704 | Elective – II : Food Biotechnology | 4.0 | 1.0 | 5.0 |

### Prerequisites

- Basic concepts of Microbiology and Fermentation Technology

### Course Objectives

- To impart knowledge of various areas related to Food science and technology
- To enable the students to understand food composition and its physiochemical, nutritional and microbiological aspects
- To familiarize the students about the processing and preservation techniques of Food products

### Course Outcomes

- Students will know the principles of preservation
- Students will understand the principles of food processing techniques and will be able to apply these principles to specific food commodities

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | Introduction to food technology, Constituents of food, contribution to texture, flavour and organoleptic properties of food; food additives coloring agents, emulsifiers, preservatives, flavours, vitamins, organic acids and their functions; enzymes in food processing | 08 |
| 2 | Sources and activity of microorganisms associated with food; Factors affecting the growth and survival of micro-organisms in foods- intrinsic and extrinsic; Food borne diseases infections and intoxications, food spoilage causes. Microbial food- yeasts, bacteria and production of new protein foods - SCP, mushroom, algal proteins | 10 |
| 3 | Microbial fermentation and production of food and beverages using microorganisms. Pickling, Sauerkraut, vinegar, bread. Dairy product- Yogurt, cheese production by microbial and enzymatic(proteases) method. Alcoholic beverages- Beer(deoxygenating and desugaring by glucose oxidase of beer, beer mashing and chill proofing), Wine (red, white, sparkling) | 10 |
| 4 | Fermentation methods for preserving foods, Preparation of various food additives like coloring agents, emulsifiers, vitamins, flavours and organic acids | 08 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 5 | Post Harvest technology for food crops. Food preservation-high temperature methods, low temperature methods, irradiation, high pressure method and chemical preservatives. Production of Fruit juices and types of Fruit juices | 08 |
| 6 | Food Packaging methods Materials used for food packaging of various food products like cheese, eggs, bread, alcoholic beverages, milk and juices | 08 |

## References


1. Frazier, Food Microbiology, Tl-IM Publications.
2. Heller, Genetic Engineering of Food: Detection of Genetic Modifications- Wiley Publications.
3. Le. A. et. al., Microorganism & Fermentations- N.Y. Chemical
4. Rehm, Biotechnology Set Wiley Publications
5. M. R. Adams and M. O. Moss, Food Microbiology, Royal society of chemistry
6. James M. Jay, Modern food microbiology, An Aspen Publications
7. Prescott and Dunn, Industrial Microbiology, CBS Publications.

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE704 | Elective – II: Pharmaceutical Biotechnology | 4.0 | 1.0 | 5.0 |

### Prerequisites

- Knowledge about biochemistry and biochemical pathways in biological systems
- Knowledge about cell biology and metabolism

### Course Objectives

- Student shall know about bioavailability, bioequivalence and factor affecting bioavailability.
- Students shall know the pharmacokinetic and pharmacodynamic on the basis of CADD. They also know the design evaluation and application related to oral, parenteral, transdermal implants, bioadhesives and targeted drug delivery systems.

### Course Outcomes

- Students will be able to tell factors affecting the bioavailability and stability of dosage form. They also know the parameters for the disposition, absorption and Michaelis-Menton constants for non-linear kinetics.
- Students will know the fabrication, design, evaluation and application of drug delivery systems.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Introduction To Pharmaceuticals:**<br>History & Definition of Drugs. Sources of Drugs - Plant, Animals, Microbes and Minerals.<br>Drug targets, Intermolecular bonding forces.<br>Classification of Drugs<br>Naming of Drugs and medicines | 06 |
| 2 | **Pharmacodynamics and Pharmacokinetics:**<br>Molecules acting as drug targets: Enzymes, Receptors, Nucleic acid, Miscellaneous (Transport proteins, lipids, carbohydrates)<br>Three Phases of drug action:<br>Drug Absorption, Distribution, Metabolism and Excretion (ADME)<br>Modes of drug administration<br>Drug dosing (half-life, steady state concentration, drug tolerance, Bioavailibility) | 08 |
| 3 | ***In vivo* and *In vitro* approach of Drug discovery, design and development:**<br>Drug discovery: finding a lead molecule<br>Drug design: Optimizing target interaction | 07 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 4 | **Final stages of drug development - trials:**<br>Preclinical and clinical trials<br>Patenting and regulatory affairs | 07 |
| 5 | **Medicinal Chemistry:**<br>Antibacterial, Anticancer, Antiviral drugs, Opioid anelgesics | 06 |
| 6 | **Biopharmaceuticals:**<br>Production of Therapeutic Proteins, Hormones, Cytokines - Interferons, Interleukins I & II, Tumor Necrosis Factor (TNF); Nucleic acids<br>Role of Biopharmaceuticals in treatment of various health disorders | 10 |
| 7 | **Drug Delivery Systems, Biomaterials And Their Applications:**<br>Controlled and sustained delivery of drugs.<br>Biomaterial for the sustained drug delivery.<br>Liposome mediated drug delivery.<br>Drug delivery methods for therapeutic proteins. | 08 |

## References


1. Biopharmaceuticals: Biochemistry & Biotechnology, Gary Walsh (1998), John Wiley & Sons Ltd.
2. Medicinal Chemistry by Graham L. Patrick, Oxford University Press
3. Remingtons Pharmaceutical sciences, (Mark Publications & Company eston PA ) year 1980.
4. Medicinal Chemistry: an introduction by Gareth Thomas, Wiley Publications
5. Theory & Practice of Industrial Pharmacy, (3rd ed.) Leon Lachman, Lea & Febiger (1986)

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE704 | Elective – II: Nanotechnology | 4.0 | 1.0 | 5.0 |

### Prerequisites

- Knowledge of Biophysics, Biochemistry, Molecular Biology, Immunology and Analytical Methods in Biotechnology

### Course Objectives

- To develop the skills of the student in the area of Nanotechnology and its application.
- To familiarize student with different techniques for synthesizing and characterizing of various nanoparticles.

### Course Outcomes

- Students will have an in depth understanding of the components of Nanotechnology and the instruments used in Nanotechnology.
- Students will be able to apply the concepts of Nanotechnology in various fields.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Basics and Scale of Nanotechnology:** Introduction, Scientific revolutions, Time and length scale in structures, Definition of a nanosystem, Dimensionality and size dependent phenomena, Surface to volume ratio-Fraction of surface atoms, surface energy and surface stress, surface defects, Properties at nanoscale (optical, mechanical, electronic and magnetic) | 09 |
| 2 | **Different Classes of Nanomaterials:** Classification based on dimensionality, Quantum Dots, Wells and Wires, Carbon-based nano materials (buckyballs, nanotubes, graphene), Metalbased nanomaterials (nanogold, nanosilver and metal oxides), Nanocomposites, Nanopolymers, Nanoglasses, Nano ceramics, Biological nanomaterials | 10 |
| 3 | **DNA and Protein based Nanostructures:** DNA-gold particle conjugates, Polymer nanocontainers, Nanopores and nanomembranes for biochemical sensing, Micro and nanofluidic devices in biological studies, Peptide nanotubes and their applications in electronics, antibacterial agents; protein self assembly, nanochips, nanopolymers | 10 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 4 | **Nano-bioanalytics:**<br>Luminescent Quantum Dots for Biological Labeling, Nanoparticle Molecular Labels<br>Surface Biology: Analysis of Biomolecular Structure by Atomic Force Microscopy and Molecular Pulling-Force Spectroscopy, Biofunctionalized Nanoparticles for Surface Enhanced Raman Scattering and Surface Plasmon Resonance, Bioconjugated Silica Nanoparticles for Bioanalytical Applications | 09 |
| 5 | **Nanotechnology in Food, Medicine and Health Sciences:**<br>Nanocomposites for food packaging, nanomaterials in cosmetics, Regenerative medicine - Nanostructured collagen mimics in tissue engineering, synthesis of nanodrugs, polymeric nanoparticle for Drug and gene delivery, Micelles for drug delivery, Nanotechnology in cancer research, Preparation of nanobiomaterials - Polymeric scaffolds collagen, Elastins, Mucopolysaccharides, proteoglycans, cellulose and derivates, Dextrans, Alginates,Pectins, Chitin<br>Toxicity and Environmental Risks of Nanomaterial | 14 |

## References


1. Pradeep T., A textbook of nanoscience and nanotechnology , Tata Mcgrew Hill Education Pvt. Ltd., 2012.
2. Hari Singh Nalwa, Nanostructured Material and Nanotechnology, Academic Press, 2002
3. Niemeyer C. M., Bionanotechnology : Concepts, Application and Perspectives Wiley-VCH, 2006

| Course Code | Course/ Subject Name | Credits |
|---|---|---|
| BTP705 | Project-A | 3.0 |

**Details**

- Project Groups: Students can form groups with not more than 3(Three).
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, six hours are allotted in Project A to the students.
- Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.
- Students are expected to do research and literature survey for their topics and submit a synopsis at the end of the semester, specifying their hypothised methodology and expected outcome of their work to be conducted in Project-B.
- Students are also expected to present their synopsis at the end of the semester.

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| BTL706 | LAB-VI | 2.0 |

**Concepts for experiments:**

A minimum of 10 experiments must be performed based on the following concepts:

- Viscometer
- Cell disruption
- Conventional filtration
- Centrifugation
- Distribution coefficient in Liq - liq extraction
- Binodal curve in liq - liq extraction
- Solid-liquid extraction of natural product and subsequent purification
- Leaching
- Protein precipitation and its recovery
- Gas Chromatography
- Ion Exchange Chromatography
- Separation of Plant Pigments using Column Chromatography

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| BTL707 | LAB-VII | 2.0 |

**Concepts for experiments:**

A minimum of 10 experiments must be performed based on the following:

- Material Balance without Reaction
- Material Balance with Reaction
- Energy Balance equations
- Solving Linear equations
- Solving Non linear algebric equations
- Parameter Estimation in kinetics
- Modelling of Batch, Fed Batch and Continuous
- Simulation of Batch Reactor
- Simulation of Continuous Reactor
- Solving Numerical integrations
- Solving Algebric equations
- Solving Differential Equations

# University of Mumbai

## Scheme for BE: Semester-VIII

| Subject Code | Subject Name | Teaching Scheme | | | Credit Assigned | | | |
|---|---|---|---|---|---|---|---|---|
| | | Theory | Pract. | Tut. | Theory | Pract. | Tut. | Total |
| BTC801 | Environmental Biotechnology | 04 | – | – | 04 | – | – | 04 |
| BTC802 | Bioseparation & Downstream Processing Technology-II | 04 | – | – | 04 | – | – | 04 |
| BTC803 | Bioprocess Plant & Equipment Design | 03 | – | 01 | 03 | – | 01 | 04 |
| BTE804 | Elective-III | 03 | – | 01 | 03 | – | 01 | 04 |
| BTP805 | Project-B | – | – | 08 | – | – | 06 | 06 |
| BTL806 | LAB VIII | – | 03 | – | – | 1.5 | – | 1.5 |
| BTL807 | LAB IX | – | 03 | – | – | 1.5 | – | 1.5 |
| | **Total** | 14 | 06 | 10 | 14 | 03 | 08 | 25 |

### Examination Scheme

| Subject Code | Subject Name | Examination Scheme | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Theory marks | | | | Term Work | Pract. | Oral | Total |
| | | Internal Assessment | | | End Sem. Exam | | | | |
| | | Test 1 (A) | Test 2 (B) | Avg.of (A) & (B) | | | | | |
| BTC801 | Environmental Biotechnology | 20 | 20 | 20 | 80 | – | – | – | 100 |
| BTC802 | Bioseparation & Downstream Processing Technology-II | 20 | 20 | 20 | 80 | – | – | – | 100 |
| BTC803 | Bioprocess Plant & Equipment Design | 20 | 20 | 20 | 80 | 25 | – | – | 125 |
| BTE804 | Elective-III | 20 | 20 | 20 | 80 | 25 | – | – | 125 |
| BTP805 | Project-B | – | – | – | – | 100 | – | 50 | 150 |
| BTL806 | LAB VIII | – | – | – | – | – | 25 | – | 25 |
| BTL807 | LAB IX | – | – | – | – | – | 25 | – | 25 |
| | | | **Total** | 80 | 320 | 150 | 50 | 50 | 650 |

## Elective Streams(BTE804)

| | | |
|---|---|---|
| **Sem.VIII** | **Elective III** | • Non Conventional Sources of Energy<br>• Biosensor & Diagnostics<br>• Protein Engineering<br>• Agriculture Biotechnology |

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTC801 | Environmental Biotechnology | 4.0 | – | 4.0 |

### Prerequisites

Knowledge of Biotechnological aspects and molecular genetics

### Course Objectives

- The main objective of this course is to introduce to the students the current biotechnological approaches and technologies in the use of microbes and/or other organisms and their processes to improve environmental quality, clean up contaminated environment, renew resources and generate valuable products for human society.

### Course Outcomes

- Apply their knowledge of environmental science and biological systems to improve the quality of life in individual context.
- Recognize key environmental problems and to apply the operating principles and biotic systems for remediation.
- Design, improve and apply biotechnological systems and processes to meet practical needs of different environmental problems.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Introduction:**<br>Environmental Degradation, types of environmental degradation, factors affecting environmental degradation, biogeochemical cycles (Nitrogen, Carbon, Oxygen, Phosphorus, Sulfur, Hydrological), pollution, pollutants and their types (general idea), Man induced impact on environment (Global warming, Green house effect, ozone depletion, acid rain, Photochemical smog), Environmental monitoring- sampling (land, air, water), analysis- physical, chemical, biological, pollution monitoring- bioindicators, biosensors, biomarkers, pollution control aspects | 07 |
| 2 | **Pollution control:**<br>Pollutants, types, sources, effects, atmospheric stability, atmospheric dispersion- (Gausian plume model), problems, air pollution control- Particulate and gaseous control, source correction methods, natural pathways of exchange of air pollutants from atmosphere to earth (wet precipitation- rain out, washout) | 06 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 3 | **Water Pollution Control:** Pollutants, types, sources, effects, measurement of organic and inorganic pollutants, DO depletion, modelling of BOD reaction, problems on BOD, Methods of waste water treatment, Microbiology and design (activated sludge process, trickling process), Rotating Biological contactors, Fluidized bed reactors, anaerobic sludge digestion, Methanogenesis, methanogenic, acetogenic, fermentative bacteria- technical process and condition, waste water treatment using aquatic plants, heavy metal removal by hairy roots. | 08 |
| 4 | **Soil Pollution Control:** Pollutants, types, sources, effects, bioremediation of contaminated soil, types of bioremediation, factors affecting bioremediation, phytoremediation, role of genetic engineering | 06 |
| 5 | **Solid waste management:** Types of solid waste, sources, effects, methods of collection, disposal methods, potential methods of disposal, disposal of hazardous waste, Biological conversion process ( aerobic, anaerobic, bioventing), biotechnology applications to hazardous waste management | 06 |
| 6 | **Special topics in Bioremediation technology:** Nanotechnology for bioremediation of heavy metals, sulphate and sulphur reducing bacteria, bioremediation of petroleum sludge using bacterial consortium and biosurfactnts | 04 |
| 7 | **Downstream Processing:** Downstream processing in biological treatment process, effluent disposal and reuse, biofiltration of waste gas, treatment and purification of biogas | 04 |
| 8 | **Effluent treatment:** Need of ETP in industry, Components of ETP, general design procedure for ETP, ETP studies of industries like dairy, metal, food etc. | 05 |
| 9 | **Environmental Legislations:** Water Prevention and Control Pollution Act, Water pollution act, Air pollution and prevention act, The environment Protection Act, Forest Conservation Act, Municipal Solid Waste Rules, Biomedical Waste Rules, Hazardous Waste Rules, Environmental Clearance, Environmental Legislation and Pollution Control Acts in India, Central Pollution Control Board, its functions and powers, Procedure to operate an industry | 03 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 10 | **Environmental Standards:**<br>Need and Use of environmental standards, Agencies and Bodies setting environmental standards, classification of environmental standards, National and International Standards for waste water | 03 |

## References


1. Environmental Biotechnology- Allen Scragg, Oxford University Press, Second edition
2. Environmental Biotechnology, 1995 S.N. Jogdand, Himalaya Publishing House.
3. Bioremediation, 1994 Barker, K.H. and Herson, D.S., Mcgraw Hill, Inc. New York
4. Waste water Engineering, Metcalf & Eddy, Tata McGraw Hill Publication, Fourth edition
5. Environmental Science, Richard T. Wright, PHI Pvt. Ltd., Ninth edition
6. Environmental Pollution Health and Toxicology, S.V.S. Rana, Narosa Publishing House Pvt. Ltd., First edition

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTC802 | Bioseparation & Downstream Processing II | 4.0 | – | 4.0 |

### Prerequisites

- Basics of Bioprocesses and Unit Operations
- Basic knowledge of mass balance.
- Concepts of molecular diffusion and diffusion coefficients

### Course Objectives

- To cover the fundamentals, and design concepts of various down stream purification steps (unit operations) involved in a biochemical process.

### Course Outcomes

- Students will be able to describe theory, principle, design, application and possible integrations of unit operations in bioprocessing

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Adsorption and Ion Exchange:**<br>Introduction to Adsorption, Types of Adsorption, Adsorption Isotherms, Single Stage Adsorption, Multistage Cross Current Adsorption, Multistage Counter Current Adsorption, Equipments for Adsorption<br>Ion Exchange Equilibria, Ion Exchange Equipments<br>Design and Construction of Chromatographic Columns for Bioseparations | 10 |
| 2 | **Membrane Separation Techniques:**<br>Membrane separation processes: Reverse Osmosis, Ultrafiltration, Microfiltration, Nanofiltration, Dialysis, Electrodialysis, Gas Permeation, Pervaporation<br>Types of Membranes, Membrane Modules and design<br>Retention coefficient, Concentration Polarization, Membrane fouling<br>Factors affecting membrane filtration<br>Advantages of membrane separation processes over conventional separation techniques<br>Industrial Applications | 10 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 3 | **Equipments for Gas-Liquid Contacting applicable for Bioprocesses:**<br>Classification of equipments for gas-liquid contacting, Gas dispersed and liquid continuous phase- Sparged Vessels (Bubble Columns), Mechanically Agitated Vessels, Tray Towers,<br>Spray Towers and Spray Chambers, Packed Towers<br>Comparison of Packed Towers with Tray Towers. | 06 |
| 4 | **Crystallization:**<br>Solubility curve, Super saturation, Method of obtaining super saturation<br>Effect of heat on size and growth of crystal, Rate of Crystal growth and Delta-L law of crystal growth, Material and energy balance for crystallizers<br>Crystallization equipment-description | 08 |
| 5 | **Drying:**<br>Introduction to drying, Equilibrium, Different types of moisture contents, Rate of Drying and drying curve, Batch Drying and calculation of time of drying, types of driers<br>Lyophilization<br>Formulation | 06 |
| 6 | **Case Studies of downstream processing:**<br>Baker's yeast, Ethanol, Citric acid, Penicillin, Insulin, interferon, Monoclonal antibodies, Tissue plasminogen activator, Taq polymerase | 12 |

## References


1. Treybal R.E. , Mass transfer operation, 3 Ed., McGraw Hill New York, 1980.
2. McCabe W.L. and Smith J.C., Unit operation in chemical engineering, 5 Ed., McGraw Hill New York 1993.
3. Geankoplis C.J., Transport processed and unit operations, Prentice Hall , New Delhi 1997.
4. Roger G. Harrison, Paul Todd, Scott R. Rudge, Demetri P. Petrides, Bioseparations Science and Engineering, Oxford University Press
5. B.Shivshankar, Bioseparations: Priniples and Techniques, Eastern Economy Edition, PHI Learning Pvt. Ltd., Publishing House, New Delhi, 2012
6. Bioseparation & bioprocessing (2nd Ed.) 2-Volume set, Ed SUBRAMANIAN Ganapathy, Wiley-VCH, ( 09-2007)
7. P.A. Belter, E.L. Cussler and Wei-Shou Hu., Bioseparations-Downstream Processing for Biotechnology, WileyInterscience Publication, 1988.
8. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw Hill, Inc., 1986.

9. R. K. Scopes, Berlin, Protein Purification: Principles and Practice, Springer, 1982.
10. Scopes Ak, Protein Purification, IRL Press, 1993
11. Biotechnology: Bioprocessing, Rhem and Reed, Vol. 3, 1993
12. Separation and purification techniques in biotechnology, Fredreich Dechow, 1989
13. Asenjo J.A. and J.Hong (Eds), Separation Processes in Biotechnolgy, Taylor and Francis
14. T. Schepler et al, Biotreatment, Downstream Processing and Modeling (Advances in Biochemical Engineering /Biotechnology, Vol 56) by Springer Verlag

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTC803 | Bioprocess plant and Equipment Design | 3.0 | 1.0 | 4.0 |

### Prerequisites

- Process Calculation
- Unit operation I and II

### Course Objectives

- To impart basic concepts of mechanical and process design of process plant.
- To impart design principles for bioreactor.

### Course Outcomes

- This course makes the students to learn the methods and practices followed in the design of Bioprocess equipments.
- This course makes the students to draw the designed equipments to scale.
- The course imparts advanced knowledge on bioreactor design for efficient utilization of the principles in bioprocess technology

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Module 1:**<br>Material of construction for process and bioprocess plants. Mechanical design of process equipment. Design of cylindrical and spherical vessel under internal and external pressure. Selection and design of enclosures- flat plate, formed heads, torispherical and hemispherical heads, standard flanges and nozzles- classification of flanges, flange thickness calculation, gasket selection and design, bolt selection and calculation (Numerical problems are not needed for design of flanges, gasket and nozzles)<br>Design of heat exchange equipments for upstream and downstream operations in bioprocessing industries: Heat exchangers - process design (TEMA and IS 4503 standards) of double pipe, single pipe and multipass shell and tube heat exchangers. | 07 |
| 2 | **Module 2:**<br>Introduction to Indian Standards for storage tanks and their use in design of process vessel. Storage vessels for volatile and non volatile liquids including unfired pressure vessels.<br>Design of supports- Bracket, leg, saddle and skirt support and fixed roof and open roof tanks. | 07 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 3 | **Module 3:**<br>Introduction to general design information for Bioprocess plants:<br>Development of flowsheet, piping and instrumentation diagram and its description. General design consideration, optimum design | 07 |
| 4 | **Module 4:**<br>Design of Distillation column:<br>Detailed design and drawing of perforated plate distillation column. Absorption columns: Detailed design and drawing of perforated plate and packed towers. | 06 |
| 5 | **Module 5:**<br>Design of fermenters:<br>Design considerations for maintaining sterility of process streams and process equipments.<br>Design of mechanically agitated fermenters and non-mechanically agitated (bubble column and air lift) fermenters. | 06 |
| 6 | **Module 6:**<br>Design of various types of evaporators employed in bioprocess operation:<br>Evaporators- Standard vertical tube evaporator, single and multiple effect evaporators and forced circulation evaporator.<br>Thermal sterilization systems in fermentation processes: batch and continuous thermal sterilizers. | 06 |

## References


1. Sinnott, R.K., Coulson & Richardson's 'Chemical Engineering', Volume 6, 3rd Edn., Butterworth Heinemann, New Delhi, 1999.
2. Perry, R.H., et al., Perry's 'Chemical Engineers Handbook', 7 th Edn., McGraw Hill, NewYork, 1997.
3. Joshi, M.V., and Mahajani, V.V., 'Process Equipment Design', 3 rd Edn., Macmillan India Limited, New Delhi, 1996.
4. Bownell, L.E., and Young, E.M., 'Process Equipment Design', Wiley Eastern, 1968.
5. Peters and Timmerhause, 'Plant Design and Economics for Chemical Engineers'
6. S.B. Thakore, B. I. Bhatt, 'Introduction to Process Engineering and Design', McGraw Hill Companies
7. Michael L Schuler and Fikret Kargi, 'Bioprocess Engineering' Printice Hall of India Pvt. Ltd
8. Pauline M Doran, 'Bioprocess Engineering Principles' Academic Press

9. Pressure vessel code-IS Code 2825, B.I.S., New Delhi, 1969
10. Heat Exchanger Design Code IS 4503, B.I.S., New Delhi, 1969
11. Process Equipment Design and Drawing by Kiran Ghadyalji,Nandu publication

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE804 | Elective – III : Non Conventional Sources of Energy | 3.0 | 1.0 | 4.0 |

### Prerequisites

- Knowledge of conventional sources of energy and energy utilization.

### Course Objectives

- The main objective of this course is to introduce to the students the current approaches and technologies in the development of non-conventional sources of energy their processes to improve environmental quality and energy requirement, clean and abundant energy, renewable resources and generate cost effecient methods to harness energy for human society.

### Course Outcomes

- Apply their knowledge of energy generation and its conservation to improve the quality of life in individual context.
- Recognize key energy problems and to apply the operating principles and biotic systems for remediation.
- Design, improve and apply biotechnological systems and processes to meet practical needs of different problems of energy requirement.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Introduction:**<br>Traditional energy systems: fossil fuel, firewood, coal; Fossil fuel based systems, Impact of fossil fuel based systems; renewable and non-renewable sources of energy; global and national energy crisis, Prospects of renewable energy sources. | 03 |
| 2 | **Solar energy:**<br>Solar energy : solar radiation spectrum, radiation measurements, applications (heating, cooling, drying, distillation); flat plate collectors, concentrating collectors, Solar air heaters-types, solar driers, storage of solar energy-thermal storage, solar pond, solar water heaters, solar distillation, solar still, solar cooker, solar heating & cooling of buildings, photo voltaics - solar cells & its applications | 08 |
| 3 | **Wind Energy:**<br>Principle of wind energy conversion; analysis of aerodynamic forces acting on wind mill blades and estimation of power output; wind patterns and wind data; types of wind mills, components of wind mill, site selection. | 03 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 4 | **Geothermal energy:**<br>Estimation and nature of geothermal energy, geothermal sources and resources: hydrothermal, geo-pressured hot dry rock, magma; Advantages, disadvantages and application of geothermal energy; prospects of geothermal energy in India. | 03 |
| 5 | **Energy from the Ocean:**<br>Ocean Thermal Electric Conversion (OTEC) systems: open cycle, closed cycle, Hybrid cycle, prospects of OTEC in India.<br>Energy from tides, basic principle of tidal power, single basin and double basin tidal power plants, advantages, limitation and scope of tidal energy.<br>Wave energy and power from wave, wave energy conversion devices, advantages and disadvantages of wave energy. | 05 |
| 6 | **Energy from Biomass:**<br>Biomass conversion principle: combution and fermentation; Biogas generation plants: classification, advantages and disadvantages, constructional details, site selection, digester design consideration, filling a digester for starting, maintaining biogas production, Fuel properties of bio gas, utilization of biogas.<br>Biodisel: principle, production, efficiency, scope in India. | 05 |
| 7 | **Fuel cells:**<br>Introduction, Design principle, operation of fuel cell, Types of fuel cells, conversion efficiency of fuel cell, application of fuel cells.<br>Microbial Fuel cells: Principle, construction, working, efficiency and scope in India. | 03 |
| 8 | **Hydrogen energy:**<br>Introduction, Hydrogen Production methods, Hydrogen storage, hydrogen transportation, utilization of hydrogen gas, hydrogen as alternative fuel for vehicles.<br>Nuclear energy: nuclear reactors, fission and fusion reactions; advantages and disadvantages of nuclear energy. | 03 |
| 9 | **Magneto Hydrodynamic (MDH) Power Generation:**<br>Principle of MHD power generation, MHD system, Design problems and developments, gas conductivity, materials for MHD generators and future prospects. | 03 |
| 10 | **Energy Management:**<br>Energy economics, energy conservation, energy audit, general concept of total energy system, scope of alternative energy system in India. | 03 |

## References


1. Non-conventional energy sources by G.D. Rai, Khanna Publishers
2. Solar Energy: Fundamentals and Applications by H.P.Garg & Jai Prakash, Tata McGraw Hill
3. Solar Engineering of Thermal Processes by Duffic and Beckman, John Wiley
4. Solar Energy: Principles of Thermal Collection and Storage by S,P Sukhatme,Tata McGraw Hill
5. Alternative Energy Sources by B.L. Singhal Tech Max Publication
6. Non Conventional Energy Resources by S.Hasan Saeed and D.K.Sharma
7. Fuel Cells by Bockris and Srinivasan; McGraw Hill
8. Magneto Hydrodynamics by Kuliovsky and Lyubimov, Addison

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE804 | Elective – III: Biosensors and Diagnostics | 3.0 | 1.0 | 4.0 |

### Prerequisites

Biochemistry , Analytical Methods In Biotechnology, Principles of Basic Instruments Used In A Biotechnology Lab.

### Course Objectives

The objectives of this course is that the students will be able to :

- Explain the role of biological macromolecules as recognition elements & biosensors.
- Describe the biomedical aspects of these sensors.
- Analyse the interplay between materials, components and systems in the field of bio sensing.
- Design an advanced biosensor for medical applications, using the current state of the art of biosensors.
- Describe what challenges are shared among and what challenged are unique to the major biosensor application areas.

### Course Outcomes

By learning this course the students will be able to :

- Apply the principles of engineering to the development of bioanalytical devices and the design of biosensors
- Explain the principles of linking cell components and biological pathways with energy transduction, sensing and detection.
- Differentiate among various biosensor systems.
- Design a biosensor in response to agricultural, bioenvironmental, food safety, and biosecurity applications.
- Apply engineering and biological approaches to solve problems in diagnosis of diseases, such as diabetes, cancer or detection of other analytes/biomarkers .

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | Biosensors: Principles, Characteristics of Ideal Biosensors, Basic measuring procedure, Components of biosensors, Advantages & Limitations | 09 |
| 2 | Biocatalysis based biosensors, Bioaffinity based biosensors & Microorganisms based biosensors, Biologically active material and analyte. Types of membranes used in biosensor constructions. | 10 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 3 | Various types of transducers, Principles and applications - Calorimetric, Optical, Potentiometric/ Amperometric, Conductrometric/ resistormetric. | 05 |
| 4 | Piezoelectric, Semiconductor, Impedimetric, Mechanical and molecular electronics based transducers, Chemiluminiscene-based biosensors. | 05 |
| 5 | Biosensors in clinical chemistry, Medicine and health care, Biosensors for veterinary, Agriculture and food, Low cost-biosensor for industrial processes for online monitoring , Biosensors for environmental monitoring. | 10 |

**References**


1. Roger, K.R. and Gerlach, C.L. 1 99. Update on environmental for biosensors.Env. Sci. Techno! 33 500A - 506A.
2. Bilitewski, U. Turner, A.P.F. 2000 Biosensors for environmental monitoring Harwood, Amsterdam.
3. Moses, V and Cape, R.E. 1991, Biotechnology the science and business,Harwood, Academic Publisher London
4. Rogers, K.R. and Mascini, M. 2001. Biosensors for analytical monitoring EPA biosensors group.
5. Aboul - Enein, H. V., Stefan, R. and Van Staden, (1999) Chemiluminiscence - based biosensors - An overview crit Rev. Anal. Chem. 29, 323-331.
6. Pearson, J.E. Gill, A., and Vadgama, P. (2000) Analytical aspects of biosensors ,Ann Clin Biochem 37, 119-145.
7. Biosensors: Fundamentals and applications, Oxford, U.K: Oxford University Press by Turner, A.P.F., Karube, I. & Wilson, GS.

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE804 | Elective – III: Protein Engineering | 3.0 | 1.0 | 4.0 |

### Prerequisites

- Principles of Biochemistry
- Principles of Recombinant DNA Technology
- Basics of Enzyme Activity

### Course Objectives

- Imparting knowledge about structure function relationships of proteins
- Studying the problem of protein folding and methods of characterization folded proteins
- Aspects of Protein Engineering in the industry

### Course Outcomes

At the end the student would have learned:

- Structure and Function relationship in proteins and its application in designing proteins
- Process of engineering proteins to increase its value by assisting folding, purification.
- Protein engineering of therapeutic proteins, industrially important enzymes and antibodies.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Structure of Proteins:**<br>Post translational Modifications of proteins.<br>Primary Structure and its determination<br>Ramchandran Plot<br>Secondary, Tertiary and Quaternary Structure of Proteins<br>Bonds that stabilize a protein molecule<br>Protein folding pathways and Energy Status of a Protein Molecule<br>Protein Degradation in the cell | 10 |
| 2 | **Techniques involved in studying protein structure:**<br>Methods of protein crystallization.<br>Methods to study the quaternary structures of proteins: X-ray Crystallography, NMR Spectroscopy.<br>MALDI-TOF, ESI-MS | 07 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 3 | **Structure Function Relationships in Proteins:**<br>Helix-turn-Helix motif in DNA binding and homeodomain protein.<br>Zinc fingers.<br>Leucine zippers.<br>Membrane proteins: General characteristics, Transmembrane segments, bacteriorhodopsin and Photosynthetic reaction center | 06 |
| 4 | **Concepts of designing a new Protein Molecule:**<br>Chemical synthesis of peptides.<br>Target molecules for Protein Engineering.<br>The protein cycle and steps involved in Engineering a new Protein.<br>*De novo* protein design | 06 |
| 5 | **Applications of Protein Engineering:**<br>Protein Engineering to enhance the solubility and assist folding of expressed proteins.<br>Protein Engineering to assist purification of expressed proteins.<br>Role in Vaccine Development.<br>Engineering blood clotting factors: factor VIII.<br>Engineering enzymes: tyrosyl-tRNA synthase.<br>Engineering therapuetic hormones: insulin.<br>Engineering humanized antibodies | 10 |

## References


1. Lilia Arbenghina; Protein Engineering in Industrial Biotechnology; Harwood Academic Publishers
2. Creghton TE; Proteins Function, A Practical Approach; Freeman WH, Second Ed, 1993
3. Branden C. and Tooze J.; Introduction to Protein Structure; Second Edition, Garland Publishing, NY, USA, 1999
4. Moody PCE, and A.J.Wilkinson; Protein Engineering; IRL Press, Oxford, 1990
5. Walsh. G; Protein Biotechnology and Biochemistry; 2nd ed.; Wiley Publications
6. Klaus Demobowsky, Novel Therapeutic Proteins; Wiley Publications
7. Voet D. and Voet G.; Biochemistry' Third Edn. John Wiley and Sons, 2001

| Course Code | Course/ Subject Name | Credits | | |
|---|---|---|---|---|
| | | Theory | Tut. | Total |
| BTE804 | Elective – III: Agriculture Biotechnology | 3.0 | 1.0 | 4.0 |

### Prerequisites

- Knowledge about plant tissue culture methods and applications
- Knowledge about genetic engineering methods for e.g. gene transfer techniques, plant vectors and basics of transgenic plants
- Knowledge about traditionally used herbicides, pesticides, its advantages and drawbacks
- Knowledge about ethical and biosafety issues and intellectual property rules associated with plants

### Course Objectives

- To understand basic plant biology and breeding methods.
- To gain knowledge about transgenic plant analysis, principle behind generation of herbicide and pest tolerant plants.
- To understand the stress condition in plants and methods to overcome it.
- To design methods for crop improvement.
- To analyse applications based on molecular farming.

### Course Outcomes

Students will be able to:

- Apply the transgenic methods to develop better quality crops.
- Understand the advantages and drawbacks of engineered plants and modify them accordingly.
- Harness the plants for imroved quality biomaterials.

### Detail syllabus

| Module | Contents | No. of hrs |
|---|---|---|
| 1 | **Agricultural Microbiology:**<br>Microbial groups in soil, Plant and Microbe interactions.<br>Plant pathogens, Biological nitrogen fixation, Microflora of Rhizosphere and Phyllosphere microflora, microbes in composting<br>Beneficial microorganisms in Agriculture: Biofertilizer (Bacterial Cyanobacterial and Fungal), microbial insecticides, Microbial agents for control of Plant diseases | 05 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 2 | **Plant Breeding:**<br>Historical milestones in plant breeding. Aims and objectives of plant breeding, Significance of plant breeding in crop development.<br>Concepts in plant breeding - Simple versus Complex Inheritance, Mating Systems, Varieties, and Pure Lines.<br>Methods of Plant Breeding.<br>Plant Hormone Signal Transduction - Auxin and GA Signaling, Cytokinin and Ethylene Signaling | 07 |
| 3 | **Transgenic Plants:**<br>Transgenic Plant Analysis: screening on selection media, PCR, Intact Transgene Integration characterization, Real time PCR, Transgene expression, western blot analysis<br>Regulations and Biosafety<br>Field Testing of Transgenic Plants - Environmental Risk Assessment (ERA) process, e.g. the case of Bt Maize, Agronomic Performance, Risk analysis.<br>Clean-gene technology. | 05 |
| 4 | **Genetic manipulation of herbicide tolerance:**<br>The use of herbicides in modern agriculture<br>Types of compounds used as herbicides<br>Strategies for engineering herbicide tolerance - Glyphosate tolerance, Phosphinothricin, Prospects for plant detoxification systems<br>Commercialization of herbicide-tolerant plants to date<br>The environmental impact of herbicide-tolerant crops<br>Development of Superweeds. | 03 |
| 5 | **Biotic and Abiotic stress:**<br>Abiotic stress: Acclimation and crop adaptation to water stress, salinity stress, temperature stress, heat and cold, Photo oxidative stress, nutrient stress, heavy metal stress, metabolite engineering for abiotic stress tolerance<br>Biotic stress: plant response to pathogens and herbivores, biochemical and molecular basis of host plant resistance, toxins of fungi and bacteria, systemic and induced resistance, pathogen derived resistance, genetic engineering for biotic stress resistance | 08 |

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| Module | Contents | No. of hrs |
|---|---|---|
| 6 | **Genetic manipulation of pest resistance:**<br>The nature and scale of insect pest damage to crops.<br>GM strategies for insect resistance: the *Bacillus thuringiensis* approach.<br>The use of *Bacillus thuringiensis* as a biopesticide.<br>Bt-based genetic modification of plants.<br>Problem of insect resistance to Bt, environmental impact of Bt crops.<br>Copy Nature strategy | 03 |
| 7 | **Improvement of crop yield and quality:**<br>Genetic manipulation of fruit ripening, softening, genetic modification of ethylene biosynthesis.<br>Golden rice and Biofortified rice.<br>Engineering plant protein composition for improved nutrition.<br>The genetic manipulation of crop yield by enhancement of photosynthesis | 04 |
| 8 | **Molecular farming:**<br>Farming of carbohydrates (e.g. starch, polyfructans)<br>Metabolic engineering of Lipids (e.g. Bioplastics)<br>Molecular farming of proteins (e.g. oleosin system: hirudin and insulin production).<br>Medically related proteins (e.g. custom made antibodies, Edible vaccines) | 04 |

## References


1. Plant biotechnology -The genetic manipulations of plants by Slater, A., Scott, N. and Fowler, M., Oxford University press
2. Principles of Plant Breeding by Allard R W 1960 .Kalyani Publishers, New Delhi.
3. Plant Biotechnology and Genetics: Principles, Techniques, and Applications - Edited by C. Neal Stewart, Jr.
4. Stress biology, by U. Chakraborty, Bishwanath Chakraborty, 2005. Narosa Publishing House.
5. Agricultural Microbiology by D. J. Bagyaraj, G. Rangaswami, Prentice Hall of India Pvt Ltd.

| Course Code | Course/ Subject Name | Credits |
|---|---|---|
| BTP805 | Project-B | 6.0 |

**Details**

- Project Groups: Students can form groups with not more than 3(Three).
- Students should spend considerable time in applying all the concepts studied, into the project. Hence, eight hours are allotted in Project B to the students.
- Students are advised to take up industrial/ experimental oriented/ simulation and/or optimization based topics for their projects.
- Students have to submit a comprehensive thesis based on the research work conducted throughout the year.
- Students are expected to present their work and defend their thesis.

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| BTL806 | LAB-VIII | 1.5 |

**Concepts for experiments:**

A minimum of 10 experiments must be performed from the following list of experiments:

- Physical property like pH, turbidity, conductivity, alkalinity determination of waste water
- Determination of total phosphorus content of waste water
- Determination of total Kjeldahl Nitrogen of waste water
- Determination of BOD of waste water
- Determination of COD of waste water
- Determination of Oil and grease content of waste water
- Determination of total solids, total suspended solids and total dissolved solids
- Determination of MLSS and MLVSS
- Determination of Sludge Volume Index
- Estimation of metals like iron, copper in waste water
- Determination of chloride content of waste water
- Estimation of coliform bacteria in waste water
- Determination of phytoplankton in waste water
- Determination of Most Probable Number of waste water
- Removal of heavy metals by chemical methods from waste water Adsorption

| Course Code | Course/Subject Name | Credits |
|---|---|---|
| BTL807 | LAB-IX | 1.5 |

**Concepts for experiments:**

A minimum of 10 experiments must be performed on the following concepts:

- Adsorption
- Membrane based filtration
- Dialysis
- Reverse Osmosis
- Storage techniques for bioactive compounds- Freeze drying, Spray drying
- Crystallization
- Isolation and purification of biomolecules (protein/s or enzyme) from crude source/fermentation broth
- Assessment of recovery and purity of the isolated product