

## Fermentation and Bioprocess

Sl. No.	Sub Code	Title	Teaching hours/week			Examination				Credits
			L	T	P	Duration	C.I.E.	End Exam	Total	
						(Hrs.)	Marks	Marks	Marks	
<b>Theory Subjects</b>										
1	FBE011	Upstream Process	4	---	---	40	50	50	100	4
2	FBE012	Biopharmaceuticals and Facility Engineering	4	---	---	40	50	50	100	4
3	FBE013	Regulatory Affairs	4	---	---	40	50	50	100	4
4	FBE014	Bioseparations Techniques/Downstream	4	---	---	40	50	50	100	4
<b>Laboratory</b>										
5	FBEL011	Upstream Laboratory		---	8	160	50	50	100	4
6	FBEL012	Downstream processing laboratory		---	8	160	50	50	100	4

L-Lecture T-Tutorials P-Practical CIE-Continuous Internal Evaluation

## **Upstream Process**

Contact Hours /Week	: 4 Hrs.	Credits	: 4
Total Lecture Hours	:40	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBE011		

### **Module I – 7 hrs**

Introduction to bioprocess & fermentation technology: Interaction between chemical engineering, Microbiology and Biochemistry. History of fermentation. Introduction to fermentation processes, Microbial culture, Screening and selection for fermentation processes; Preservation and improvement of industrially important microorganisms, Inoculum production for bacterial and fungal processes. Strain development by mutagenesis, protoplast fusion and transformation of cloned genes.

### **Module II - 7 hrs**

Raw material and media formulation for fermentation process: Fermentation media- Natural media, synthetic media sources of Carbon, Nitrogen and vitamins, formulations, antifoams and optimization. Microbial growth kinetics: Microbial growth cycle, measurement of growth, Batch culture, continuous culture, fed-batch culture, applications and examples, scale up of fermentation processes. Sterilization of media, Solid Substrate Fermentation; Process parameters and measurement techniques: measurement of temperature, pressure and pH, DO, foam etc.; flow rate of liquid and gases; Automation (processes computerization).

### **Module III - 8 hrs**

Fermentors: Design of a Fermentor: Functions, construction, and maintenance of aseptic conditions. Control of various parameters: temperature control; Aeration and agitation system (Non-newdonian fermentations), baffles; types of fermentors, computer applications in fermentation technology. Sterilization of fermentor, aseptic inoculation and sampling methods, Specialized bioreactors: tubular bioreactors, membrane bioreactors, tower bioreactors, fluidized bed bioreactors, Immobilized system and packed bed reactors and Photobioreactor.

### **Module IV - 9 hrs**

**Microbial fermentation:** Industrial fermentation, fermentation growth kinetics, sterilization of Fermentor and validation issues, media for industrial fermentation, inoculum development for industrial fermentation, aseptic operation of industrial Fermentor, validation of Fermentor, fermentation process control for the production of commercially important compounds, aeration and agitation, maintenance and calibration of sensors used in fermentation, scale up of fermentation process, scale down methods for

fermentation, good manufacturing practices, recombinant protein production, regulatory aspects of products produced by recombinant DNA technology, CIP of bioreactors. High cell density fermentation process for recombinant products; Metabolic engineering, Kinetics; Modeling; Rheology, mass and heat transfer, STR, Airlift Bioreactors; Fed batch and continuous cultures; Immobilized system and packed bioreactors; Solid state fermentation.

### **Module V - 9 hrs**

**Animal cell culture:** Cell culture practices, biology of the cultured cell, nutritional requirement of cultured cell, cell growth and propagation, mass culture technology, prevention and eradication of contamination, cell banking, hybridoma technology, genetic engineering, stem cells. Animal Cell cultures-Bioprocess development; PAT( Process Analytical Technologies) for Control of large scale Cell culture , Expression of recombinant proteins in animal cell culture systems, Insect cell-based systems.

Cell synchronization; Cell cloning and micromanipulation; Cell transformation; Application of animal cell culture; Scaling-up of animal cell culture.

cell banking - Stem cell cultures, embryonic stem cells and their applications; Cell culture based vaccines, Somatic cell genetics.

Organ and histotypic cultures; Measurement of cell death; Apoptosis

Retroviral vector method, DNA microinjection method and engineered embryonic stem cell method. Cloning by nuclear transfer. Yeast artificial chromosome transgenesis.

Cryopreservation and transport of animal germplasm (i.e. semen, ovum and embryos).

#### References:

1. Biopharmaceuticals – Biochemistry and Biotechnology, 2<sup>nd</sup> Edition, by Gary Walsh, John Wiley, 1994.
2. Biopharmaceuticals, An industrial Perspective by Gary Walsh and Brendan Murphy, Kluwer Academic Publishers, 1998.
3. Industrial Microbiology: An Introduction, Michael J. Wates, Neil L. Morgan, John S. Rocky, Garg Higton, Blackwell Science, 2001.
4. Modern Industrial Microbiology and Biotechnology by Nduka Okafor, Science Publishers, 2007.
5. Industrial Pharmaceutical Biotechnology by Heinrich Klefenz, Wiley-VCH Verlag GmbH, 2002.

## **Biopharmaceuticals and Facility Engineering:**

Contact Hours /Week	: 4 Hrs.	Credits	: 4
Total Lecture Hours	: 40	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBE012		

### **Module I – 9 hrs**

**Biopharmaceuticals:** Introduction to Biopharmaceuticals and pharmaceutical biotechnology, History of the pharmaceutical industry, the age of biopharmaceuticals, Biopharmaceuticals: current status and future prospects, Traditional pharmaceuticals of biological origin - Pharmaceuticals of animal origin, Pharmaceutical substances of plant origin, and Pharmaceutical substances of microbial origin.

Biosimilars - Introduction, current status and future (Growth hormones, Interferon, MAbs, EPO, Insulin, Interleukins, Colony Stimulating factors etc.); Fermentation process development for Small molecules – primary and secondary Metabolites (Organic acids, solvents, antibiotics, enzymes, polysaccharides, lipids, Pigments and aroma, steroids; subtilisin, chymosin, vitB<sub>12</sub>, hepatitis B vaccine, erythropoietin.

**Sources of biopharmaceuticals:** E. coli as a source of recombinant, therapeutic proteins, Additional production systems: yeasts, fungal production systems, Host-Vector Interactions in *Escherichia coli*, Parameters Influencing the Productivity of Recombinant *E. coli* Cultivations. Production of pharmaceuticals by genetically engineered cells (hormones, interferon). Microbial transformation for production of important pharmaceuticals (steroids and semi-synthetic antibiotics). Techniques for development of new generation antibiotics.

### **Module II - 8 hrs**

Cleanroom - What is a Cleanroom? , The Need for Cleanrooms, Types of Cleanrooms, What is Cleanroom Technology? The History of Cleanrooms.

Basis of Cleanroom Standards, Federal Standard 209, Pharmaceutical Cleanroom Classification - *EU Guide to Good Manufacturing Practice, Guideline on Sterile drug products.*

Information Sources - The International Confederation of contamination Control Societies (ICCCS) International Cleanroom Standards- *ISO standards, Federal Standard 209E, Pharmaceutical standards.* Recommended Practices and Guides of the Institute of Environmental Sciences and Technology (IEST), Sources of Pharmaceutical Cleanroom Documents, International Cleanroom Forum.

### **Module III - 8 hrs**

The Design of Turbulently Ventilated and Ancillary Cleanrooms - Turbulently Ventilated Cleanrooms - *Air supply, High efficiency air filters, Air movement within a turbulently ventilated Cleanroom, Room pressurization and air movement control between rooms, Construction materials and finishes.* Ancillary Clean Rooms – Clothing change area, Material transfer area, Containment Rooms.

Design of Unidirectional Cleanrooms and Clean Air Devices - Unidirectional Cleanrooms – *Vertical flow unidirectional Cleanrooms, Horizontal flow unidirectional flow rooms,* Clean Air Devices-*Unidirectional air devices, Isolators and minienvironments*

High Efficiency Air Filtration - Air Filters Used in Cleanrooms, the Construction of High Efficiency Filters, Particle Removal Mechanisms, Testing of High Efficiency Filters  
Cleanroom Testing and monitoring – principles of class room testing, clean room tests.

### **Module IV - 7 hrs**

Measurement of Air Quantities and Pressure Differences - Air Quantities - *Measuring air quantities from within a Cleanroom,* Differential Pressure Tests - *Apparatus for measuring pressure difference, Methods of checking pressure differences.*

Air Movement Control Between and Within Cleanrooms - Cleanroom Containment Leak Testing – *Methods of checking infiltration,* Air Movement Control within a Cleanroom.

Filter Installation Leak Testing - The Use of Aerosol Test Challenges, Artificial Smoke and Particle Test Challenges – *Cold generated oils, hot generated smokes, polystyrene latex spheres,* Apparatus for Measuring Smokes - *Photometer, Single particle counters,* Methods of Testing -*Filters and Filter Housings.*

### **Module V- 8 hrs**

Airborne Particle Counts - Airborne Particle Counters, Continuous Monitoring Apparatus for Airborne Particles, Particle Counting in Different Occupancy States, Measurement of Particle Concentrations (ISO 14644- 1) - *Sample locations and number, Airborne sampling volume, Acceptance criteria,*

Microbial Counts - Microbial Sampling of the Air - *Impaction onto agar,* Microbial Deposition onto Surfaces - *Settle plate sampling, Calculation of the likely airborne contamination,* Microbial Surface Sampling – *Contact surface sampling, Swabbing,* Personnel sampling

Operating a Cleanroom: Contamination Control - Identification of Sources and Routes of Contamination - *Sources of contamination, Airborne and contact routes of transfer, Construction of a risk diagram,* Assessment of the Importance of Hazards, Identification of Methods to Control Hazards, Sampling Methods to Monitor Hazards and Control Methods, Establishing a Monitoring Schedule with Alert and Action Levels, Verification and Reappraisal of the System, Documentation, Staff Training

Cleanroom Disciplines - People Allowed into Cleanrooms, Personal Items Not Allowed into the Cleanroom, Discipline within the classroom. Entry and Exit of Personnel - Prior to Arriving at the Cleanroom, Changing into Cleanroom Garments - Approaching the

pre-change zone, Pre-change zone, Changing zone, Cleanroom entrance zone, Exit Changing Procedures

Cleanroom Clothing – Sources and Routes of Inert Particle Dispersion, Routes and Sources of Microbial Dispersion, Types of Cleanroom clothing, Cleanroom Masks and Gloves, Cleaning a Cleanroom

References:

1. Clean Room Technology – Fundamentals of Design, Testing and Operation by W Whyte, John Wiley & Sons, 2001.
2. Bioprocess Engineering: Systems, Equipments and Facilities by Linderson, D'Elia, Nelson, John Wiley 1994.
3. Bioprocess Engineering: Basic Concepts, 2<sup>nd</sup> Edition by Michael L. Shuler and Fikret Cargy, Prentice Hall, 2002.
4. Bioprocess Engineering Principles by Pauline M Doran. Academic Press, 1995.
5. Fermentation and Biochemical Engineering Handbook – Principles, Process Design and Equipments, Henry C. Vogel and Celeste L. Todaro, Noyes Publication, 1997.

## **Regulatory Affairs**

Contact Hours /Week	: 4 Hrs.	Credits	: 4
Total Lecture Hours	:40	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBE013		

### **Module I - 7 hrs**

**Quality life cycle-** Introduction; Research and development (Pre-clinical studies, Clinical studies); Good laboratory practice (GLP) -GLP in Europe, GLP in the UK, GLP in the USA; Good clinical practice (GCP) - GCP in the USA, GCP in Europe, ICH guidelines on GCP, Manufacture of clinical trials material; Drug registration in the European Union Drug registration in the USA; Unlicensed medicines; Good manufacturing practice (GMP); Good distribution practice (GDP).

### **Module II –8 hrs**

**Quality assurance and control** - Introduction; Relationship between quality management, QA, GMP and QC; Definition of quality management; Definition of quality assurance; Definition of quality control; Responsibilities of QA –QA requirements in EU, PIC/S, WHO and FDA; Responsibilities of QC.

Quality systems: ISO 9000 series; ISO 14000 series; Use of the quality systems approach within the pharmaceutical industry (Quality systems inspection technique (QSIT), Drug manufacturing inspections.

Good manufacturing practice - Definition of GMP; Different versions of GMP (UK, European Union, USA, Australia , WHO ,Arab World ); Comparison of different GMP guidelines; Responsibilities under GMP; Rules versus guidelines; Application of GMP (Quality management, Personnel, Premises and equipment, Documentation , Production, Contract manufacture and analysis, Complaints and recalls, Self-inspection).

Good distribution practice - Principles of GDP; Quality system; Personnel; Documentation; Premises and equipment;

Deliveries to customers; Returns; Self-inspections; Provision of information to Member States; The role of the responsible person (Statutory basis, Eligibility and duties of the responsible person, The responsible person and the management representative).

### **Module III - 9 hrs**

Calibration - Objectives of calibration; Calibration programme; Different types of standards; Different types of calibration equipment ; Maintenance of calibration equipment ; Categorization of instrumentation (Critical instruments , Major instruments, Reference instruments) ; Purchase of new instruments ; Review of calibration programme; Training of calibration technicians.

Inspections and Auditing - Types of inspections( Internal inspections, External inspections, Suppliers Approaches to inspections) ; Mutual recognition of inspections (PIC/S , PIC/S, EMEA ,ICH), WHO certification scheme; Guidance on participating in inspections; GMP certification in the developing world.

### **Module IV - 8 hrs**

Pharmaceutical microbiology - Overview of micro-organisms ; The microbiology of raw materials; Non-sterile products; Sterile products ( Small volume potentials, Large volume potentials, Ointments and creams, Eye drops, Medical devices); Sterile Manufacturing(Area classification, Terminally sterilized products, Aseptic manufacturing, Mixed manufacturing); Risks of contamination and their control (Personnel, Premises, Equipment, Operation of the facility, Cleaning and sanitation); Validation and environmental monitoring (Monitoring of the air, Monitoring of surfaces, Monitoring of personnel, Media trials); Sterilization ( Sterilization by heat, Irradiation, Ethylene oxide sterilization, Filtration, Validation and monitoring of sterilization cycles).

### **Module V- 8hrs**

Quality improvement Programmes - Elements of TQM, TQM and the pharmaceutical industry, Definition; Prerequisites for successful quality improvement Programmes (Management support, Management commitment, Team working, Asking the right question, Breaking out of the silos, Acceptance of change, User driven)

Quality tools and techniques - Tools for identification of problems; Tools for the analysis of problems; Benchmarking; Using the tools and techniques (Type of quality teams, Team working – the problem-solving approach, Team working – the process skills).

### **References:**

1. Biopharmaceuticals – Biochemistry and Biotechnology, 2<sup>nd</sup> Edition, by Gary Walsh, John Wiley, 2003.
2. Pharmaceutical Engineering Series: Quality and Regulatory Compliance by Kate McCormic, Butterworth and Heinemann, 2002.
3. Biopharmaceuticals, An industrial Perspective by Gary Walsh and Brendan Murphy, Kluwer Academic Publishers, 1998.



## **Bioseparations Techniques/Downstream**

Contact Hours /Week	: 4 Hrs.	Credits	: 4
Total Lecture Hours	:40	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBE014		

### **Module I: - 8 hrs**

Basic concepts of Bio-separation Technology, Separation characteristics of proteins and enzymes – size, stability, properties; purification methodologies Characteristics of bio products; Flocculation and conditioning of broth, overview of reaction processes involved in separation, numerical examples illustrating the process. Mechanical separation processes; Filtration at constant pressure and at constant rate; empirical equations for batch and continuous filtration, centrifugal and cross-flow filtration, Methods for extraction of proteins - Cell distribution methods for intracellular products Osmotic shock, Homogenization, The Polytron/Ultra-Turrax-type homogenizer, under high pressure, Sonication, Micro-cavitations, Enzyme digestion. Centrifugation: basic principles, design characteristics; ultracentrifuges; principles and applications.

### **Module II: - 8 hrs**

Membrane based separation processes, Micro-filtration; Reverse osmosis, Nanofiltration, Ultrafiltration and Affinity ultrafiltration, concentration polarization, rejection, flux expression, membrane modules, dead-ended and cross-flow mode, material balances and numerical problems.

### **Module III: - 8 hrs**

Product Resolution/Fractionation - Chromatography: Gel filtration chromatography-effect of particle size, mobile phase flow rate, hydrostatic pressure, sample preparation, loading sample, molecular weight determination, spin columns. Equipment required for low pressure liquid.

Chromatography: Ion-exchange chromatography (IEC), Ion-exchange resins, Chromatofocusing, Molecular exclusion chromatography (MEC), Determination of MW by MEC. Hydroxyapatite chromatography,. Affinity chromatography: Immunoaffinity purification, Immunoaffinity matrices, ligand affinity. Adsorptive chromatographic separations processes, hydrophobic interaction chromatography (HIC), RP - HPLC

#### **Module IV : - 8hrs**

Analysis of the final product - Protein-based contaminants, Removal of altered forms of the protein of interest from the product stream, Product potency, Determination of protein concentration, Detection of protein-based product impurities, High-pressure liquid chromatography (HPLC), Mass spectrometry, Immunological approaches to detection of contaminants, Amino acid analysis, Peptide mapping, N-terminal sequencing, Analysis of secondary and tertiary structure, Endotoxin and other pyrogenic contaminants, Endotoxin - the molecule, Pyrogen detection, DNA, Microbial and viral contaminants, Viral assays, Miscellaneous contaminants, Validation studies

#### **Module V: - 8 hrs**

Final product formulation, Some influences that can alter the biological activity of proteins, Proteolytic degradation, Protein deamidation, Oxidation and disulphide exchange, Alteration of glycoprotein glycosylation patterns Stabilizing excipients used in final product formulations, Final product fill, Freeze-drying, Labeling and packing.

#### **References:**

1. Bioseparations , Belter PA and Cussler E, Wiley, 1985.
2. Product Recovery in Bioprocess Technology , BIOTOL Series, VCH, 1990.
3. Separation processes in Biotechnology , Asenjo J.M,Marcel Dekker Inc,1993.
4. A guide to protein isolation-Clive Dennison, Klumer, Academic publisher.
5. Biophysical chemistry part II: Techniques for the study of biological & function by Cantor & Schimmel
6. Fermentation and Biochemical Engineering Handbook – Principles, Process Design and Equipments, 2<sup>nd</sup> Edition by Henry C Vogel and Celeste L Todaro, Noyes Publication, 1997.

## **Upstream process and Biopharmaceutical Engineering Laboratory**

Contact Hours /Week	: 16Hrs.	Credits	: 3
Total Lecture Hours	: 160	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBEL011		

### **1. Preparation of Media and Sterilization – 20 hrs**

Preparation of Media and Sterilization, Fermentor's parts familiarization, Empty and Full Vessel sterilization, Valve Matrix, Operation of Lab and Pilot fermentors, Development of inoculum at Lab and Fermentor, Inoculation of fermentors (Seed & Production), Software familiarization – HMI & SCADA, Fermentation monitoring, process design and optimization of process, Batch and fed batch fermentation,  $k_L a$  determination, Effect of aeration and agitation for critical DO level maintenance, Broth harvest, Cleaning and validation of Fermentor – IQ, OQ, P&ID check, pH & Temperature control loop, CIP

### **2. Shake Flask Fermentation: 10 hrs**

Media Preparation and autoclaving, Shake flask optimization (medium/pH/volume/inoculum percentage)

### **3. Fermentation studies at 5L lab Fermentor: 10 hrs**

Inoculum preparation, Preparation of fermentation medium, Calibration of pH/DO probes, Set up of Lab fermentor and autoclaving, inoculation of lab fermenter, Dynamic ways of  $K_L a$  estimation, Monitoring and maintenance of process condition (Agitation, aeration, temperature, pH, DO), Sampling and analysis, Harvest and cleaning of lab fermenter.

### **4. Fermentation studies at 20L Pilot Fermentor: 20 hrs**

Setting up of a pilot fermentor, Empty Sterilization in Place (ESIP), Media preparation and charging, calibration of pH and DO probes, Mechanical seal sterilisation, Full Vessel Sterilisation (FSIP), Filter sterilisation, Foam control, Setting up aeration and agitation, Aseptic inoculation, Dynamic ways of  $K_L a$  estimation, Monitoring and maintenance of process condition (Agitation, aeration, temperature, pH, DO), Sterile Sampling and analysis, Monitoring growth and calculation of growth rates, Feed pump calibration Fed batch nutrient dosing, Broth Harvest, Cleaning in Place (CIP)

## **5. Animal Cell Culture - 20 hrs**

### **Good cell culture practices**

Aseptic techniques in Biosafety cabinet, Validation of Biosafety cabinet by plate method, Staining of cells and examination of cell biology – Mon & Polychromatic, Contamination studies.

## **6. Cell growth and propagation - 20 hrs**

In vitro cell growth behavior, Culture of adherent cells, Microcarriers technology, Feeding, subculture and propagation of cells from primary cultures to established cell lines, Cell line characterization, Cell enumeration, Set up of monolayers culture, Subculturing and maintenance of adherent cultures, Seeding suspension culture, Scale up of adherent cultures using microcarriers, Growth curve establishment and analysis, Cytotoxicity assay, Metaphase spread of chromosomes.

## **7. Cell Banking - 20 hrs**

Cryo preservation of cultures, thawing of cells and viability assessment.

## **8. Nutritional requirements of cultured cells -20 hrs**

Media preparation and filtration, Effect of serum supplementation on cell proliferation.

## **9. Animal Cell Culture in Bioreactor – 20 hrs**

Scale up of suspension cultures in a 5L bioreactor, Set up of fermentor and autoclaving, Calibration of pH, DO probes, Inoculation of fermentor, Monitoring & maintenance of process condition (Agitation, Temperature, pH, DO), Sampling and analysis, Harvest and cleaning of fermentor.

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## **Downstream Laboratory**

Contact Hours /Week	: 16 Hrs.	Credits	: 4
Total Lecture Hours	: 160	CIE Marks	: 50
	:0	SEE Marks	: 50
Total Tutorial Hours	:0		
Sub. Code	:FBEL011		

### **Downstream processing**

Centrifugation, Filtration: TFF – principles and function, Membrane selection criteria, Diafiltration, Cleaning and sterilization

Chromatography: Affinity Chromatography, Hydrophobic Interaction, Ion Exchange, Gel Filtration.

Cleaning-in-Place (CIP), Sterilization-in-Place (SIP), Sterilization by Filtration.

Validation - Autoclave, Hot Air Oven; WFI (conductivity, endotoxin testing); swap test of vessels.

### **Electrophoretic techniques, Protein quantification techniques**

#### **1. Centrifugation – 20hrs**

Functions and process optimization for centrifugation processes at variable speed and flow rate, Continuous centrifugation for cell concentration or cell debris removal, Cleaning and sterilization of continuous centrifuge, Microbial concentration / separation analytical method by spectrometry and assay validation

#### **2. Cleaning-In-Place – 20 hrs**

Familiarization with process vessel, CIP processes, Generation of P& ID and valve matrix for CIP processes, OQ of process vessel: spray ball coverage test with riboflavin

#### **3. Sterilization-In-Place – 25 hrs**

SIP processes, Generation of P&I D and valve matrix for SIP processes, SIP PV: Heat penetration study for ESIP and FSIP using temperature probes / biological / chemical Indicator.

#### **4. Sterilization by Filtration – 20 hrs**

Familiarization with filtration system, Generation of P&I D and valve matrix for all processes, SIP of filtration system and media transfer line, Integrity test of filters (Bubble point, Diffusion and Water Intrusions tests), Media filtration (maintenance of Flow rate, Differential for increasing filter service life), CIP of filtration system and media transfer line

#### **5. Sterilization-Out-of-Place – 25 hrs**

Familiarization and operation of industrial double door heat sterilizers, Generation of P&ID and valve matrix for all cycles (Standard, HPHV and liquid), IQ: verification of designed system vs actual system, OQ: Bowie dick test / Vacuum leak test / thermal mapping of a sterilizer, PQ: Heat penetration studies for standard, porous and liquid loads with temperature probes/ biological/ chemical indicator, Evaluation of endotoxin inactivation after dry heat sterilization with CSE and LAL test

**Electrophoretic techniques, Protein quantification techniques** SDS-PAGE (Polyacrylamide Gel), horizontal and vertical type, methods.

#### **6. Food Processing and Fermentation Technology -50 hrs**

- To draw layouts of different food industries. (Demo)
- To plan normal and therapeutic diets. (Demo).
- To study the design of fermenter and its working. . (Demo)
- Fermentative production of Organic solvents: - Ethanol/Acetone/ Butanol,
- Alcoholic beverages: Beer/ Wine/ Rum/ Gin/ Whisky/ Brandy.
- Fermentative production of Amino Acid & Vitamins: L-glutamic acid/Phenylalanine/ L-lysine. Vitamin B12.
- Standardization of milk.
- Preparation of dahi/ lassi/ shrikhand/ paneer/chhana/ flavoured milk.
- Preparation of Fermented foods- Idly/ Dosa. Yoghurt, Acidophilus Milk/ Butter Milk/Bulgarian milk.
- Food processing principles: chilling/ freezing/ dehydration, control of water activity, drying of vegetables, Canning of vegetables/fruits.