

Section - I

## Unit -1 Bioprocess Microbiology – I

15 hours

- 1.1. Introduction: Scope of Biotechnology and Industrial Microbiology : Nature of Biotechnology and Industrial Microbiology; Characteristics of Industrial Microbiology; Patents and Intellectual Property Rights in Industrial Microbiology and Biotechnology; The Use of the Word 'Fermentation' in Industrial Microbiology; Organizational Set-up in an Industrial Microbiology Establishment
- 1.2. Screening for Productive Strains and Strain Improvement in Biotechnological Organisms: Sources of Microorganisms used in Biotechnology; Selection from naturally occurring variants; Manipulation of the genome of industrial organisms in strain improvement
- 1.3. Metabolic Pathways for the Biosynthesis of Industrial Microbiology Products: The Nature of Metabolic Pathways; Industrial Microbiological Products as Primary and Secondary Metabolites; Trophophase-idiophase Relationships in the Production of Secondary Products; Role of Secondary Metabolites in the Physiology of Organisms Producing Them; Pathways for the Synthesis of Primary and Secondary Metabolites of Industrial Importance; Carbon Pathways for the Formation of Some Industrial Products Derived from Primary Metabolism; Carbon Pathways for the Formation of Some Products of Microbial Secondary Metabolism of Industrial Importance.
- 1.4. Overproduction of Metabolites of Industrial Microorganisms: Mechanisms Enabling Microorganisms to Avoid Overproduction of Primary Metabolic Products Through Enzyme Regulation; Derangement or Bypassing of Regulatory Mechanisms for the Over-production of Primary Metabolites; Regulation of Overproduction in Secondary Metabolites; Empirical Methods Employed to Disorganize Regulatory Mechanisms in Secondary Metabolite Production

## Unit -2 Bioprocess Microbiology – II

15 hours

- 2.1. Growth Kinetics : Introduction; Kinetics of batch culture; Disadvantages of batch culture ; Advantages of continuous culture ; Growth kinetics for continuous culture; Material balance for CSTR: Rate of product formation, Growth kinetics, biomass and product yields,  $YX/S$  and  $YP/S$ , Biomass balances (cells) in a bioreactor, Material balance in terms of substrate in a chemostat, Modified chemostat, Fed batch culture
- 2.2. Industrial Media and the Nutrition of Industrial Organisms : The Basic Nutrient Requirements of Industrial Media; Criteria for the Choice of Raw Materials Used in Industrial Media; Some Raw Materials Used in Compounding Industrial media; Growth Factors; Water; Some Potential Sources of Components of Industrial media, Carbohydrate sources, Protein sources; The use of plant waste materials in Industrial Microbiology media: Saccharification of Polysaccharides, Starch, Cellulose, hemi-celluloses and lignin in plant materials
- 2.3. Sterility in Industrial Microbiology : Introduction; The basis of loss by contaminants; Physical and Chemical Methods of Achieving Sterility : Hot plates; High temperature sterilization; Dry heat sterilization; Sterilisation with filtration; Microwave sterilization; Electron beam sterilization; Chemical sterilization; Batch sterilization; Continuous sterilization; The sterilization of the fermentor and its accessories; Media sterilization; Viruses (Phages) in Industrial Microbiology
- 2.4. Bioprocess Scale-up: Introduction; Scale-up procedure from laboratory scale to plant scale( Scale-up for constant  $K_La$ , for shear forces, constant mixing time); Bioreactor design criteria ; CSTR chemostat versus tubular plug flow; Dynamic model and oxygen transfer rate in activated sludge; Aerobic wastewater treatment; Fermentation economics

Section II

## Unit- 3 Biochemical Engineering

15 hours

- 3.1. Bioreactor : Introduction; Background; Bioreactor for batch type fermentation : The Aerated Stirred Tank, Anerobic Batch, Airlift bioreactors, Bubble column, Surface or Solid State; Bioreactor Configurations for Fed-batch Cultivation and Continuous fermentations; Calculation for bioreactor: Heat transfer; Design equations for CSTR fermenter; Monod model for a chemostat ; Temperature effect on rate constant; Scale-up of stirred-tank bioreactor
- 3.2. Dissolved Oxygen Measurement and Mixing: Introduction; Measurement of dissolved oxygen concentrations; Oxygen transfer rate (OTR); Respiration quotient (RQ); Agitation rate studies ; Gas and Liquid System (Aeration and Agitation): Introduction; Aeration and agitation; Effect of agitation on dissolved oxygen; Air sparger; Oxygen transfer rate in a fermenter; Mass transfer in a gas-liquid system; Gas hold-up; Agitated system

- and mixing phenomena; Characterisation of agitation; Types of agitator; Gas-liquid phase mass transfer (Oxygen transport, Diameter of gas bubble formed  $D_0$ )
- 3.3. Material and Elemental Balance: Introduction; Growth of stoichiometry and elemental balances; Energy balance with example of continuous ethanol fermentation; Conservation of mass principle with example of Acetic acid fermentation process
  - 3.4. Fermentation Process Control: Introduction; Bioreactor controlling probes; Characteristics of bioreactor sensors; Temperature measurement and control; DO measurement and control; pH/Redox measurement and control; Detection and prevention of the foam; Biosensors

#### Unit - 4 Downstream Processing, Scale up and Economics

15 hours

- 4.1. Extraction of Fermentation Products: Solids (Insolubles) Removal: Filtration, Centrifugation, Coagulation and flocculation, Foam fractionation, Whole-broth treatment; Primary Product Isolation: Cell disruption, Liquid extraction (Continuous extraction column process, rotating disk contactors), Dissociation extraction, Adsorption ( Ion-exchange, Langmuir isotherm, Freundlich isotherm and Fixed-bed), Precipitation; Purification: Chromatography, Carbon decolorization, Crystallization; Product Isolation: Crystalline processing, Drying
- 4.2. Membrane Separation Processes: Introduction; Types of membrane; Membrane processes; Nature of synthetic membranes; General membrane equation; Cross-flow microfiltration; Ultrafiltration; Reverse osmosis; Membrane modules.
- 4.3. Advanced Downstream Processing in Biotechnology: Introduction; Protein products; Cell disruption; Protein purification; General problems associated with conventional techniques; Fluidised bed adsorption; Design and operation of liquid fluidised beds; Interfaced and integrated fluidised bed/expanded bed system
- 4.4. Immobilized Enzymes and Immobilized Cells: Advantages of immobilized biocatalysts in general; Methods of immobilizing enzymes; Methods for the immobilization of cells; Practical Application of Immobilized Biological Catalyst Systems; Bioreactors Designs for Usage in Biocatalysis ; Immobilised cell reactor(ICR) experiments and ICR rate model

#### List of Experiments

1. Amylase Production: Screening, Optimization, production and Purification (affinity chromatography)
2. Protease Production: Screening, Optimization, Production and Purification (Salt precipitation, ion exchange chromatography)
3. Immobilization of enzyme
4. Estimation aeration efficiency
5. Reverse micelle formation
6. Screening of Organic acid producer microorganism
7. Screening of Antibiotic producer microorganism
8. Operation of fermentation
9. Sterility testing

#### List of Reference Books

1. Okafor, Modern Industrial Microbiology and biotechnology.
  2. Najafpour, Biochemical Engineering and Biotechnology.
  3. Shigeo, Biochemical engineering.
  4. Whittaker, Principles of fermentation technology.
  5. Alexander, Microbial Biotechnology.
  6. Sikyta, Techniques in Applied Microbiology.
  7. Vogel, Fermentation and Biochemical Engineering Handbook.
  8. Mcneil, Practical Fermentation Technology.
  9. Doran, Bioprocess engineering Principle.
  10. Nathan, Modern Biotechnology.
  11. Mansi, Fermentation microbiology and Biotechnology, Taylor and Francis
  12. Waites, Industrial Microbiology: An Introduction, Blackwell publication
  13. Michal, Bioprocess Engineering Basic Concept, Prentica Hall of India
  14. Crueger, A text book of Industrial microbiology.
  15. Volkmar, Microbial Fundamentals of Biotechnology
- Peppler, Microbial technology: fermentation technology