M.Sc. Semester – III

MB-301: Fermentation Technology & Bioprocess Engineering

Objective: This course is designed to impart the knowledge of basic principle of fermentation process. Which help students to design, develop and operate industrial level fermentation process along with the engineering aspects of bioprocess with rheological behavior of fluids and mass transfer.

UNIT 1	**Microbial growth kinetics & Fermentor control systems**		
	Reference: Stanbury	**Teaching Duration**	**Lectures: 08**
1.1	Batch culture		
1.2	Continuous culture		
1.3	Multistage & Feedback systems		
1.4	Fed-batch culture.		
1.5	Methods of measuring process variables		
1.6	On-line analysis of other chemical factors.		
1.7	Control systems		

UNIT 2	**Strain improvement & Recovery of fermentation product**		
	Reference: Stanbury	**Teaching Duration**	**Lectures: 08**
2.1	Strain improvement (**Nduka Okafor)**		
2.2	Removal of microbial cells and other solid matter.		
2.3	Cell disruption		
2.4	Liquid-liquid extraxtion		
2.5	Solvent recovery		
2.6	Two phase solvent extraction		
2.7	Chromatography		
2.8	Membrane processes		
2.9	Drying		
2.10	Crystalization		
2.11	Whole broth processing		

UNIT 3	**Fluid flows and mixing**		
	Reference: Doran	**Teaching Duration**	**Lectures: 08**
3.1	Classification of fluids.		
3.2	Fluids in motion		
3.3	Viscosity.		
3.4	Momentum transfer		
3.5	non-newtonian fluids		

3.6	viscosity measurement
3.7	Rheological properties of fermentation broth.
3.8	Factors affecting broth viscosity.
3.9	Mixing.
3.10	Power requirement for mixing.
3.11	Scale-up of mixing system.

UNIT 4	**Mass transfer**		
	Reference: Doran	**Teaching Duration**	**Lectures: 07**
4.1	Molecular diffusion.		
4.2	Role of diffusion in bioprocessing.		
4.3	Convection mass transfer.		
4.4	Oxygen uptake in cell culture.		
4.5	Mass transfer correlation.		
4.6	Measurement of Kla.		

Reference:

1. Stanbury P.F., Whitaker A., Hall S.J.,(1997) *Principles of fermentation technology.* 2nd ED, Aditya books(P) Ltd, New Delhi.
2. Okafor N. (2007) *Modern industrial microbiology and biotechnology,* Science publishers, USA.
3. Doran P.M. (2008) Bioprocess engineering principles, Academic press, California.

Further Reading:

1. Shuler M. L. and Kargi F. (2003) *Bioprocess engineering Basic concepts,* 2nd ED, Pearson education Pvt Ltd, India.
2. Bailey J. S. and Bhatia S.C. (2009) Biochemical engineering. CBS publishers & distributors, India.
3. Moo-Young M. (2004) Comprehensive biotechnology, Vol- 1 to 4, Pergamon press Ltd, England.

302: Industrial Microbiology

Objective: Industrial microbiology is a branch of applied microbiology in which microorganisms are used in industrial processes; for example, in the production of high-value products such as drugs, chemicals, fuels and food product. This paper explains production and processes of various microbial metabolites at industrial scale by use of microbes.

UNIT 1	**Industrial production of Biomolecules**		
	Reference: Flickinger	**Teaching Duration**	**Lectures: 08**
1.1	Antibiotics: Cephalosporin and Streptomycin		
1.2	Organic acids: Citric acid and Lactic acid Ref: Ratledge		
1.3	Amino acids: Glutamic acid and L-Lysine		
1.4	Enzymes: Amylase and Protease		
1.5	Hormones: Erythropoietin and Human Insulin		
1.6	Immuno therapeutic: Monoclonal Antibody production and Recovery		
1.7	Anticancer agent: Anthracyclines		

UNIT 2	**Modern trends in microbial production -1**		
	Reference: Flickinger	**Teaching Duration**	**Lectures: 08**
2.1	PHA: Sseparation, purification, and manufacturing Methods		
2.2	Food grade pigments Ref: Dufossé L		
2.3	Biosurfactant Ref: Lederberg J.		
2.4	1, 2 pentane diols (Optically active 1,2 diols)		
2.5	Nitrile Hydratase (Acrylamide)		

UNIT 3	**Modern trends in microbial production-2**		
	Reference: Nduka Okafor	**Teaching Duration**	**Lectures: 08**
3.1	Biocatalyst: Immobilized enzymes and immobilized cells		
3.2	Production of microbial insecticides		
3.3	Manufacture of *Rhizobium* inoculants		
3.4	Techniques and technology to produce biomass of cyanobacteria and Microalgae Ref; Rhem and Reed		
3.5	Cyanobacteria and Microalgae exploitation Ref; Rhem and Reed, Vol 10		

UNIT 4	Microbial production of Food and Beverages		
	Reference: Prescott & Dunn	**Teaching Duration**	**Lectures: 07**
4.1	Fermented Milk Products		
4.1.1	Cheese		
4.1.2	Yogurt		
4.1.3	Kefir		
4.2	Fermented Soy Products Ref: Flickinger		
4.2.1	Soy sauce		
4.2.2	Soy paste		
4.2.3	Tempeh		
4.2.4	Natto		
4.2.5	Tofu		
4.3	Wine and Brandy Ref; Rhem and Reed, Vol 9		

References:

1. Moo-Young, M. *et al* (1985) *Comprehensive Biotechnology: The Practice of Biotechnology: Current Commodity Products.* Pergamon.

2. Flickinger, M. & Drew, S.(1999) *Encyclopedia of Bioprocess Technology,(Volumes 1 - 5)* Wiley-Interscience.

3. Ratledge, C. & Kristiansen, B.(2006) *Basic Biotechnology 3Ed.* New Delhi: Cambridge University Press.

4. Lederberg, J. (2000) *Encyclopedia of Microbiology, 2Ed (Volumes 1 to 4).Academic Press.*

5. Reed, G.(1981) *Prescott and Dunn's Industrial Microbiology.* Chapman & Hall.

6. Dufossé, L.(2006): *Food Grade Pigments.* Food Technol. Biotechnol. 44 (3) 313–321.

7. Nduka Okafor, (2007): *Modern Industrial Microbiology and Biotechnology.* Science pulishers, Enfield, NH, USA

8. H.J. Rehm and G.Reed (2010) *Biotechnology*. (Vol 9) Wiley India Pvt. Ltd.

9. H.J. Rehm and G.Reed (2010) *Biotechnology*. (Vol 10) Wiley India Pvt. Ltd.

MB-303: Molecular Pathogenesis and Immunology

Objective: This paper focuses on principles of immunology, molecular pathogenesis, immunotechnology and uses in immunotherapy. It also throws light on understanding and studying molecular pathogenesis of the disease causing organisms which lends helping hands to therapy, control of transmission, vaccine development and to the science of immunology. This paper is planned to acknowledge the students regarding advances in immunology, immunotechnology and immunotherapy.

UNIT 1	**Receptor Biology**		
	Reference: Abbas	**Teaching Duration**	**Lectures: 08**
1.1	The Major Histocompatibility Complex		
1.1.1	Structure of MHC molecules		
1.1.2	Genomic organization of MHC		
1.1.3	Antigen processing & presentation MHC I & II molecules.		
1.2	T-cell receptor		
1.2.1	T cell receptor complex: TCR-CD and accessory membrane molecules		
1.2.2	T cell activation		
1.3	B-cell receptor		
1.3.1	The B cell receptor and co-receptor complex		
1.3.2	Signal transduction by BCR		
1.3.3	Second signals for B cells provided by complement receptors		
1.3.4	Presentation of protein antigens by B lymphocytes to helper T cells		
1.3.5	Helper Tcell mediated activation of B lymphocytes		

UNIT 2	**Immunotherapy**		
	Reference: Paul	**Teaching Duration**	**Lectures: 08**
2.1	A major goal for immunotherapy - Immunotolerance.		
2.2	Cellular therapeutics		
2.3	Antibody therapeutics		
2.4	Engineered antibodies for therapy		
2.5	Engineering antibodies for cancer therapy		
2.6	Immunomodulators and their application in cancer (Paul 5th ed.)		
2.7	Cytokines and their application in cancer (Paul 5th ed.)		
2.8	Immunoconjugates and their application.		

Unit-3	Molecular Pathogenesis		
	Reference: MIMS	**Teaching Duration**	**Lectures: 08**
3.1	Attachment and Entry of microorganisms in to the body		
3.1.1	Enteropathogenic *E. coli*		
3.1.2	Phagocytosis in polymorhonuclear leucocytes		
3.1.3	Phagocytosis in macrophages		
3.1.4	Consequences of defects in the phagocytic cell		
3.2	The spread of microbes through the body		
3.2.1	Microbial factors promoting spread		
3.2.2	Spread via lymphatics		
3.2.3	Spread via the blood		
3.3	Antigenic variation		
3.4	Mechanisms of tissue and cell damage		
3.4.1	Microbial toxins		
3.5	Host and Microbial factors Influencing Susceptibility		
3.5.1	Genetic Factors in the Microorganisms		
3.5.2	Genetic Factors in the Host		
3.5.3	Pathogenesis of animal virus (Hepatitis)		

UNIT 4	Molecular Plant Pathology		
	Reference: Mehrotra and Agarios	**Teaching Duration**	**Lectures: 07**
4.1	Host pathogen interaction Ref. Mehrotra and Agarios		
4.2	Genetics of virulence in pathogens and of resistance in host plant.		
4.3	Horizontal and vertical resistance, Disease Escape		
4.4	Examples of molecular genetics of selected plant diseases : Powdery mildew		
4.5	and Rice blast		
4.6	Compatible and incompatible reactions		
4.7	Recognition of host and gene for gene concept Ref. Flor and Agarios		
4.8	Resistance genes of plants, Signal transduction between pathogenicity and resistance genes, Signaling and regulation of programmed cell death		
4.9	Pathogenesis of plant virus (TMV)		

References:

1. Murray, P. (2003). *Manual of Clinical Microbiology Vol-1*, 8th Ed. ASM Press.
2. Mims, C. A. *et al* (2000).*MIMS' Molecular pathogenesis of Infectious Disease,5th Ed.* Academic Press.
3. Pa005) *Plant Pathology: Pathogen and Plant disease*, S. Chand & Company Ltd. New Delhi. ehrotra, R. S. and Aggarwal, A. (2007) *Plant Pathology*, 2nd Ed., Tata McGraw-Hill Publishing Company Limited New Delhi.
5. Agarios, G. N. (2005). *Plant Pathology*, 5th ed. Elsevier.

6. Flor, H. H. (1971). Current status of the gene-for-gene concept. *Ann. Rev. Phytopath.*, 9:275-296.
7. Mitra, S. (2007). *Genetic Engineering-Principles and Practise*. Macmillan India Ltd, New Delhi.
8. Kindt, T; Osborne, B.& Goldsby, R.(2006) *Kuby Immunology 6Ed.* W. H. Freeman.
9. Janeway, C. *et al*. (2004) *Immunobiology 6 Ed.* Garland Science.
10. Lichtman, A. & Abbas, A.(2003) *Cellular and Molecular Immunology 5Ed.*Saunders.
11. Paul, W. (1999) *Fundamental Immunology 4Ed.* Lippincott Williams & Wilkins.

MB-304: ADVANCES IN PHARMACEUTICAL MICROBIOLOGY

Objective: This paper gives insight of microbiological analysis and quality control in pharmaceutical industries. It includes the learning of good manufacturing practices and its monitoring in pharmaceutical companies.

UNIT 1	**MICROBIOLOGICAL ASSAY FOR PHARMACEUTICAL ANALYSIS**		
	Reference: Ref: W. Hewitt	**Teaching Duration**	**Lectures: 08**
1.1	Microbiological assay		
1.2	The agar diffusion assay: Its quantitative basis		
1.3	The theory and practice of Tube assays for growth promoting substances		
1.4	The theory and practice of Tube assays for growth inhibiting substances		
1.5	Standard reference materials		

UNIT 2	**MONITORING MICROBIOLOGICAL QUALITY**		
	Reference: Denyer, S.P	**Teaching Duration**	**Lectures: 08**
2.1	Good manufacturing practice and good industrial large scale practice **Ref: Flickinger**		
2.2	Monitoring microbiological quality – Conventional testing methods		
2.3	Monitoring microbiological quality – Application of rapid methods		

UNIT 3	**MICROBIAL ASPECTS OF PHARMACEUTICAL PROCESSING**		
	Reference: Hugo and Russell's	**Teaching Duration**	**Lectures: 08**
3.1	Microbial spoilage and preservation of pharmaceutical products		
3.2	Sterilization control and sterility assurance		
3.3	The quality assurance and quality control of pharmaceutical products		

UNIT 4	**PHARMACEUTICAL MICROBIOLOGY**		
	Reference: Denyer, Walsh, Gad	**Teaching Duration**	**Lectures: 07**
4.1	Pharmaceuticals, biologists and biopharmaceuticals r**ef: G. Walsh**		
4.2	Bioinformatics and Pharmacogenomics for developing information – Based medicine and pharmacotyping in health care management **Ref: Gad**		
4.3	Microbiological auditing **Ref: Denyer, S.P**.		

Reference:

1. Denyer, S. P. and Baird, R. M. (2008). *Guide to microbiological control in pharmaceuticals*

and medical devices. 2nd Edition, CRC Press, Boca Raton.
2. Flickinger, M. C. and Drew, S. W. (1999). *Encyclopedia of Bioprocess Technology.* Wiley-Interscience, New Jersey.
3. Barredo, J. L. (2005). *Microbial Processes and Products.* Humana Press, New Jersey.
4. Gad, S. C. (2007). *Handbook of Pharmaceutical Biotechnology.* Wiley-Interscience, New Jersey.
5. Hugo and Russell's(2007). *Pharmaceutical Microbiology*, Blackwell Publishing.
6. Walsh, G. (2007). *Pharmaceurcal Biotechnolog- Concepts and Applications*, Wiley.
7. Hewitt,W.(2004). *Microbiological Assays for Pharmaceutical Analysis-A rational approach*, Indian Edition, CRC.

LIST OF PRACTICALS
SEMESTER 3

1. Screening of citric acid and lactic acid producing microorganisms.
2. Screening of cellulase, amylase and protease producing microorganisms.
3. Production of fungal amylase by solid state or submerged fermentation.
4. Partial purification of amylase by ammonium sulphate precipitation and dialysis/column chromatography and calculation of specific activity & fold purification.
5. Determination of *KLa* of laboratory fermenter.
6. Sterility testing of pharmaceutical products by direct inoculation & membrane filtration methods as per Indian Pharmacopoeia (IP).
7. Cell disruption by sonication and estimation of intra cellular protein.
8. Comparison of ethanol production using pure carbohydrate and agro industrial waste.
   a) Determination of pH, TSS (0Brix).
   b) Determination of alcohol (ethanol) percentage.
   c) Determination of phenol content.
   d) Estimation of reducing & total sugar.
9. Microbial production of dextran by *Leuconostoc mesenteroides.* (Estimation of reducing & total sugar, Dextransucrase activity, extraction of dextran, pH, Characterization by TLC and viscosity)
10. ELISA detection of anti-HIV sera.
11. ELISA detection of HBsAg.

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