BOARD OF STUDIES (BOS) MEETING
Held on 03-12-2021

The Board of studies in Microbiology meeting was held on 03-12-2021(by circulation) and unanimously resolved to revise the I Semester M.Sc. Microbiology and M.Sc. Industrial Microbiology syllabus for the academic year 2021-2022 onwards. As per the NEP 2020 guidelines.

MEMBERS PRESENT:

1) Prof. Ch. Paramageetham Dept. of Microbiology S.V. University TIRUPATI – 517 502.	Chairperson Board of studies	... Ch. Paramageetham
2) Prof. OVS. Reddy Dept. of Biochemistry S.V. University TIRUPATI – 517 502.	Member	... OVS Reddy
3) Prof. T. Vijaya Dept. of Botany S.V. University TIRUPATI – 517 502.	Member	...
4) Dr. J. Pramoda Kumari Dept. of Microbiology S.V. University TIRUPATI – 517 502.	Member	... Retired
5) Prof. J. Savitha Dept. of Microbiology Bangalore University BAMGALORE.	Member	... Out of country
6) Prof. T. Rathnakumar Dept. of Botany Andhra University VISAKHAPATNAM.	Member	... Retired

Ch. Paramageetham.

Programme Code	Programme name	Year of Introduction	Status of implementation of CBCS/Elective Course System (ECS)	Year of implementation of CBCS/ECS	Year of revision (if any)	If revision has been carried out in the syllabus during the last 5 years, Percentage of Content added or replaced	Link to the relevant documents
	M.Sc. Microbiology	2006	CBCS: Yes	CBCS: 2006	2020-21	80%	Enclosed

A TWO YEAR

MASTER OF SCIENCE IN MICROBIOLOGY

(Choice Based Credit System-semester system)

REVISED SCHEME OF INSTRUCTION & SYLLABUS

As per the action plan of

National Education Policy (NEP)-2020

(Effective from the batch of students admitted from the academic year 2021-2022)

DEPARTMENT OF MICROBIOLOGY

SRI VENKATESWARA UNIVERSITY:TIRUPATI

DEPARTMENT OF MICROBIOLOGY

Vision

Up gradation of the Knowledge in theory and research activities in order to keep pace with the global scientific progress and to meet the requirements of the society and for the development of the Country.

Mission

The mission of the department of microbiology is to educate and train students in the discipline of microbiology and to expand their scientific knowledge through research.

CHOICE BASED CREDIT SYSTEM (CBCS):

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enables the potential employers in assessing the performance of the candidates.

DEPARTMENT OBJECTIVES

1. To offer courses within National education policy (NEP-2020) to enhance the intellectual foundation and preparation of students for life in a complex, dynamic technological world
2. To prepare students careers in clinical and Pharma industries and for careers in basic, environmental and biomedical research
3. To prepare students (M.Sc. and Ph.D.) with in-depth knowledge and research skills for professional careers in Microbiology
4. To enhance opportunities for research and scholarship for faculty members as well as undergraduate and graduate students
5. To preserve, add to, evaluate, and transmit knowledge in the field of Microbiology
6. To serve the society by promoting science
7. To promote the sustainable goals of the country

PROGRAM EDUCATIONAL OBJECTIVES

The Program Educational Objectives (PEOs) for the M.Sc. Microbiology program describe accomplishments that post graduates are expected to attain within two years after post graduation:

PEO-1: To exhibit ability to pursue careers in the industry, agriculture, and applied research where microbial systems are increasingly employed.

PEO-2: To address the increasing need for skilled scientific manpower, contributing to application, advancement and impartment of knowledge in interdisciplinary areas related to Microbiology and life sciences.

PEO-3: To exhibit excellent professional skills, communication skills and ethical attributes as an effective team member. in a competitive global environment

PEO-4: To demonstrate right mixes of innovative ability, equipped with entrepreneurship abilities contributing to self and national development.

PEO-5: The graduates will be cognizant and responsive to the societal needs and will possess the initiative and critical acumen required to continuously improve their knowledge through life long learning.

PROGRAM OUTCOMES

This program will help post graduates to:

PO1: Have Knowledge and technical skills associated with microbiology laboratory for delivering quality clinical investigations.

PO2: Perform safe use of basic laboratory glassware and equipment including the cell counter, microscope, centrifuge, incubator, Hot air oven, autoclave, colorimeter, and Laminar air flow.

PO3: Perform advanced molecular microbial methods including Polymerase Chain reaction, Site directed mutagenesis, SDS-PAGE, Agarose gel electrophoresis, Western blotting, Southern blotting, Transformation ,Transduction, Conjugation and AMES test etc,

PO4: Conduct routine clinical laboratory procedures within acceptable quality control parameters in bacteriology, virology, mycology, parasitology and immunology.

PO5: Learn Problem solving techniques in identification and correction of pre analytical, post analytical & analytical variables.

PO6: Demonstrate technical skills, social behavior and professional awareness for functioning effectively as a microbiology technician.

PO7: Maintain & operate laboratory equipment utilizing appropriate quality control and safety procedures.

PO8: Identify the impact of laboratory tests in a global and environmental context.

PO9: Perform as a leader/team member in diverse professional and industrial research areas.

PO10: Use the fundamentals of research process to complete and present research studies that enrich the all areas of advanced research.

PO11: Gain practical knowledge through internship at various food industries.

PO12: Ability to inculcate an attitude of enquiry towards developing innovative ability and enhancing entrepreneurship skills.

PROGRAM SPECIFIC OUTCOMES

PSO-1: Equips capacity to venture into a career in bio based industries as scientists or technologists in the division of production, research and developmental settings.

PSO-2: Demonstrate the concepts and research approach for their higher career in the field of microbiology and develop their scientific interest.

PSO-3: Administer skill sets to understand the rationales behind various regulatory/legal bodies governing the R&D in the industry.

PSO-4: Exhibit in-depth practical oriented knowledge to students in various thrust areas of microbiology, so as to meet the global demands of industry and academia.

PSO-5: Ability to designs aids in developing solutions for complex problems with appropriate consideration to the public health and safety, and the cultural, societal, and environmental considerations.

SRI VENKATESWARA UNIVERSITY::TIRUPATI
COLLEGE OF SCIENCES
M.SC.,MICROBIOLOGY SYLLABUS
CHOICE BASED CREDIT SYSTEM (CBCS) 2020 – 2021

DEPARTMENT OF MICROBIOLOGY

SEMESTER – I

Sl. No.	Components of Study	Course code	Title of the course	Credit hours/ week	No. of Credits	IA	SEEM	Total Marks
1	Core-Theory	MB-101	Introductory Microbiology	6	04	20	80	100
2	Core-Theory	MB-102	Microbial Physiology	6	04	20	80	100
3	Compulsory Foundation	MB-103	Biochemistry	6	04	20	80	100
4	Elective Foundation	MB-104	Biophysics and Biostatistics	6	04	20	80	100
5	Practical-I	MB-105	Introductory Microbiology & Microbial Physiology	6	04	-	100	100
6	Practical-II	MB-106	Biochemistry & Biophysics and Biostatistics	6	04	-	100	100
Total				36	24	80	520	600
7	Audit Course** (Self-Study)		**Human and Professional Ethics - I**	0	-	100	-	-

SEMESTER – II

Sl. No.	Components of Study	Course code	Title of the course	Credit hours/ week	No. of Credits	IA	SEEM	Total Marks
1	Core-Theory	MB-201	Molecular Biology	6	04	20	80	100
2	Core-Theory	MB-202	Recombinant DNA technology	6	04	20	80	100
3	Compulsory Foundation	MB-203	Immunology	6	04	20	80	100
4	Elective Foundation	MB-204	Medical Microbiology	6	04	20	80	100
5	Practical-I	MB-205	Molecular Biology and Recombinant DNA Technology	6	04	-	100	100
6	Practical-II	MB-206	Immunology and Medical Microbiology	6	04	-	100	100
Total				36	24	80	520	600
7	Audit Course** (Self-Study)			0	-	100	-	-

SEMESTER – III

Sl. No.	Components of Study	Course code	Title of the course	Credit hours/ week	No. of Credits	IA	SEEM	Total Marks

1	Core-Theory	MB-301	Bacteriology and Virology	6	04	20	80	100
2	Core-Theory	MB-302	Agricultural Microbiology	6	04	20	80	100
3	Generic Elective	MB-303	a) Industrial Microbiology b) Downstream processing Technology	6	04	20	80	100
4	Practical	MB-304	Bacteriology and Virology and Agricultural Microbiology	6	04	-	100	100
5	Skill Oriented Course	MB-305	Food and Diary Microbiology	6	04	20	80	100
6	Open Elective	MB-306	a) Computational biology b) Microbial genomics and proteomics	6	04	-	100	100
Total				36	24	80	520	600
7	Audit Course** (Self-Study)		**Online Courses from MOOS/ NPTEL**	0	-	100	-	-

Downstream Processing Technology

SEMESTER – IV

Sl. No.	Components of Study	Course code	Title of the course	Credit hours/ week	No. of Credits	IA	SEEM	Total Marks
1	Core-Theory	MB-401	Molecular Cell biology and Technology	6	04	20	80	100
2	Core-Theory	MB-402	Environmental Microbiology	6	04	20	80	100
3	Generic Elective	MB-403	a) Pharmaceutical Microbiology b) Industrial based microbial clean Technology	6	04	20	80	100
4	Practical	MB-404	Molecular Cell biology and Technology and Environmental Microbiology & elective	6	04	-	100	100
5	Project Work	MB-405	Field Trip/ Industrial Tour Report / Dissertation	6	04	20	80	100
6	Open Elective	MB-406	a) Bioethics, Biosafety and Intellectual property rights b) Microbial Production of Alcoholic beverages.	6	04	-	100	100
Total				36	24	80	520	600
7	Audit Course** (Self-Study)		**Online courses from MOOCs / NPTEL**	0	-	100	-	-

- All CORE Papers are Mandatory
- Generic Elective - Choose any one
- Project Work –In house/Research institutes, National laboratories, Central Universities
- Multi-disciplinary course is Mandatory.
- Skill based course Mandatory
- Open Electives are for the Students of other Departments. Minimum One paper should be opted. Extra credits may be earned by opting for more number of open electives depending on the interest of the student through self study
- Interested students may register for MOOC with the approval of the concerned DDC

FIRST SEMESTER

MB - 101: INTRODUCTORY MICROBIOLOGY

Course Learning Objective

1. To provide information on microscopy and staining materials that helps to observe microorganism.
2. To provide detailed knowledge on isolation, cultivation and enumeration of microorganisms.
3. To provide in depth knowledge about classification and taxonomy of microorganisms.
4. To provide information on prokaryotic and eukaryotic microorganisms.

UNIT – I

History and Scope of Microbiology - Discovery of microorganisms and development of microbiology - Contributions of pioneers- Prokaryotic and Eukaryotic microorganisms - Origin and evolution of microorganisms. Distinguishing of different microorganisms-Scope and relevance of Microbiology - Future of Microbiology.

Microbial Structure - Microscopy – principles and applications of light microscope-Bright field-Dark-field, Phase – contrast, Fluorescent, Scanning and Transmission electron microscopes, Confocal microscopy, Scanning tunneling microscope. Preparation of microbiological samples for microscopy-simple and differential staining, special and structural staining. Negative contrast staining for virus samples. Preparation of tissues for thin sectioning (fixation, dehydration, infiltration, embedding and sectioning).

Physical and Chemical methods of sterilization and disinfection : Heat, radiation, pH, atmospheric pressure, filters, various chemical agents, safety precautions. The concept of containment facility.

UNIT – II

Microbiological media: Types of media-natural and synthetic; autotrophic, heterotrophic and prototrophic media; basal, defined, complex, enrichment, selective, differential, maintenance and transport media.

Isolation, cultivation and enumeration of microorganisms : Isolation from different natural sources. Approaches for obtaining pure cultures. Cultivation of aerobes and anaerobes. Continuous, batch, synchronous broth and stock cultures. Enumeration / measurement of growth of microorganisms.

Maintenance and preservation of microbial cultures : Repeated sub-culturing, sterile soil/sand preservation, glycerol-deep freezing, oil overlay, drying methods, freeze-drying.

UNIT-III

Microbial Taxonomy: Classification of microorganisms – introduction – Hackel's three kingdom concept – Whittaker's five kingdom concept – three domain concept of Carl Woese. Basis of microbial classification. Concepts, nomenclature and taxonomic ranks; major characteristics used in Taxonomy – morphological, physiological and metabolic, ecological, numerical taxonomy; genetic and molecular classification systems; the kingdoms of organisms and phylogenetic trees. Characteristics of prokaryotes and eukaryotic cells.

UNIT – IV

Prokaryotic microorganisms:

Brief outlines on discovery, nature, origin, evolution, morphology and structure, composition, reproduction and other characteristics of Bacteria (Eubacteria) Spirochetes, Rickettsias, Chlamydias, Pseudomonads, Acetic acid bacteria, Mycloplasmas, Cyanobacteria, Archaebacteria, Actinomycetes (Actinobacteria).

Eukaryotic microorganisms:
Fungi : Classification, structure, composition, reproduction and other characteristics of fungal divisions – *Zygomycota, Ascomycota, Basidiomycota* and *Deuteromycota* and slime and water molds. General characteristics and importance of fungi – *Saccharomyces, Candida, Pichia, Pencillium, Neurospora, Rhizopus, Aspergillus, Agaricus, Cryptococcus, Fusarium, Trichoderma, Claviceps.*

Algae : Classification, structure, reproduction and other characteristics of algal divisions. Characteristics of *Chlorella, Senedesmus, Gelidiella* and *Gracellaria.* Economic importance of algae, phytoplantanic microalgae.

Protozoan parasites : Classification, morphology and structure, reproduction and other characteristics of pathogenic protozoa like *Entamoeba, Plasmodium, Leishmania, Cryptosporidium, Trichomonas, Taxoplasma, Trypanosoma, Giardia.*

Courses Learning Out Comes

1. Be able to know the microbial structure, sterilization and disinfection techniques
2. Be able to know the maintainence and preservation of microbial culture.
3. Be able to know nomenclature, taxonomic trends and major characteristics used in taxonomy.
4. Be able to know the discovery, classification, structure and importance of prokaryotes, fungi, algae and protozoa.

Suggested Books:

1. Brock Biology of Microorganisms. 1997, 8th ed. Madigan et al., Prentice-Hall International, Inc.
2. Microbiology. 1999. 3rd ed. Prescott et al. Wm. C. Brown Publ.
3. Principles of Microbiology. 1997. 2nd ed. R.A. Atlas. Wm.C. Brown. Publ.
4. Foundations in Microbiology. 1996. 2nd ed. K. Talaro and A. Talaro. Wm. C. Brown Publ.
5. Microbiology. 1996. 5th ed. Pelczar et al. Tata McGram-Hill Publ. Company Ltd.
6. General Microbiology, 1999 by S.B. Sullia, Oxford and IBH Publishers.
7. General Microbiology, 1999 by Stainer et al., Macmillan Educational Ltd.
8. Instant Notes in Microbiology. 1999. J. Nicklin et al. Viva Books Pvt. Ltd.
9. Microorganisms, Biotechnology and Disease : Students Book. 1997 by Pauline Lourie and Susanwells. Cambridge University Press.
10. Introductory Mycology. 1996. 4th ed. Alexopoulos et al., John Wiley and Sons.
11. Introductory Psychology by H.D. Kumar. 2nd ed. 1999. East West Press.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	2	2	1	1	-	-	-	1	1
CO_3	3	2	1	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB - 102: MICROBIAL PHYSIOLOGY

Course Learning Objective

1. To provide insights in to nutrition and microbial growth.
2. To know the concepts of bioenergetics, photosynthesis and carbon metabolisms.
3. To provide in depth information about aerobic and anaerobic respiration and lipid metabolism.
4. To provide detailed information on protein, nucleic acids and secondary metabolisms.

UNIT – I

Nutrition : Elemental nutrient requirements of microbes; nutritional groups of bacteria; autotrophy-photoautotrophy and bacterial photosynthesis; chemoautotrophy and autotrophic metabolism; heterotrophy – photoheterotrophy and chemoheterotrophy, heterotrophic metabolism in bacteria; nutritional mutants and their use in metabolic studies.

Uptake and Transport of nutrients in microbes – Structural organization of plasma membrane in relation to transport, types and mechanisms of transport (passive, simple, facilitated, active, chemical modification) with reference to sugars, amino acids and ions; methods for studying of transport, coupling of transport of ions and metabolites to ATP/proton gradient.

Microbial Growth: building of macromolecules from elemental nutrients, supramolecules, cell components and cells; cell cycle in microbes and generation times; batch culture phases and importance of each phase, continuous cultures, synchronous culture, factors influencing the microbial growth.

Nature and properties of spores – Physiology and biochemistry of sporulation and germination of spores.

UNIT – II

The concepts of microbial metabolism, primary and secondary metabolism and their significance.

Bioenergetics : Concepts of free energy and thermodynamic principles in biology, energy transformation, ATP cycle, standard free energy of hydrolysis of phosphate compounds, energy transducers, redox potentials, free energy changes in redox reactions.

Photosynthesis : Oxygenic and anoxygenic photosynthesis, photosynthetic pigments, basic photochemistry of PS I and PS II and photosynthetic electron transport; modes of CO_2 fixation, halobacterial photosynthesis, sulphur, nitrogen and iron assimilating bacteria. Chloroplast mediated electron transport; chemolithotrophic electron transport systems. Biolumenescence.

Carbohydrate metabolism : Pathways underlying the utilization of different sugars (EMP, ED, HMP and phosphoketolase) in microorganisms, gluconeogenesis; synthesis of peptidoglycans and glycoproteins.

UNIT – III

Aerobic respiration : TCA cycle – intracellular location and reactions of the cycle, amphibolic nature of the cycle, energetics of the cycle; the glyoxalate cycle. Mechanisms of substrate-level phosphorylation; respiratory electron transport in mitochondria and bacteria along with its components (carriers); mechanism of oxidative phosphorylation, uncouplers, inhibitors;

Anaerobic respiration : nature of fermentation, the relationship of oxygen to growth and fermentation, biochemical mechanisms of lactic acid, ethanol, butanol, citric acid and acetone fermentations, study of fermentations, relationships between fermentation and energy production; nitrate and sulphate respiration.

Lipid metabolism: Biosynthesis of triacyl glycerols, phospholipids and glycolipids; oxidation of saturated and unsaturated fatty acids; microbial metabolism of aromatic and aliphatic hydrocarbons.

UNIT – IV

Protein metabolism: Assimilation of inorganic nitrogen and sulphur, biochemistry of nitrogen fixation; hydrolysis of proteins-exo-and endo-proteinases, outlines of biosynthesis and catabolism of amino acids in microbes (deamination, decarboxylation and transamination reactions). Urea cycle.

Nucleotide metabolism : biosynthesis of bases, nucleosides and nucleotides including deoxyribonucleotides, regulation of nucleotide synthesis; break down of nucleic acids – exo-and endo-nucleases (RNases and DNases) and phosphodiesterases, salvage pathways; catabolism of purines and pyrimidines.

Secondary metabolism : Utilization of secondary metabolites for production of vitamins, toxins (aflotoxin and corynebacterial), hormones (GA), and antibiotics (penicillin and streptomycin).

Microbial toxins and extra cellular enzymes : Exo-and endotoxins: physiology of toxin production; mode of action of toxins and extra cellular enzymes and their importance in pathogen virulence and pathogenesis.

Course Learning Out Comes

1. Be able to know about the nutrition and microbial growth.
2. Be able to know about photosynthesis and carbon fixation.
3. Be able to know in depth details about aerobic and anaerobic respiration.
4. Be able to know in depth about various pathways in protein and nucleotide metabolisms.

Suggested Books:

1. Microbial Physiology and Metabolism. 1995, by D.R. Caldwell. Wm.C. Brown Publ.
2. Microbial Physiology. 1999, 3rd ed. by A.G. Moat & J.W. Foster. Wiley-Liss.
3. Principles of Biochemistry. Lehinger. 2000.
4. Foundations in Microbiology. 1996. by K. Talaro & A. Talaro, Wm. C. Brown Publ.
5. Microbiology. 2000. By Prescott et al. Wm. C. Brown Publ.
6. Molecular Cell Biology. 2000 – by Lodish et al.
7. General Microbiology, 1999 by Stainer et al., Macmillan Educational Ltd.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	1	2	1	1	-	-	-	1	1
CO_3	3	1	1	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 103: BIOCHEMISTRY

Course Learning Objective

1. To provide basic concepts of chemistry in life.
2. To provide in depth information lipids and amino acids.
3. To provide in depth information on proteins and catalytic proteins.
4. To provide in depth information in nucleic acids, hormones and vitamins.

UNIT – I

Basic concepts of Chemistry of life : The major elements of life and their primary characteristics; atomic bonds and molecules – bonding properties of carbon, covalent and non-covalent bonds, Vander waals forces; polarity, hydrophilic and hydrophobic interactions; asymmetry of carbon compounds and cis-trans isomerism; electron transfer and oxidation/reduction; functional groups of organic compounds; hydrogen ion concentration of biological systems; Brownsted – Lowry acids and bases; ionization and titration of acids; dissociable biological compounds and physiological buffer systems.

Carbohydrates : Classification of carbohydrates; outline structure and properties of important mono-, di-and oligosaccharides and their identification and analysis; structure, occurrence and biological importance of structural polysaccharides (cellulose, chitin, agar, alginic acids, pectins, proteoglycans, sialic acids, blood group polysaccharides, bacterial cell wall polysaccharides).

UNIT – II

Lipids: Building blocks of lipids. Classification of lipids. Fatty acids-physico-chemical properties, separation, distribution in nature characterization and saponification and iodine number. Nomenclature, outline structures, properties and functions of glycerides, neutral lipids (waxes, fats, oils, phospholipids, sphingolipids and glycolipids. Steroids – plant sterol, ergosterol, stigmasterol, cholesterol. Lipoproteins-classification, composition and importance. Salient features of bacterial lipids.

Amino acids : Classification, structure, physico-chemical properties, acid-base behaviour of amino acids.

Peptides : Characteristics of peptide bond, peptides of non-protein origin, properties and functions of peptides, determination of amino acid composition and sequence in peptides, chemical synthesis of peptides, peptides profiling.

UNIT – III

Proteins : Classification, properties and biological functions of proteins; structural organization of proteins – primary, secondary, tertiary and quaternary; Ramachandran's plot; proteins denaturation and renaturation (ribonuclease); structure-function relationships of certain proteins – myoglobin, hemoglobin, collagen; chaperones.

Catalytic proteins(enzymes) : Classification, nomenclature, composition and structure, enzymes as biocatalysts, outlines of purification and assay of enzymes, kinetics of enzyme catalyzed reactions, factors influencing enzyme catalyzed reactions, regulation of enzyme activity – activators and inhibitors and mechanism of action of enzymes (chymotrypsin). Regulatory enzymes – allosteric enzymes. Isoenzymes, conzymes, ribozymes, abzymes.

UNIT – IV

Nucleic acids : Types and their composition, structures of purines, pyrimidines, modified bases, nucleosides, nucleotides and polynucleotides; properties of bases and functions of nucleotides; types and structural polymorphism of DNA and RNA; denaturation and renaturation of nucleic acids, factors influencing hybridization, cot values.

Hormones and Growth regulators : Classification, outline structures and functions of major animal and plant hormones.

Vitamins : Discovery and outline chemistry of fat soluble (A,D,E and K) and water soluble (riboflavin, pantothenic acid, niacin, pyridoxine, biotin, cobalamine folic acids and ascorbic acid) vitamins and their role in body functions.

Porphyrins and other pigments : Classification, structures and biological functions of porphyrins, brief account of haemoglobin and chlorphylls, cytochromes, xanthophylls and carotenoids of microorganisms.

Course Learning Out Comes

1. Be able to identify and analyze carbohydrates and lipids.
2. Be familiar with behavior of amino acids and structure functional relationships of proteins and their profiling.
3. Be able to know the separation methods such as centrifugation and Electrophoresis.

Suggested Books :

1. Principles of Biochemistry, Lehninger, 3rd edition, 2000 by Nelson and Cox (Worth).
2. Biochemistry, Stryer 5th edition, W.H. Freeman, 2001.
3. Microbial Physiology and Metabolism. 1995, by D.R. Caldwell. Wm.C. Brown Publ.
4. Microbial Physiology. 1999, 3rd ed. By A.G. Moat & J.W. Foster. Wiley-Liss.
5. Foundations in Microbiology. 1996. By K. Talaro & A. Talaro, Wm. C. Brown Publ.

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CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	1	2	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	1	-	-	-	1	1

MB – 104: BIOPHYSICS & BIOSTATISTICS

Course Learning Objective

1. Gives in sights on electrochemical and spectroscopy concepts.
2. Provide in depth knowledge on separation techniques such as centrifugation, electrophoresis and chromatography.
3. Give detailed information on interval date, proportion data and count data.
4. Provide knowledge on statistical basis of biological assays and design of experiments.

UNIT – I

Electrochemcial techniques (Principles and applications): Redox reactions; pH and Clarke oxygen electrodes; biosensors.

Cell sorting and Flow cytometry (Principles and applications):

Radioisotope techniques - Nature and types of radioactivity, half-life of isotopes; detection and measurement of radioactivity-GM counter, liquid scintillation counter, gama-ray counter, Cerenkov counting and autoradiography; quenching and quench correction; laboratory safety measures in handling isotopes; biological uses of radioisotopes.

Spectroscopy : Electromagnetic spectrum of light; simple theory of light absorption by biomolecules; Beer's – Lambert law; transmittance; extinction co-efficient; light sources; monochromators; types of detectors; working principle and applications of visible, UV-visible, IR, Raman, ESR, mass, plasma emission, atomic absorption, and NMR spectrophotometry; fluorimetry and flame photometry; ORD and CD; X-ray diffraction and X-ray crystallography.

Amino acid and nucleotide sequencers: Basic principle, functioning and applications of amino acid and nucleotide sequencers.

UNIT – II

Centrifugation: Simple theory of preparative and analytical centrifuges and rotors; sedimentation analysis; differential, rate-zonal and equilibrium density gradient centrifugations. Applications – isolation of cells, subcellular organelles, viruses and macromolecules.

Electrophoresis (Principles and applications) : Types of electrophoresis – paper, gel (starch, acrylamide and agarose) disc, vertical, horizontal submarine, gradient, 2-dimentional, pulse-field and capillary; isoelectrofocussing; isolation and analysis of gel separated molecules – recovery of molecules from paper/gels; Southern, Northern and Western blottings.

Chromatography: Principle/simple theory and applications of partition, adsorption, ion-exchange, gel permeation and affinity chromatography based techniques – paper, thin-layer, column, GLC, HPLC, FPLC.

UNIT – III

Introduction: Definition of statistics: population and universe, the sample and population, statistical inference; parameter and statistics.

Interval Data: Mean, mode, median and standard deviation. Concept of probability – classical and frequency definitions; axiones of probability; addition and multiplication theorems (statements only); conditional probability-Baye's theorem (statement only); simple applications. Binomial, Poisson and Normal distributions (definitions and uses only).

Uncertainties in estimation of mean, comparison of means and variances – t, F, and Z tests.

Proportion data: examples of proportion data; (MPN, sterility testing of medicines, animal toxicity, therapeutic trial of drugs and vaccines, animal toxicity, infection and immunization studies) statistical treatment to proportion data. Chi-square test, goodness of fit.

Count data: examples of count data (bacterial cell count, radioactivity count, colony and plaque counts) statistical treatment to count data: Poisson distribution, standard error, confidence limits of counts.

UNIT – IV

Analysis of variance: Analysis of variance: Introduction, procedure and tests for one-way and two-way classified data. Multiple comparisons. Analysis of CRD, RBD and LSD. Factorial experiments-main effects and interaction in a 2^2 design, Duncan's Multiple Range Test.

Correlation and regression, formulae and application. Fitting straight line through a series of points. Fitting of exponential curves. Standard curve and interpolation of unknown Y-values. Multiple linear regression, logistic regression.

Statistical basis of biological assays: Response-Dose metameter. Delusion Assays, Direct and indirect assays. Quantal Responses, Probit, logit, LD_{50}, ED_{50}, PD_{50} – Standard line interpolation assay, parallel assay (4 point, 6 point assays), slope ratio assay.

Design of Experiments – Multiple comparison tests, Dunken's, Tukey's, Scheffic's, Dunnelt's etc.

Probit Analysis

Multiple Regression, Logistic regression

Discriminate Analysis

Clinical trails – Phase I, Phase II etc.

Clinical trails (meaning and importance only).

Course Learning Out Comes

1. Be able to know the principal, instrumentation and applications of spectroscopy, amino acid ,nucleotide sequencers.
2. Be able to know principle, methods and applications of separation techniques.
3. Be able to gain knowledge on basic concepts in statistics.
4. Be able to design the experimental and statistical basics of biological assays.

Suggested Books :

1. Practical Biochemistry: Principles and Techniques 1995, 4th ed. by K. Wilson and J. Walker, Cambridge University Press.
2. Modern Experimental Biochemistry. 1993. 2nd ed. by R.F. Boyer. The Benjamin Cummings Publ. Company.
3. Physical Biochemistry: Applications to Biochemistry and Molecular Biology, 1982, 2nd ed. by David Freifelder. W.H. Freeman and company.
4. Introduction to Practical Biochemistry. 2000. by S.K. Sawhney and Randhir Singh (eds). Narosa Publ. House.
5. Biochemical Methods for Agricultural Sciences. 1992 by S. Sadasivam and A. Manikam. Wiley Eastern Ltd.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1

CO_4	3	2	2	2	2	2	2	-	-	-	1	1

PRACTICAL:
MB – 105: INTRODUCTORY MICROBIOLOGY & MICROBIAL PHYSIOLOGY:

1. Microbiological laboratory safety measures
2. Sterilization methods - Wet method, Dry method, Filters. Evaluation of alcohol effectiveness, Phenol coefficient method
3. Preparation of different media for cultivation of bacteria & fungi
4. Plating techniques – streak plate, spread plate methods
5. Enumeration of Bacteria by serial dilution, viable count
6. Qualitative tests for identification of Carbohydrates, amino acids, nucleic acids
7. Quantitative tests for Protein, glucose, glycine, bilirubin, cholesterol, Inorganic phosphorous
8. Determination of activity of – Peroxidase and Polyphenol oxidase in plant tissues.
9. Purification and study of Acid Phosphatase from potato tubers: Extraction of enzyme; effect of substrate concentration; enzyme concentration; temperature; pH on enzyme activity.
10. Determination of Bacterial growth curve
11. Determination of effect of temperature on bacterial growth
12. Determination of effect of pH on bacterial growth
13. Determination of effect of salt on bacterial growth
14. Determination of growth of fungi
15. Determination of concentration of cyanobacterial pigments
16. Determination of concentration of oligodynamic action
17. Determination of activity of microbial hydrolytic enzymes like amylases, lipases and proteases.
18. Demonstration of aerobic and anaerobic respiration in microbes.
19. Demonstration of Microbial fermentation
20. Demonstration of microbial toxins

PRACTICAL: MB – 106: BIOCHEMISTRY & BIOPHYSICS AND BIOSTATISTCS:

1. Calculating Mean, Mode Median
2. Problems related to T test & F test & Z test
3. Problems related ANOVA
4. Measurement of pH
5. Micrometry for cell size determination
6. Cell counting by Haemocytometer
7. Beer's Law
8. Determination of λ max for coloured solutions
9. Determination of DNA & RNA by UV spectrophotometry
10. Determination of nucleic acid Bases by UV spectrometry
11. Paper chromatography for separation of amino acids / pigments
12. TLC for separation of lipids / amino acids
13. Dialysis
14. Separation of proteins by SDS-PAGE
15. Separation of DNA by Agarose gel electrophoresis
16. Isolation of chloroplasts by sucrose density gradient centrifugation
17. Determination of concentration of green/yellow pigments by spectrophotometry

SECON SEMESTER

MB - 201: MOLECULAR BIOLOGY

Course Learning Objective

1. Gives basic concepts in genetics of bacteria and fungi
2. Provides in depth knowledge on genetic recombination

3. Gives overall picture about DNA replication and transcription
4 .Provides in depth information about RNA biosynthesis and gene regulation

UNIT – I

Genetic notations, conventions and terminology
Nucleic acids as genetic information carriers – experimental evidences.

Modern concept of gene – Gene structure, co-linearity and polypeptide, one gene – one enzyme, protein polypeptide or product concepts; types of genes.

Genetics of Bacteria and Fungi : *E. coli, Bacillus, Streptomyces, Sacchromyces,* Filamentous fungi *(Neurospora).*

Gene transfer mechanisms in bacteria : Transformation, conjugation, sexduction and transduction (generalized, abortive, contrasduction, specialized,) and gene mapping. Role of Rec gene products.

Genome diversity : Viruses – linear, circular and dividend genomes of RNA and DNA viruses. Prokaryotes – nucleoid and chromosome organization, genome evolution in microbes, phylogenetic trees. Eukaryotes – chromosome organization / structure, histones, nucleosomes, genome complexity, chromosomal banding. Organelle genomes. Genetic mapping of genomes.

Plasmids : bacterial and yeast plasmids, purification, properties, detection, transfer, replication an curing, significance / importance.

Transposal / mobile genetic elements : Prokaryotes – (IS elements, composite and complex transposons), mechanisms of transposition and importance – Eukaryotes (Yeast, Drosophila and Maize) – retrotransposons, retroelements. Exploitation of transposable elements in genetics.

UNIT – II

Mutations : Types, mutagens and molecular mechanisms of mutation, isolation and analysis of mutants, significance of mutants.

Genetic recombination : General of homologous recombination, site specific recombination, transposition; illegitimate recombination and artificial recombination.

Genetics of viruses : Prokaryotic virus (phages) – Benzer's studies on r-II region of T4 and complementation, recombination in bacteriophages (T2), uses of phages in microbial genetics, Eukaryotic viruses-recombination and reassortment, cross-and multiplicity reactivation, complementation, phenotypic mixing, ploidy, DI particles, transduction of genes by retroviruses, evolution of viruses (influenza, HIV, herpesviruses).

UNIT-III

DNA replication : general principles, various modes of replication. Continuous and discontinuous synthesis, relation between cell cycle and DNA synthesis, replication fork and enzymology of DNA replication in prokaryotes and eukaryotes, replication of ssDNA, retroviruses and their unique mode of DNA synthesis, inhibitors of DNA replication.

DNA damage and repair : types of DNA damage-deamination, oxidative damage, alkylation and pyrimidine dimers; repair pathways – mismatch, short patch repair, nucleotide/base, excition repair, recombination repair and SOS system.

Transcription (RNA biosynthesis) : Types of RNA and their role, organization of protein and RNA (rRNA, tRNA, 5 sRNA) encoding transcription units (promoters and regulatory elements) and their transcription in prokaryotes and eukaryotes, polycistronic and monocistronic mRNAs. Types of RNA polymerases. Promoters and other regulatory elements and transcription factors, events of transcription. Maturation and processing of different RNAs : methylation, processing of rRNA; capping, polyadenylation, splicing and editing of mRNA; processing and modification of tRNA. Catalytic RNAs (ribozymes). Inhibitors of transcription. *Invitro* transcription systems.

UNIT – IV

Translation (Protein biosynthesis) : Central dogma theory and flow of genetic information, genetic code and its elucidation, structure and composition of prokaryotic and eukaryotic ribosomes, structural features of rRNA, mRNA and tRNA in relation to function, steps of protein biosynthesis (activation of amino acids, initiation, elongation, termination) in prokaryotes and eukaryotes; post-translational modification of proteins and their sorting and targeting; regulation of translation; inhibitors of protein biosynthesis; invitro translation systems.

Regulation of gene expression : An overview on levels of regulation, terminology and operon concepts, enzyme induction and repression; positive and negative regulation in *E. coli*- lac and ara operons; regulation by attenuation – his and trp operons; antitermination – N protein and nut sites in Lambda phage. Organization and regulation of nif and nod gene expression in bacteria; gal operon in yeast. Global regulatory responses-heat shock response, stringent response and regulation by small molecules such as cAMP and PPGPP.

DNA binding proteins : Enhancer sequences and control of transcription. Identification of protein – binding sites on DNA, control of transcription by interaction between RNA polymerases and promoter region, use of alternate sigma factors, controlled termination attenuation and anti termination.

Course Learning Out Comes

1. Be able to gain knowledge on genome diversity and gene transfer mechanisms,.
2. Be able to gain information on mutations and gene transfer mechanisms
3. Be able to gain in depth-knowledge on DNA and biosynthesis
4. Be able to understand about positive and negative gene regulation

Suggested Books:

1. Microbial Genetics by S.R. Maloy et al. 1994
2. Molecular Genetics of Bacteria, 3rd ed. 1998. J.W. Dale. Wiley Publ.
3. Bacterial and Bacteriophage Genetics. 4th ed. 2000. By E.A. Birge. Springer.
4. Principles of Molecular Virology. 4th ed. 2004. By A. Cann. Academic Press.
5. Modern Genetic Analysis by Griffith.
6. Genetics by Gardner.
7. Molecular Cell Biology. 1995, 3rd ed. by Lodish et al. Scientific American books, W.H. Freeman and Company.
8. Molecular Biology. 1995, by David Freifelder, Narosa Publ. House.

9. Text Book of Molecular Biology. 1994, by Sivarama Sastry et al, Macmillan India Ltd.
10. Advanced Molecular Biology : A Concise Reference. 1998, by R.M. Twyman. Viva Books Pvt. Ltd.
11. Instant notes in Molecular Biology, 1998. by P.C. Turner et al. Viva Books Pvt. Ltd.
12. Genes VIII. 1997. by B. Lewin. Oxford University Press. The Biochemistry of nucleic acids. 1992, 11th ed. by Adams et al, Chapman and Hall.
13. Biochemistry. 1995 by L. Stryer. W.H. Freeman and Co.Biochemistry, 1998, 4th ed. by G.L. Zubay. W.C.B. Publ.
14. Microbial Genetics. 1995, by David Freifelder. Narosa Publ. House.
15. Biochemistry and Molecular Biology. 1997, by W.H. Elliott & D.C. Elliott. Oxford University Press.
16. Molecular biology of the Gene. 1998, 5th ed. Watson et al, Addison Wesley Longman.
17. Schaums Outlines – Molecular and Cell Biology. 1996. W.D. Stansfield et al., McGraw-Hill Publ.

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CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB - 202: RECOMBINANT DNA TECHNOLOGY

Course Learning Objective

1. Gives basic concepts in genetic engineering tools
2. Provides in depth knowledge on molecular tools
3. Gives overall picture about transgnics
4 .Provides in depth information about proteome and genomes microbiology

UNIT – I

Scope and importance of recombinant DNA technology / genetic engineering.

Genetic Engineering tools : Vectors- types, plasmids, transposons, bacterial and animal virus based vectors, bacterial and yeast artificial chromosomes; **enzymes-**restriction endonucleases, different DNA and RNA polymerases ligases, nucleases, kinases, nucleotidyl transferases, alkaline phosphatase; **oligonucleotides-** linkers, homopolymer tails, primers, promoters; **cloning and expression hosts –** *E.coli Bacillus, Agrobacterium,* yeast and plant and animal cell cultures.

Cloning strategies : Generation of DNA molecules, attachment to vectors, delivery of recombinant molecules into host cells, screening and identification of positives clones – antibiotic, nucleic acid and protein based approaches. Construction and screening of cDNA and genomic DNA libraries.

UNIT – II

DNA sequencing : Chemical method of Maxum and Gilbert, Sanger's dideoxy chain termination and primer walking methods. Automated sequencing. Sequence assembly. Genome sequencing and physical mapping of genomes.

Site-directed mutagenesis : Different approaches and its potential in changing genes.

Molecular diagnostics : Preparation of DNA and RNA probes, nucleic acid hybridization, factors influencing hybridization and their applications; PCR-principles, factors affecting PCR, different types of PCR and their applications and limitations; profiling of nucleic acids by DNA fingerprinting, RFLP, RAPD and AFLP.

UNIT – III

Transgenic plants : Construction of plant cell expression vector with desired genes, biological and physical approaches for delivering genes into plant tissues, identification and regeneration of transformed tissues to transgenics. Transgenic plants as bioreactors.

Transgenic animals : Construction of animal cell expression vectors and delivering of genes into cultured animal cells. Production and use of transgenic animals (mice, sheep/goat, cow).

UNIT – IV

Microbial genomics and proteomics : DNA microarray – printing of oligonucleotides and PCR products on glass slides. Whole genome analysis for global pattern of gene expression using fluorescent labeled cDNA or end labeled RNA. Analysis of single nucleotide polymorphisms using DNA chips. **Proteome analysis-**two-dimentional analysis of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Protein microarray, advantages and disadvantages of DNA and protein microarray.
Applications and implications of genetic engineering in biology, agriculture, medicine and industry.

Course Learning Out Comes

1. Be able to gain knowledge on genetic engineering tools,.
2. Be able to gain details on molecular tools
3. Be able to gain in depth-knowledge on transgenic plants
4. Be able to understand about 'omics"

Suggested Books:

1. Principles of Gene Manipulation : An introduction to genetic engineering. 1994. 5th ed. Old and Primrose. Blackwell Scientific Publ.
2. Molecular Biotechnology. 1994. Glick and Pasternak. Panima Publ.
3. Recombinant DNA. 1992. 2nd ed. J.D. Watson et al. Freeman and Co.
4. Protein expression : A Practical Approach by S.J. Higgins and B.D. Hames (eds). Oxford University Press.
5. Functional Genomics : A Practical Approach. 2000, by S.P. Hunt and R. Liveey (eds.). Oxford University Press.
6. DNA Microarrays : A Practical Approach by M. Schena (ed.). Oxford University Press.
7. Molecular biology and Biotechnology. 2002. 4th ed. by J.M. Walker and R. Rapley, Panima.
8. Manual of Industrial Microbiology and Biotechnology, second edition., ed. by Demain, A.L., Editor in Chief, 1999, ASM Press.
9. Recombinant DNA and Biotechnology : A guide for Teachers : 2nd ed. H. Kreuzer and A. Massey. ASM Press.
10. Recombinant DNA and Biotechnology : A guide to students : 2nd ed. H. Kreuzer and A. Massey. ASM Press.
11. Basic Biotechnology, 2001. 2nd ed. by C. Ratledge & B. Kristiansen. Cambridge University Press.
12. Molecular Cloning, 2001. Vol. I-III by Sambrook and Russel, CSH Press.
13. Current Protocols in Molecular Biology, 2000. Ausbel et al.
14. Genome analysis. 2000. 4 Vols. CSH Press.

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CO_2	3	2	2	1	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	1	2	-	-	-	1	1

MB - 203: IMMUNOLOGY

Course Learning Objective

1. Gives a detailed information on cells and organs of the immune system.
2. Gives in depth knowledge about Antigen-antibody interaction.
3. Provides the details on immuno pathology.
4. Gives central concepts in transplantation and transfusion immunology.

UNIT – I

History : Historical perspective of Immunology, milestones in immunology.

Cells and Organs of the Immune system : Hematopoiesis, Lymphoid cells, stem cells, Mononuclear cells, Granulocytes, Mast cells, Dendritic cells. Lymphoid organs – Primary and Secondary lymphoid organs.

Types of immunity : Innate immunity and adaptive immunity, comparative immunity, Immune dysfunction and its consequences.

Immune responses to infectious diseases : Viral, bacterial, protozoan and other parasitic diseases.

UNIT – II

Antigens : types, properties, study of antigenicity, immunogenicity versus antigenicity, factors influencing immunogenicity. Epitopes, haptens, mitogens, superantigens. Viral and bacterial antigens.

Antibodies : Basic and fine structure of Immunoglobulins, classes and biological activities of Immunoglobulins, Antigenic determinants – Iso, allo and idiotypes. Immunoglobulin super family, antibody diversity, organization and expression of immunoglobulin genes. Production of polyclonal antibodies-animals, additives, adjuvants, routes, dose, collection and preservation of antisera, purification of immunoglobulins, quantitative and qualitative analysis of immunoglobulins.

Monoclonal antibodies : Hybridoma technology – principle and production of monoclonal antibodies, advantages and disadvantages over polyclonal antibodies, application of monoclonal antibodies.

Recombinant antibodies : Production and their advantages over conventional antibodies.

Antigen and Antibody interactions : Affinity, Avidity, Cross reactivity.

***In vivo* serological reactions :** Phagocytosis, Opsonization, Neutralization, Protection tests.

***In vitro* serological tests :** Precipitation tests in liquid and semisolid media, single and double immuno diffusion tests. Immuno electrophoresis tests (Rocket, counter current). Agglutinations tests-

HA and HI, latex agglutination. Complement fixation tests, Labeled antibody based tests – Enzyme linked immunosorbent assays (ELISA), Western blotting, Radio immuno assay (RIA), Immunoflurescent and Immuno specific electron microscopy. Infectivity neutralization test. The relative advantages and disadvantages and their applications in Microbiology.

UNIT – III

Humoral immune response : Primary and secondary immune responses, induction, regulation of the immune effector response.

Cell mediated immune response : Induction and mechanism, antibody-dependent cell mediates cytotoxicity (ADCC).

Immune effector mechanisms : Cytokines, Lymphokines, Chemokines and their classification, properties and functions.

Complement cascade system : Complements nomenclature, classification, complement components, functions, activation, regulation, biological consequences, complement deficiencies.

Hypersensitive and Allergic reactions : Classification, types I, II, III and IV.

Immunopathology : Immunodefficiencies – Primary immunodeficiency (genetic) diseases due to B cell, T-cell and combined defects (Hypogamma globulinemia, SCID, ADA) phagocyute and complement defects. Autoimmune diseases – Autoimmunity, induction, mechaniss of tissue damage in autoimmunity. Autoimmune diseases – Organ specific (Autoimmune anemias, Autoimmune thyroid diseases, Diabetes mellitus, Multiple sclerosis), Systemic autoimmune diseases (Rheumatoid arthritis, Systemic lupus erythematousus) and their therapy.

UNIT-IV

Major histocompatability complex (MHC) : Organization and Inheritance of HMC, cellular distribution of HMC molecules, regulations of HMC expression, MHC-immune responsiveness, disease susceptibility, MHC restriction, HLA antigens-Class I, II, III and their functions, Murine antigens and its functions.

Transfusion Immunology : Blood cell components, blood group systems in human and in animals, Rh typing, transfusion reactions, diseases associated with blood transfusion – Hemolytic anemias, Erythroblastosis featalis.

Transplantation Immunology : Transplantation antigens, types of transplants, Graft versus host reactions – immunological basis of graft rejection mechanism, prevention of graft rejection, clinical manifestations of graft rejection, Immunosuppressive therapy of allograft response, clinical transplantation.

Tumor immunology : Cancer and the Immune system, tumor specific antigens, tumors of the immune system, immune response to tumors, cancer immunotherapy.

Vaccinology : Type of immunization procedures, active and passive immunization, designing of vaccines, classical and novel/modern approaches for the production of vaccines, purified macromolecules as vaccines, Recombinant – vector vaccines, DNA vaccines, Synthetic peptide

vaccines, Multivalent sub-unit vaccines, uses of vaccines, benefits of vaccination, mass immunization programmes.

Course Learning Out Comes

1. Be able to describe immunology basics.
2. Be able to understand the theoretical principles of *in vitro* selogical tests.
3. Be able to explain allergic reactions.
4. Be able to explain immunization procedure and immunization programmes.

Suggested Books:

1. Immunology. 2000. 4th edition. J. Kuby. W.H. Freeman and Company.
2. Immunology. 1996. 4th edition. I. Roitt, J. Brostoff and David Male. Mosby publications.
3. Fundamental Immunology. 1992. 2nd edition. R.M. Coleman, M.F. Lombard and R.E. Sicard. Wm. C. Brown Publishers.
4. Immunology. 1997. 3rd edition. R.M. Hyde. B.I. Waverly Pvt. Ltd.
5. Immunology. 1995. 4th edition. I.R. Tizard. Saunders College Publishing.
6. Immunology – The Science of self and non-self discrimination. 1982. Jon Klein. John Wiley and Sons.
7. Immunology – An illustrated outline. 1986. David Male. Churchill Living Stone.
8. Viruses that affect immune system. 1991. H.Y. Fan, I.S.Y. chen, N. Rosenberg and W. Sugden. American Society for Microbiology.
9. Immunobiology : The immune system in health and disease, 1994. C.A. Janeway, Jr., P. Travers. Current biology Ltd.

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CO_1	3	2	2	2	2	1	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	1	2	3	2	2	-	-	-	1	1
CO_4	3	1	2	2	2	2	2	-	-	-	1	1

MB - 204: MEDICAL MICROBIOLOGY

Course Learning Objective

1. Provides information on infections and pathogenesis.
2. Helps to learn chemotherapy principle.
3. Be able to explain the symptoms of bacterial infections.
4. Be able to explain the symptoms of viral, fungal and parasitic diseases.

UNIT – I

Principles of Medical Microbiology: Historical developments Classification of medically important microorganisms. Normal microbial flora of human body: Origin of normal flora; Infectious diseases.

Infection: Sources of infection for man; vehicles or reservoirs of infection. Exogenous infection: 1) Patients 2) carriers – (Healthy; convalescent; contact; paradoxical and chronic) 3) Infected animals (zoonosis) 4) Soil endogenous infection. Mode of spread of infection: 1) Respiratory 2) skin 3) Wound and burn infection 4) Venereal infections 5) Alimentary tract infection 6) Arthorpod-borne

blood infections 7) Laboratory infections. Nosocomial infections: common types of hospital infections, their diagnosis and control.

Pathogenesis: Adhesion in various hosts, cell damage, release of pathogens, Transmissibility, infectivity and Virulence. Opportunistic pathogens and True pathogens. Toxigenicity: Invasiveness, other aggressins (Hyaluronidase), coagulase, fibrinolysins or kinase, depolymerizing enzymes, (mucinase, lipases, proteases, nucleases, collagenase, neuraminidase). Organotropism, variation and virulence.

UNIT – II

Microbial Toxins: Types of microbial toxins, Endotoxins, Exotoxins, LC_{50} of toxins, Effective dose of toxins, Assay of toxins, Mechanism of action of Diphtheria, Cholera, Staphylococcal toxin and Clostridial neurotoxins. Virulence and virulence factors of microbial toxins. Signs and symptoms of microbial intoxication.

Diagnostic methods: Collection, transport and preliminary processing of clinical samples. Clinical, microbiological, immunological and molecular diagnosis of microbial diseases.

Principle of Chemotherapy: Chemotherapeutic agents, Mechanism of action of antimicrobial agents, Synthetic compounds and antibiotics and their assay in body fluids, drug resistance, Mechanisms of drug resistance, MDR. Various methods of drug susceptibility testing. Brief account on available vaccines and schedules, passive prophylactic measures.

UNIT – III

Bacterial diseases: Symptoms, diagnosis , treatment and prevention of the diseases caused by *Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Corynebacterium, Bacillus, Clostridium, Actinomycete, Rickettsiae, Chlamydiae, Mycoplasma, Enterobacteriacea, Vibrios, Yersinia; Haemophilus; Bordetella, Brucella; Mycobacteria, Spirochetes; Salmonella* species.

UNIT – IV

Viral diseases: Virus-host interactions at cellular and organism levels. Common diseases caused by Poxviruses; Herpes virus; Adeno viruses; Picorna viruses; Orthomyxo viruses; Paramyxo viruses; Arbo viruses, Rhabdo viruses, Hepatitis viruses; Oncogenic viruses; Human Immuno deficiency viruses (HIV/AIDS). Prion diseases – Kuru, CJD disease and GSS syndrome.

Fungal diseases: Diseases caused by dermatophytes, dimorphic fungi and opportunistic fungal pathogens. Description and classification of pathogenic fungi and their laboratory diagnosis.

Parasitic diseases: Disease caused by parasites like *Entamoeba, Plasmodium, Trichomonas, Leishmania* and *Toxoplasma, Giardia, Wuchereria, Dracunculus.*

Course Learning Outcomes

1. Be able to explain about various infections.
2. Be able to understand the diagnostic methods.
3. Be able to explain the symptoms of bacterial infections.
4. Be able to explain the symptoms of viral, fungal and parasitic diseases.

Suggested Books:

1. Ananthanarayan R, Panikar CKJ (2000). Textbook of Microbiology. 2013. 9th Edition. Orient Longman Ltd.
2. Warren Levinson (2014).Review of Medical Microbiology and Immunology. Mc Graw Hill education
3. Bailey & Scott's (2013). Diagnostic Microbiology (13th Edition), Published by: Mosby.
4. Color atlas and Text book of Diagnostic microbiology (6th Edition), 2005, edited by: Eimer W Koneman, published by: Lippinctt.
5. Subash CP (2000). Text Book of Medical Parasitology, by published by : All India Publishers & Distributors. 1st edition.
6. Jayaran Paniker C.K, Text Book of Medical Parasitology (7th Edition), 2013, by Published by: Jaypee Brothers.
7. Cruichshank *et al.*,(2012). Manual of Clinical Microbiology, 7th ed. by E.H. Lennette et al. ASM Publications.
8. Patrick R. Murray, Ken S. Rosenthal, Michael A. Pfaller (2012), 7th edition. Medical Microbiology. Elsevier saunders.
9. Koen Venema and Ana Paula do Carmo (2015). Probiotics and Prebiotics: Current Research and Future Trends. Caister Academic Press.
10. Sergio Sánchez and Arnold L. Demain (2015). Antibiotics: Current Innovations and Future Trends. Caister Academic Press.

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CO2	3	1	2	2	1	2	1	-	-	-	1	1
CO3	3	2	2	2	3	2	2	-	-	-	1	1
CO4	3	2	2	2	2	2	1	-	-	-	1	1

PRACTICALS:

MB: 205 - Molecular Biology and Recombinant DNA Technology

Course Learning Objective

1. Gives hands on experience in important molecular methods.
2. Provides hands on experience on PCR and Recombinant DNA techniques .
3. Will gain knowledge in bio informatics and molecular biology information

1. Isolation of Genomic DNA from microbes, plant/animal tissues.
2. Isolation of plasmids from Bacteria.
3. Curing of plasmids.
4. Competent cell preparation.
5. Bacterial transformation.
6. Bacterial transduction.
7. Bacterial Conjugation.
8. Mapping of bacterial genes by conjugation / transformation (problems).
9. Side directed mutagenesis
10. AMES test.
11. Screening and isolation of streptomycin mutant resistant bacteria by gradient plate technique.
12. Lethality curve construction.
13. Study of DNA methylation

14. Study of DNA repair
15. Invitro transcription assay
16. Setting of Genetic Engineering laboratory
17. Restriction enzyme analysis of plasmids
18. Recovery of DNA from gels – Electroelution and extraction of DNA from low melting agarose gels.
19. Southern blotting.
20. Western blotting for heterologous gene expression
21. Polymerase chain reaction
22. Induction of enzyme (Beta galactosidase) in Bacteria
23. Calculation of proportion of bases in nucleic acids, number of turns in DNA, length and Mol. Wts. of DNA, Tm values and buoyant densities of DNAs and DNA replication times

Course Learning Outcomes

1. Able perform DNA and plasmid isolations.
2. Be able to amplify the given gene.
3. Be able to gain practical knowledge about molecular tools.
4. Be able to create a chimeric molecule.
5. Be able to perform bioinformatics tools in genomics.

MB: 206 - Immunology and Medical Microbiology

Course Learning Objective

1. Gives hands on experience in Immuno precipitation test.
2. Provides hands on experience on various ELISA methods.
3. Will gain knowledge in immune globulins.
4. Gives hands on experience on blood related tests.
5. Given knowledge on virus cultivation.
6. Provides hands on experience on various diagnostic tests.

1. Purification of immune globulins
2. Electrophoretic separation of normal and immune serum.
3. Ouchterlony double Immuno diffusion
4. Single radial Immuno diffusion
5. Immuno precipitation test
6. Rocket Immuno electrophoresis
7. Counter current Immuno electrophoresis
8. Isolation & Identification of Rosettee cells.
9. Dot ELISA
10. Sandwich ELISA
11. Antigen Capture ELISA
12. Antibody Capture ELISA
13. ASO titre.
14. Complement fixation test
15. Widal Test
16. VDRL Test
17. Total counting of RBC & WBC
18. Differential count of WBC
19. Hemoglobin estimation
20. Latex agglutination test
21. Blood typing and Rh determination

22. Identification of pathogenic organisms based on HIV& DOT-BLOT test

Course Learning Outcomes

1. Able performs various immune precipitations tests.
2. Be able to perform various types of ELISA methods.
3. Be able to gain practical knowledge about immunoglobulin's and their separation.
4. Be able to perform widal, VDRL and types.
5. Be able to perform various staining procedures.
6. Be able to identify blood cell types.

THIRD SEMESTER

MB – 301: BACTERIOLOGY AND VIROLOGY

Course Learning Objective

1. Gives basics concepts on animal & plant virus cultivation.
2. Provides in depth knowledge on properties and purification of Viruses
3. Gives outlines on nomenclature and classification of viruses.
4. Give in-depth understanding on viral genomes and their replication.

UNIT – I

Domain Eubacteria – morphological types – cell walls, Gram positive – Gram negative eubacteria – L-forms, cell wall synthesis, antigenic properties – capsule – types, composition and function, cell membranes – structure – composition – properties.

Domain Archaea : The unique characteristics, habitats, cell wall structure, membrane structure, pigments, genome, unique enzymes, evolutionary significance.

UNIT – II

Structure and function of flagella – flagella – pili – gas vesicles – chromosomes, carboxysomes, magnetosomes and phycobolisomes – nucleoid – cell division – endospores structure, formation and germination.

Reserve food materials – polyhydroxybutyrate – polyphosphate granules – oil droplets – cyanophycin granules and sulphur inclusions.

UNIT – III

Taxonomy : Classification of bacteria according to the Bergey's manual of systematic bacteriology. Domain Archaea, Domain Eubacteria-kingdoms, classes, orders/groups. Phylogenetic relationships among different bacteria.

UNIT-IV

Plant pathogenic bacteria – Characteristics of *Xanthomonas, Pseudomonas, Agrobacterium, Corynebacterium, Erwinia, Xylella.*

Characteristics of nonpathogenic / beneficial bacteria : *Rhizobium, Azospirillum, Azotobacter, Cyanobacteria (Nostoc, Anabaena, Spirulina), Nitrosomonas, Nitrobacter, Frankid, Klebsiella, Zymomonas, Nocardia, Streptomyces, Acetobacter, Lactobacillus, Streptococcus, Leuconostoc, Serratia, pseudomonas, Alcaligenes, Bacillus, Thiobacillus, Desulfovibrio Methylophilus, Methylococcus.*

UNIT – V

History of Virology : Discovery of viruses and development of Virology (contribution of pioneers). Nature, origin and evolution of viruses. New emerging viruses.

Isolation and cultivation of viruses : Animal viruses - experimental animals, embryonated eggs, animal cell cultures-primary and secondary cell cultures. Plant viruses - experimental plants and tissue cultures. Infectivity assay methods of viruses- physical, serological and chemical approaches. Assay and maintenance of viruses, qualitative and quantitative analysis of viruses.

UNIT – VI

Purification of viruses : Extraction of viruses from tissues, clarification, concentration of viruses in clarified extracts by physical and chemical methods, further purification of viruses by rate zonal / equilibrium density gradient centrifugation, approaches and criteria of virus purity, quantification and preservation of purified virus preparations.

Properties of viruses : Biological characteristics of viruses, host-range, transmission (vector and non-vector), virus stability. Physical-morphology and structure, sedimentation, electrophoretic mobility, buoyant density. Biochemical – chemical composition, nucleic acids, proteins, enzymes, lipids, carbohydrates, polyamines, cations. Antigenic nature of viruses.

Architecture of viruses : Morphology, structure and composition of viruses-Principles of virus structure- Icosahedral, helical and binal symmetry.

UNIT-VII

Nomenclature and classification of viruses : Criteria used for naming and classification of viruses. Current ICTV classification of viruses of bacteria, plants, animals, humans, algae, fungi and protozoans. Major characteristics of the virus families / genera / groups.

Sub-viral agents : Characteristics of sub-viral agents – Viroids, Satellite viruses, Satellite nucleic acids and Prions.

UNIT – VIII

Viral genomes : Diversity of viral genomes – DNA genome – linear and circular, single stranded and double stranded. RNA genomes – positive and negative, linear and circular, single and double stranded, partite of viral genomes – mono, bi, tri and multipartite genomes.

Replication of viruses : Outlines of replication of viruses – approaches to study replication of viruses, replication strategies of viruses – Baltimore strategies of viral genome replication and expression. Replication of viruses like MS_2, T_4, Lambda, Phi X-174, M_{13}, TMV, cauliflower mosaic virus, geminivirus, parvovirus, polio, HIV, Influenza, reovirus, SV-40 and poxviruses.

Prevention and Control of viruses : The infection control policyaseptic techniques, cleaning and disinfection, protective clothing, isolation; Prevention – sanitation, vector control, vaccines and immunization; Control- chemoprophylaxis, chemotherapy (antiviral drugs, Interferon therapy), efficacy of infection control.

Course Learning Outcomes

1. Be able to explain about bacteria and viruses cultivation method.
2. Be able to describe properties of viruses and bacteria
3. Be able to classify the viruses according to ICTV and Bergey's manual
4. Be able to conversant with viral genome diversity and control of viruses.

Suggested Books:

1. Virology: 1994. 3rd ed. Frankel-Conrat et al, Prentice-Hall.
2. Fundamental Virology, 1996. 3rd ed. B.N. Fields et al. Lippincott-Raven.
3. Principles of Virology : 2000. by S.J. Flint et al., ASM Press.
4. Introduction to Modern Virology. 1994. 4th ed. Primrose and Dimmock. Blackwell Scientific Publ.
5. Principles of Molecular Virology. 2005. 4th ed. A. Cann. Academic Press.
6. Basic Virology, 1999. By Waginer and M. Hewlett, Blackwell Science Publ.
7. Plant Virology, 4th ed. 2001 by R. Hull (R.E.F. Matthews). Academic Press.
8. Applied Plant Virology. 1985. D.G.A. Walkey. Heinemann Publications.
9. Bergey's Manual of Systamatic Bacteriology, Vol. 1-4, 1st Edition.

10. Bergey's Manual of Determinative Bacteriology, 2000. 9th ed. by J.G. Holt et al. Lippincott Williams and Wilkins.
11. Fundamental Principles of Bacteriology by A.J. Salle.
12. Biology of Microorganisms by T.D. Brock, and M.T. Madigan, Prentice Hall Int., Inc.
13. General Microbiology by Stainer et al., 1999. Macmillan Educational Ltd.
14. Microbiology. 1999. 3rd ed. Prescott et al. Wm. Co. Brown Publ.
15. Principles of Microbiology. 1997. 2nd ed. R.M. Atlas. Wm. C. Brown. Publ.
16. Foundations in Microbiology. 1996. 2nd ed. K. Talaro and A. Talaro. Wm. C. Brown Publ.
17. Biology of the prokaryotes. 1998. By J.L. Lengeler et al., Blackwell Science Publ.
18. General Microbiology, 1999 by S.B. Sullia, Oxford and IBH Publishers.
19. Fields Virology. 1996. B.N. Fields, D.M. Knipe and P.M. Howley. Lippincott-Raven Publishers.
20. Encyclopedia of Virology. 1994. R.G. Webster and Allan Granoff (Eds). Vol I,II,III. Academic Press.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	1	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1
CO_4	3	1	2	1	2	2	2	-	-	-	1	1

MB – 302: AGRICULTURAL MICROBIOLOGY

Course Learning Objective

1. To provide in-depth information about plant –microbe interactions
2. To give information on principles of plant pathology
3. To give knowledge on symptoms, epidemiology / disease cycle of various plant diseases
4. To provide in-depth knowledge about various organisms for practical applications.

UNIT – I

Microbes and Plant interactions : Rhizosphere-microbial flora, rhizosphere influence on plant growth, plant pathogens and rhizophere; ectotrophic and endotrophic microrrhizal associations and importance; phyllosphere- ecology of phyllosphere flora and importance. Spermosphere

Nitrogen fixation : Ecology and biology of non-symbiotic and symbiotic nitrogen fixers, infection and nodulation, associative symbiosis, mechanism of nitrogen fixation, role of nitrogenase and hydrogenase, methods for evaluation of biological nitrogen fixation, significance of nitrogen fixation.

Biofertilizers : Cultivation and mass production of *Rhizobium* and *Azotobacter*, phosphate solubilizing bacteria, blue-green algae, carrier based inoculants. Methods of application.

UNIT – II

Decomposition of waste agricultural products : Microbiology and biochemistry of decomposition of cellulose, hemi-cellulose, starch, pectin, lignin, chitin. Factors governing the decomposition.

Microbial pesticides for biocontrol of pests and pathogens : Introduction, useful microbes (bacteria, fungi and viruses), production, formulation, economics, safety, advantages and disadvantages.

Principles of Plant Pathology : Brief history and development of plant pathology (contributions of pioneers). Types of plant diseases and their significance. Symptoms of plant diseases. Basic

procedures in the diagnosis of plant diseases. Host-pathogen interactions-virulence factors of pathogens and defense mechanisms of plants against pathogens. Environmental effects on disease development and disease epidemiology. Control of plant diseases by various approaches.

UNIT – III

Plant diseases : Symptoms, etiology, epidemiology / disease cycle and control measures with reference to the following : **Fungal :** damping of seedlings, *Phytopthora* root and stem rots, downy mildew of grapes, powdery mildew of cucurbits, rust of groundnut, *Fusarium* wilts, red rot of sugarcane, tikka disease of groundnut, blast disease of rice. **Bacterial :** Citrus canker, blight of rice, angular leaf spot of cotton. **Viral and viroid –** rice tungro, sugarcane mosaic/ streak, potato leaf roll and spindle tuber viroid diseases, tomato/tobacco leaf curl, okra yellow vein mosaic, yellow mosaic of grain legumes, pigeon pea sterility mosaic, peanut bud and stem necrosis, citrus tristeza and yellow mosaic, papaya ringspot, banana bunchy top. **Phytoplasmal :** Little leaf of brinjal.

UNIT – IV

Diseases of animals (symptoms, etiology, pathogenesis, epidemiology and prevention and control) : Poultry : Viral-New castle, infectious bursal, Marek's, egg drop syndrome, avian influenza, infectious laryngotrachites; Bacterial – Avian pasteurellosis, salmonellosis; Fungal – Aspergillosis, Aflotoxicosis.

Fish : Viral – infectious pancreatic necrosis, viral haemorrhagic septicemia, infectious haemorrhagic necrosis, Bacterial-*Pseudomonas, Chondrococcus, Vibrio,* Nocardial infections.

Prawn : Viral-Monodon baculovirus, yellow head, white spot diseases; Bacterial – *vibrio* sp. and *Pseudomonas* sp. caused diseases; Fungus- Larval mycosis caused by *Fusarium* sp., Red disease caused by mycotoxins; Protozoa – *Microsporidia, Zoothamnium* caused diseases.

Mulberry and Silkworm diseases : Mulberry: Fungal – Leaf spot, powdery mildew, rust; bacterial blight. **Silkworm:** Viral-Nuclear polyhedrosis, cytoplasmic polyhedrosis; Bacterial – Septicemia, Sotto; Fungal- White and green muscardine, aspergillosis; protozoan- pebrine.

Course Learning Outcomes

1. Be able to acquaint themselves plant –microbe interaction
2. Be able to understand the microbial -.plant pathogens
3. Be able to gain knowledge on various viral,bacterial and fungal .diseases on plants
4. Be able to know about diseases of poultry, fish ,prawn and silkworm .

Suggested Books:

1. Agricultural Microbiology. 2001. By G. Rangasamy and Bagyaraj. Printice Hall.
2. Biofertilizers in Agriculture and Forestry. 1995. By N.S. Subba Rao.
3. Plant Pathology, 1996 by G.N.Agrios. A.P.
4. Diseases of Crop Plants by Rangasami and A. Mahadevan. Printice-Hall.
5. Soil Microbiology and Plant Growth. 1995. By N.S. Subba Rao.
6. Diseases of Poultry,1995 by Calneck et al.
7. Hand book of Sericulture Technologies, 2001, 2nd edition by S.B. Dandin et al., Central Silk Board, Mysore.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	1	2	2	1	2	-	-	-	1	1
CO_2	3	1	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	1	2	2	2	-	-	-	1	1

MB – 303: a) INDUSTRIAL MICROBIOLOGY

Course Learning Objectives

1. To give information on industrial applications of microorganisms
2. To know about industrial production of various value added products
3. To provide information on microbial transformations
4. To provide in depth information on microbial production of recombinant molecules

UNIT – I

Industrial application of microorganisms : Bacteria, fungi, their characteristics and industrial products.

Screening of microbes for products : Primary and secondary screening, detection and assay of products by physico-chemical and biological assays.

Industrial strains : strategies for selection and improvement, maintenance, preservation and containment of recombinant organisms.

Bioreactors : Types and their designs and working principles, agitation, aeration, antifoam, pH and temperature controls, cleaning and sterilization, variations in fermenter design – Batch and continuous (Flow-through) fermenters, Feed-back fermenters, Tubular fermenters, membrane fermenters. Fluidized bed, packed bed bioreactor, solid state fermentations.

Inoculum and media : Inoculum preparation, substrates for fermentation media; solid state, surface and submerged fermentations. Batch and continuous fermentations, direct, dual or multiple fermentations, scale-up of fermentations and fermentation economics. Fermentation kinetics, fermentation type reactions. Computer control of fermentation processes.

Immobilization of cells and enzymes techniques : Techniques and supports – Adsorption, covalent linkage, entrapment and cross-linkage, their advantages and disadvantages, applications-microbial fermentations with immobilized cells/enzymes.

UNIT – II

Downstream processing : a multistage operation, solid-liquid separation, release of intracellular components, concentration of biological products, purification by chromatography, product formulation, monitoring of downstream processing, process integration.

Process economics : The starting point, cost estimates, process design, design exercise, capital cost estimates, the operating cost estimates.

Industrial production of ethanol, citric acid, lactic acid, acetic acid, glutamic acid, lysine, acetone, butanol, fructose syrup, vitamins C and B12, biocatalysis (microbial enzymes), antibiotics like pencillins, tetracyclines, aminoglycosides, steroids and hormones, biosurfactants, microbial lipids, xanthan gums.

Biofuels (ethanol, methane, hydrogen) : Microbial groups involved in biogas production and interaction among them, factors affecting biogas production, design of digester, feed stocks, uses of spent slurry.

UNIT - III

Commercial production of useful products (ethanol) from starch, cellulose and lignin.

Production of bacterial, yeast and mold cultures for food fermentation and their applications.

Microbial transformations : Types of bioconversion reactions, biotransformation of steroids, Application of microbial systems / processes in plastic, petroleum, mining and mineral processing industries. Microbial leaching of minerals (copper, uranium), factors affecting leaching and leaching processes, microbial mining and metal recovery.

Patenting : concept and its composition and protection of right and their limitation and intellectual property rights (IPR); patenting biotechnology inventions.

UNIT – IV

Microbial production of recombinant molecules: Requirement of recombinant molecules in pharmaceutical, health, agricultural and industrial sectors and in research / diagnostic labs. Rationale for the design of vectors for oven expression of recombinant proteins; selection of suitable promoter sequences, ribosome binding sites, transcription terminator, fusion protein tags, purification tags, protease cleavage sites and enzymes, reporter/marker genes, plasmid copy number, inducible expression systems. Over expression conditions, production of inclusion bodies, solubulisation of insoluble proteins. Purification protocols and up-scaling. Determination of purity and activity of over expressed proteins. Experiments using model systems : *E. coli*, Yeast, Baculovirus and *Agrobacterium.*

Course Learning Outcomes

1. Be able to know about microbes and bioreactors
2. Be able to understand the process economics and down stream processing
3. Be able to understand about patenting
4. Be able to gain in depth idea about recombinant therapeutic molecules

Suggested Books:

1. Principles of Fermentation Technology. 1997 by P.F. Stanbury et al. Aditya Books Ltd.
2. Basic Biotechnology, 2001. 2nd ed. ed by C. Ratiedge & B. Kristiansen, Cambridge University Press.
3. Manual of Industrial Microbiology and Biotechnology, Second edition. 1999. A.L. Demain, Editor in Chief, ASM Press.
4. Biotechnology : A test Book of Industrial Microbiology. Second edition, 2000. Ed. W.Crueger & A.Crueger.Panima Publishing corporation.
5. Industrial Microbiology : An Introduction by M.J. Waites et al. Blackwell Science. 2001.
6. Prescott & Dunn's Industrial Microbiology.Fourth edition, 1999.Edited by Gerald Reed. CBS Publishers and distributors.
7. Microbial Technology by J.H. Peppler and D. Perlman.
8. Microbial Enzymes & Biotechnology by W.M. Fogarty and C.T. Kelly.
9. Industrial Microbiology, 1999 by L.E. Casida, Jr. New Age International Publ.
10. Industrial Microbiology. 1984. A.H. Patel. Macmilan India Limited.
11. Industrial Microbiology by B.M. Miller and W. Litsky.
12. Microbial Biotechnology – Fundamentals of Applied Microbiology. 1995. by Alexander N.
13. Fermentation : A Practical Approach. 1990. B.McNiel and L.M.Harvey. IRL Press.
14. Computer Applications in Fermentation Technology : modeling and control of biotechnological processes. 1989. N.M. Fish, R.I. Fox, and N.F. Thomhill. Elsevier.
15. Biogas systems : Principles and Applications. 1996. K.M. Mital, New Age International (P) Ltd. Publ.
16. Molecular Biotechnology : Principles and Applications of recombinant DNA. 1994. by B.R. Glick and J.J. Pastermak. Panima Publ. Corporation.
17. Microbial Biotechnology; Fundamentals of Applied Microbiology. 1995. A.N. Glazer and H. Nikaido. W.H. Freeman and Company.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	1	2	2	2	-	-	-	1	1
CO_2	3	1	2	2	2	1	1	-	-	-	1	1
CO_3	3	2	1	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 303: b) DOWN STREAM PROCESSING TECHNOLOGY

Course Learning Objective

1.To give detailed knowledge about upstream and down stream processing
2.To give information on various separation processes
3.To give information on membrane separation and enrichment operations
4.To understand the various technologies such as dialysis,crystallization etc.,

UNIT-I

Processing: Industrial fermentations: Importance of upstream processing (USP) and downstream processing (DSP). Role of downstream processing in industrial fermentation process.

Downstream processing during fermentation:

1) Growth and product formation during fermentation.
2) Concept of primary (growth associated) and secondary (growth non-associated) metabolites and their control, kinetics of growth and product fermentation (growth rate, yield coefficient, efficiency etc.).
3) Production, Recovery, Assay and Applications of (a) Vitamin C (b) Antibiotics (cycloheximide, tetracyclins) (c) Microbial enzymes (Penicillin acylase, Chitinasa, Lipase) (d) Recombinant and synthetic vaccines.

Distillation and various finishing steps: crystallization, drying. Inclusion bodies and the role of genetic engineering in DSP. Economics of downstream processing.

UNIT-II

Physico- chemical basis of bio-separation processes: Recent development in product isolation, one step purification, reverses microcellular extraction, on line membrane separation. Primary separation and recovery process – cell disruption methods for intracellular products, removable of insoluble biomass separation techniques, flocculation and sedimentation and filtration methods.

UNIT-III

Membrane separation: Membrane based separation – micro and ultrafiltration theory, design and configuration of membrane separation and applications of equipment used.

Enrichment operation: Precipitation methods – salts, organic solvents, polymers, extractive separations, aqueous two-phase extraction, supercritical extraction, *in situ* product removal and integrated bioprocessing.

UNIT-IV

Separation and product resolution: Fractionation of downstream processed products by using different technologies – electrophoresis (1D and 2D gels), chromatography – (Paper, TLC, absorption, Ion exchange, Gel filtration, Affinity chromatographic separation, GC, HPLC, FPLC and Chromato focusing electrophoretic separations). Dialysis, crystallization, super liquid extraction, foam based separation.

Suggested Books:

1) Ratiedge C and Kristiansen B (2001) Basic biotechnology 2nd ed. Ed by Cambridge University press.
2) Demain AL (1999) Manual of industrial microbiology and biotechnology, Second edition. Editor in Chief, ASM Press.
3) Crueger W and Crueger A (2000) Biotechnology: A textbook of industrial microbiology. Second edition, Ed. Panima Publishing corporation.
4) M. J. Waites (2001) Industrial microbiology: An introduction by Blackwell Science.
5) Prescott and Dunn's industrial microbiology (1999) Fourth edition, Edition by Gerald Reed. CBS Publishers and distributors.
6) Colin Ratledg and Jorn Kristiansen (2001) Basic biotechnology editor (second edition). By Cambridge university press.
7) Laurence R. Weatherley (2013) Engineering Processes for Bioseparations. By Elsevier.
8) Ronald W. Rousseau (2009) Handbook of Separation Process Technology. wiley.
9) Michael C. Flickinger. (2013) Downstream Industrial Biotechnology: Recovery and Purification. By wiley.
10) Harker JH, Backhurst JR, Richardson JF (2013) Chemical Engineering, Volume 2.By Butterworth HeinemannRatiedge C and Kristiansen B (2001) Basic biotechnology 2nd ed. Ed. by Cambridge University press.

Course Learning Outcomes

1. Be able to produce and assay the various industrial products
2. Be familiar with various physic-chemical methods involved in bio separation process
3. Be acquint themselves with enrichment operations and membrane separations
4. Be able to carry out separation and product resolution

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	1	2	1	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	1	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 304: PRACTICALS: Bacteriology and Virology and Agricultural Microbiology

Course Learning Objective

1. To provide in depth knowledge on plant –microbe interaction
2. To acquaint microbial -.plant pathogens
3. To provide information on various viral, bacterial and fungal diseases on plants
4. To provide information about diseases of poultry, fish ,prawn and silkworm

1.Hanging drop experiment for bacterial motility.
2. Microbiological staining techniques – Simple, Gram negative, spore, capsular, acid fast and Lactophenol-cotton blue staining.
3. Isolation of bacteriophages from sewage water.

4. Cultivation of viruses in embryonated Chicken eggs: different routes of virus inoculation – Yolk sac, Allontoic and Chorio Allontoic Membrane (CAM)
5.Isolation and enumeration of bacteria,actinomycetes and fungi from agricultural soil
6.Isolation of nitrogen fixing bacteria from legume root nodule
7.Enumeration of rhizospheric and non rhizospheric population bacteria
8.Isolation of antagonistic fluorescent pseudomads from soil
9.Microscopic observation by root colonization by VAM fungi
10.Isolation of Azospillum from grass roots
11.Isolation of Azatobacter from rice fields
12.Isolation of Anabena from azolla plants
13.Isolation and enumeration of Phosphate solubilizers
14.Field Visit and Herbarium preparation of Local Plant-disease specimens
15. Demonstration of different bioferlizers and biopesticides types,formulation and application methods.

Course Learning Outcomes

1. Be able to acquaint themselves plant –microbe interaction
2. Be able to understand the microbial -.plant pathogens
3. Be able to gain knowledge on various viral, bacterial and fungal .diseases on plants
4. Be able to know about diseases of poultry, fish , prawn and silkworm

MB – 305: FOOD MICROBIOLOGY

Course Learning Objective

1. To provide knowledge on quality control of food products.
2. To provide in depth knowledge about food poisoning and fermentation product.
3. To understand the about fermentation technology concepts.
4. To given concentrate knowledge on microbials application modern technology.

UNIT – I

Food as substrate for microorganisms : Microorganisms important in food microbiology – Molds, Yeasts and Bacteria- General characteristics-classification and importance. Principles of food preservation. Asepsis-Removal of microorganisms, (anaerobic conditions, high temperatures, low temperatures, drying). Factors influencing microbial growth in food-Extrinsic and intrinsic factors; Chemical preservatives and Food additives. Canning, processing for Heat treatment-D, Z, and F values and working out treatment parameters.

UNIT – II

Contamination and spoilage : Cereals, sugar products, vegetables, fruits, meat and meat products, Milk and Milk products- Fish and sea foods- poultry- spoilage of canned foods. Detection of spoilage and characterization.

Food-borne infections and intoxications : Bacterial and nonbacterial- with examples of infective and toxic types- *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Staphylococcus, Vibrio,*

Yersinia; Nematodes, protozoa, algae, fungi and viruses. Food borne outbreaks-laboratory testing procedures; Prevention Measures- Food sanitation in manufacture and retail trade, Food control agencies and its regulations, Plant sanitation- Employee's Health standards- waste treatment – disposal – quality control.

UNIT – III

Food fermentations : bread, cheese, vinegar, fermented vegetables, fermented dairy products; Experimental and Industrial production methods. Spoilage and defects of fermented dairy products – oriental Fermented foods, their quality standards and control.

UNIT – IV

Food produced by Microbes : Microbial cells as food (single cell proteins)- mushroom cultivation. Bioconversions- production of alcohol-fermented beverages- beer and wine. Genetically modified foods.

Steroid conversion : Industrial Enzymes production- amylases, proteinases, cellulases, aminoacid production- glutamic acid and lysine productions. Hazard analysis and critical control points (HACCP).

Course Learning Outcomes

1. Be able to understand presentation methods.
2. Be able to understand the food infections and microbial sancer.
3. To gain knowledge on Fermentation process.
4. Be able to know the advantages and biofuels and microbial frerapeulic compounds.

Suggested Books:

1. Food Microbiology: Fundamentals and Frontiers. 4th ed. 2012. ed by M.P. Doyle et al., ASM Press..
2. Food Microbiology: 3rd ed. 2007. Adams, M.R. and Moss M.O. Royal Society of Chemistry Publication, Cambridge.
3. Food Microbiology: 4th ed., 1988. Frazier WC and Westhoff Dc. Tata McGraw Hill Publishing Company Ltd., New Delhi.
4. Principles of Fermentation Technology. 2nd Edition : 1999. Stanbury, PF., Whitekar, A and Hall, S.J. Pergamon Press.
5. Basic Food Microbiology: 2nd ed.1989. Banwart, GJ. CBS Publishers and Distributors, Delhi.
6. Food poisoning and Food Hygiene: 7th ed. 2007. Hobbs BC and Roberts D. Edward Arnold (A division of Hodder and Stoughton) London.
7. Dairy Microbiology: 3rd ed. 2002. Robinson RK., Elsevier Applied Sciences, London.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	1	2	-	-	-	1	1
CO_2	3	2	2	1	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 306: a) BIOINFORMATICS AND COMPUTERS

Course Learning Objective

1.To give information on Networking of computers
2.To provide indepth knowledge on databases and tools
3.To provide knowledge on operating systems
4.To give detailed knowledge on MS-office techniques

UNIT – I

Internet and Biologist : Internet basics, getting onto the internet, e-mail, file transfer protocols, gopher, the world-wide web, browsing and down loading from sites.

Networking of computers, need and advantages, an overview of International and Indian networks – Virtual Library-I: Searching MEDLINE; Pubmed. Virtual Library II: Science Citation Index and current awareness services; Virtual Library III: Electronic Journal; International and Indian Networks- NICNET, INFLIBNET, AGRIS.

Information Networks: WWW, HTTP, HTML, URLs, EMB net, NCBI net, Virtual tourism.

UNIT-II

Databases and Tools: Primary information resources- Protein and genomic information resources-Biological databases; primary, secondary and composite protein sequence databases, structure classification databases, DNA sequence databases, specialized genomic resources; DDBJ, Gen Bank and EMBL public DNA sequence databases; SWISSPROT Database, information retrieval from biological databases; the NCBI data model. Submitting DNA sequences to the Database and updating.

Sequence analysis : Wisconsin GCG, DNASIS, DNASTAR, CLONE MANAGER packages for nucleotide sequence analysis; sequence alignment and database searching; practical aspects of multiple sequence alignment.

Phylogenetic analysis: Phylogenetic models; multiple alignment procedures (CLUSTAL, ALIGN, PHYLIP); tree building methods and trees evaluation; rooting trees, phylogenetics software.

Predictive methods using nucleotide and protein sequences : Detection regulatory elements in the DNA; physical properties of proteins based on sequences, different protein structural motifs RNA binding domains and folding classes; Transcription factors and their DNA binding.

UNIT – III

Basics of personal computer and its components. Concept of programming Languages. Hardware and Software. The idea of operating systems.

Disk Operating Systems (DOS)- Simple commands to create directories and handle files. DOS based software for creating biological databases-dBASE,

Windows-98 operating system – Starting Windows, Desk Top items, folders and files, explorer, notepad and word pad and their applications. Features of Windows 2000

Microsoft Office - 2000 : Introduction and facilities available. Shortcut Bar; customizing toolbars; using common office techniques-starting an office application.

UNIT – IV

Microsoft Word : Starting a new document, opening existing documents, saving, closing, and printing documents, moving and copying text, proofing the documents, working with multiple documents. Creating and editing work documents; formatting documents; working the tabs, tables and columns; working with long documents; working with graphics; formatting shortcuts; streamlining repetitive work.

Microsoft Excel : Introducing Excel Worksheet, formatting and printing worksheets, workbooks, functions and formulae, excel graphics, creating databases. Solving simple statistical problems and curve fitting using Excel.

Microsoft Power point : Creating presentations, working with slides, showing slide shows, creating an organization charts and graphs, printing a presentation.

Course Learning Outcomes

1.Be able to give familiarize with various networking tools
2.Be able to acquaint themselves with construction of phylogenetic trees
3. Be able to learn basics of computers
4.Be able to create excel worksheets and slide shows

Suggested Books:

1. Biostatistics by Daniel.
2. Campbell R.C. 1974 : Statistics for Biologists, Cambridge University Press, Cambridge.
3. Statistics made simple – Do it yourself on PC. 2001. By K.V.S. Sarma. Printice Hall of India Publ.
4. An introduction to Biostatistics. 1997. Third Edition. P.S.S. Sundar Rao and J. Richard, Prentice-Hall of India Pvt. Ltd., New Delhi.
5. Fundamentals of Biostatistics. 1994. First Edition. Irfan A. Khan and Atiya Khanum, Ukaaz Publications.
6. Biostatistics. 1996. First Edition. P.N. Arora and P.K. Malhan, Himalaya Publishing House.
7. Statistics for Biologists. 1980. D.J. Finney.
8. Statistics and Experimental design : An Introduction for Biologists and Biochemists. 1994. 3rd edition. G.M. Clarke. Edward Arnald Publications.
9. Statistical methods. 1967. 6th edition. Snedecor and Cochran, Oxford Press. 1967.
10. Elements of Computer Science, 1998. S.K. Sarkar, A.K. Gupta. S. Chand & Company (Chapters – 1,2,9,12,14).
11. Microsoft Office. 1997. Stultz. Office 2000 – The Basics and beyond, 2000. A Lan Neibauer. Tata Mc Graw-Hill Publishing Comp. Part I, II, III, IV, V.
12. Windows-98, 2000, Vickram Crishra. Tata Mc Graw-Hill Publishing.
13. The Internet : Complete Reference, Harley Hahn. 1996. Second Edition. Tata Mc Graw-Hill Publication.
14. Introduction to Bioinformatics, 2001 by T.A. Attwood & D.J. Parry-Smith, Pearson Education Asia Publ.
15. Bioinformatics : Methods and Protocols, Edited by Stephem Misener and Stephen A. Krawetz. 2000. Methods in Molecular Biology Series. Humana press.
16. Bioinformatics : A Practical guide to the analysis of genes and proteins. 1998. Edited by A.D. Baxevanis and B.F.
17. Francis Ouellette. Wiley – Interscience. Computational Methods in Molecular Biology by S.L. Saizberg.
18. Computer Applications in Biotechnology. 1998. by T. Yosida. Introduction to Bioinformatics by Atwood.
19. Bioinformatics – From Nucleic Acids and Proteins to Cell Metabolism. 1995, by Schomburg and Label VCH Publ.
20. Bioinformatics : Sequence and Genome Analysis. By D.W. Mount. CSHL Press.
21. Bioinformatics : Methods and Protocols,. Ed by S. Misener and S.A. Krawetz. Humana Press, 2000.
22. Principles of Biostatistics, 2000. Marcello Pagano; Kimberlee Gauvreau, Published by Duxbury, Thomson Learning, USA.
24. Biostatistical Analysis, 1999. Jorrold H. Zar Published by Pearson Education, Inc., Delhi.
25. Statistical methods for survival data analysis, 1992. Elisa T. Lee. Published by Wiley Series in probability and mathematical statistics; John Wiley & Sons, Inc. New York.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	1	2	-	-	-	1	1
CO_2	3	2	2	1	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 306: b) Microbial genomics and proteomics

Course Learning Objective

1. To give information on biological sequences
2. To provide in depth knowledge on functional and structural genomics
3. To provide knowledge on functional proteomics
4. To give detailed knowledge on microarray

Unit-I

Introduction to microbial genomics - sequencing genomes – first generation DNA sequencing – shot gun sequencing – second generation DNA sequencing – third and fourth generation DNA sequencing

Biological sequences as information – DNA, RNA and protein as informative molecules – general characteristics of microbial genomes – genome assembly – genome annotation – identification of an open reading frame in a genome.

Microbial genomes size and content – small genomes and large genomes – genomes of organelles – symbionts and organelles – eukaryotic microbial genomes an introduction: genomes of microbial parasites – the yeast genome.

Unit-II

Functional genomics: microarrays and transcriptomes – gene chips and gene expression and its applications – RNA sequence analysis – methods in proteomics – comparative genomics and proteomics – the interactome.

Culture independent studies of microorganisms – metagenomics: principles and applications – steps in construction of a metagenomes – examples of metagenomic studies – metagenomics as a tool to reveal the vast microbial diversity.

Unit III

Functional proteomics :Molecular analysis of gene expression (RTPCR)., CRISPR (CRISPR/Cas9)- Mechanism and applications.: Gene functions through protein interactions: Identification of Protein–Ligand Interactions. Combining yeast two-hybrid and phage display data, Detecting Interactions with Protein Fragment Complementation Assays. Mass Spectrometry for Protein–Protein Interaction Mapping: Overview, Identification of substrates for E. coli GroEL, Studying the transcriptome and proteome of Escherichia coli and Saccharomyces cerevisiae.

Unit IV

Protein microarrays: overview, principle, limitations; Protein microarray Manufacturing technology, solid supports, different formats, experimental approach and detection, peptidomics; Microarray for protein-carbohydrate interaction (phage display technology); protein domain microarray; protein biochips; Antibody microarray; protein microarray for drug discovery

Course Learning Outcomes

1. Be able to give familiarize with microbial genomes
2. Be able to acquaint themselves with metagenomics
3. Be able to learn basics of protein identification method
4. Be able to gain knowledge on drug discovery

Suggested readings:

1. Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

2. Sanders E.R. and Miller J.H. (2010) I Microbiologist: A discovery based course in Microbial Ecology and Molecular Evolution, ASM press.

3. Fraser C.M., Read T. and Nelson K.E. (2004) Microbial Genomes, Springer.

4. Highlander S.K., Rodriguez-Valera F. and White B.A. (2015) Encyclopedia of Metagenomics: Environmental Metagenomics, Springer Science.

5. Dale J.W. and von Schantz M. (2007) From Genes to Genomes: Concepts and Applications of DNA Technology, 2nd Edn. Wiley publishers.

6.Protein Microarrays, edited by Mark schena, Jones and Bartlet pblisher, 2005.

7.Microbial Functional Genomics, Jizhong Zhou, Dorothea K. Thompson, Ying Xu, James M. Tiedje, A John Wiley & Sons, Inc., Publication, 2004.

8.Microarrays for an Integratiul J. But. Kho and Atte, Published in India by Ane Books, 2003.

9.Gene Cloning and DNA analysis An Introduction, Sixth Edition, T. A. Brown, Wiley Blackwell publications, A John Wiley & Sons, Inc., Publication, 2010.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	1	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	1	2	-	-	-	1	1

FOURTH SEMESTER:

MB - 401: MOLECULAR CELL BIOLOGY AND TECHNOLOGY

Course Learning Objective

1. To provide information on signaling mechanisms.
2. To gives detailed information on cancer biology.
3. To provide in depth information about culture media.
4. To gives information on transgenic technology.

UNIT – I

Cell cycles : Bacterial and eukaryotic cell cycles, molecular basis of cell cycle regulation, progress through the cell cycle. Prokaryotic and eukaryotic cell signaling mechanisms : eukaryotic cell-to-cell signaling, endocrine signaling, cyclins. Prokaryotic signaling : Quorum sensing and bacterial pheromones. Intracellular signaling. Signaling pathways. Cell cycle and growth regulation.

UNIT – II

Molecular Biology of tissue transformation and tumerogenesis in plants and animals : Terminology, experimental approaches to study transformation and tumerogenesis. **Plants :** induction of crown gall by *Agrobacterium.* **Animals :** types of tumors, physical, chemical and biological carcinogens, chromosomal changes induced by carcinogens, oncogenes (v-onc, c-onc), antioncogenes and their products, induction of tumors by DNA and RNA viruses, regulation of gene expression by oncogene products; role of oncogene products in signal transduction.

Cancer : Biology of human cancer, Growth of cells, Cell transformation. Oncogenes and Chromosome , Translocation, Amplification of Oncogenes in Tumors, Tumor Suppressor Genes, Role of Oncogenes and Tumor Suppressor Genes in the Pathogenesis of Neoplasms. Oncogene and proto-oncogene functions

UNIT – III

Cell culture media – Components of the medium, physical, chemical and metabolic functions of media. Role of serum and supplements, serum-free media, features and specifications of MEM, DHEM, RPMI and Ham's medium. Role of antibiotics in media. Cell viability and cytotoxicity. Dye exclusion and inclusion tests, colonigenic assay, macromolecular estimation, MTT based assay. **Primary culture** – Mechanical and enzymatic mode of disaggregation. Cell lines – Definite and continuous cell lines, characterization, authentication, maintenance and preservation of cell lines.

UNIT- III

In vitro fertilization – Concept of superovulation, collection, maintenance, and maturation of oocytes, fertilization of oocytes. Cloning – Concept of nuclear transfer, nuclear reprogramming and creation of Dolly. **Transgenic animals** – Retroviral, microinjection, and engineered embryonic stem cell method of transgenesis. Application of transgenic animals – Biopharming, disease models, functional knockouts. **Gene therapy** – *Ex vivo* and *in vivo* gene therapy methods, and their applications. Application of animal cell culture - Vaccine production, specialized cell types. Concepts of tissue engineering – Skin, liver, kidney, blader and heart.

Course Learning Outcomes

1. Able to understand the cell cycle and quorum sensing
2. Able to acquire with carcinogens and oncogenes.
3. Be able to acquaint with cell cultures media and cell lines.
4. Be able to acquaint themselves with transgenic animal production technology.

Suggested Books:

1. Molecular Cell Biology. 6th ed. 2007 by Lodish et al. Scientific American books, W.H. Freeman and Company.
2. Molecular Biology. 4th ed. 2008, by David Freifelder, Narosa Publ. House.
3. Text Book of Molecular Biology. 1994, by Sivarama Sastry et al, Macmillan India Ltd.

4. Advanced Molecular Biology : A Concise Reference. 1998, by R.M. Twyman. Viva Books Pvt. Ltd.
5. Instant notes in Molecular Biology,2nd ed. 2000. by P.C. Turner et al. Viva Books Pvt. Ltd.
6. Schaums Outlines – Molecular and Cell Biology. 1997. W.D. Stansfield et al., McGraw-Hill Publ.
7. Oncogenes. 1990. G.M. Cooper. Jones and Bartlett Publishers, Boston.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	1	2	2	-	-	-	1	1
CO_2	3	2	2	1	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB - 402: ENVIRONMENTAL MICROBIOLOGY

Course Learning Objective

1. To provide overview of microbial ecology.
2. To give in-depth information about soil microbiology.
3. To give knowledge about aquatic microbiology.
4. To provide information about waste treatment methods.

UNIT – I

Brief account of the habitat for microorganisms : soil, water and atmosphere. General description of soil, water, air. Physical and chemical factors influencing the distribution of microbial flora.

Populations and communities interactions : Population interactions (commensalisms, synergism, mutalism, competition, ammensalism, predation, parasitism), microbial population and community dynamics, microbial growth in open and closed environments, the kinetic principles of competition between microbial populations.

Extremophiles – acidophilic, alkalophilic, thermophilic, barophilic and osmophilic microbes – mechanisms and adoption. Halophiles – membrane variation – electron transport – application of thermophiles and extremophiles.

Methods in microbial ecology : Enrichment and isolation methods, microbial activity measurements.

UNIT – II

Soil Microbiology : Diversity of microorganisms (bacteria, fungi, algae, viruses), their distribution and abundance, methods of isolation and estimation, beneficial and antagonistic interactions among microorganisms. Survival of soil-borne pathogens.

Organic matter in soil : Nature, synthesis and decomposition. Humus formation in the soil.

Microbiology and ecological significance of ammonification, nitrification and denitrification : microbes involved, biochemistry of the above processes, factors influencing the processes.

Bio-geo-chemical cycles : Carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur and iron. Microbiological transformation of phosphorus, sulfur and iron.

UNIT – III

Aerobiology : Microbes and microbial propagules in air. Methods for microbial analysis of air. Brief account of air-borne transmission of microbes – viruses, bacteria and fungi, their diseases forcasting and preventive measures.

Aquatic Microbiology : Water ecosystems – types – fresh water (ponds, lakes, streams) – marine habitats (esturies, mangroves, deepsea, hydrothermal vents, saltpans, coral reefs). Zonations of water ecosystems- upwelling – eutrophication – food chain. Potability of water. Sampling and microbial assessment of water quality. Water purifications – sanitary quality of water. Municipal water treatment, filtration. Disinfection of water by heat, solar energy, UV and gamma radiation, ultra sound, ozone and chlorine. Brief account of major water-borne diseases and their control measures.

UNIT – IV

Waste treatment : Wastes – Solids and liquids and their characterization : Liquid wastes : microbial diversity and treatments- physical, chemical, biological – aerobic – anaerobic-primary-secondary tertiary. Solid waste treatment: saccharification-gassification – composting, utilization of solid wastes – food (SCP, mushroom, yeast) fuel (ethanol, methanol), fertilizers (composting). Liquid waste treatment – trickling – activated sludge-oxidation pond – oxidation ditch. Subterranean microbes and bioremediation. Treatment of industrial fermentation unit effluents.

Positive and negative roles of microbes in environment : Bioremediation, biodegradation of recalcitrant compounds – lignin – pesticides; bioaccumulation of metals and detoxification – biodeterioration – of paper – leather, wood, textiles – metal corrosion – mode of deterioration – organisms involved – its disadvantages – mode of prevention. GMO and their impact.

Course Learning Outcomes

1. Be able to acquaint with microbial communities and their interaction.
2. Be able to know about bio geochemical cycle.
3. Be able to understand the water borne diseases and their control measure.
4. Be able to understand the solid waste management.

Suggested Books :

1. Extremophiles, by B.N. Johri, 2000. Springer Verlag., New York.
2. Microbial Diversity, by D. Colwd, 1999. Academic Press.
3. Manual of Environmental Microbiology, second edition, by C.J. Hurst, Editor in Chief, 2002. ASM Press.
4. Microbial ecology: Fundamentals and Applications. 1998. Atlas, RM & Barta, R.
5. Aerobiology. 1997. By Tilak.
6. Environmental Microbiology by Ralph Mitechell.
7. Bioremediation Principles by Eweis.
8. Techniques in Microbial Ecology by Buruage.
9. Soil Microbiology and Plant Growth, 1995 by N.S. Subba Rao.
10. Soil Microbiology by Alexander. 2nd ed. 2011.
11. Environmental Microbiology. 1981 by W.P. Grant and P.E. Long.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	1	2	2	2	1	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	1	2	2	2	-	-	-	1	1

MB - 403: a) PHARMACEUTICAL MICROBIOLOGY

Course Learning Objective

1. To provide overview antimicrobial agents.
2. To give in-depth information about antibiotic action with the celll.
3. To give knowledge about production of pharmaceuticals.
4. To provide information about GLPs .

UNIT-I

Antibiotics and synthetic antimicrobial agents: Antibiotics and synthetic antimicrobial agents(Aminoglycosides, lactams, tetracyclines, ansamycins, macrolid antibiotics) Antifungal antibiotics, antitumor substances. Peptide antibiotics, Chloramphenicol, Sulphonamides and Quinolinone antimicrobial agents. Chemical disinfectants, antiseptics and preservatives.

Mechanism of action of antibiotics: Mechanism of action of antibiotics (inhibitors of cell wall synthesis, nucleic acid and protein synthesis)Molecular principles of drug targeting.

Drug delivery system in gene therapy, Bacterial resistance to antibiotics, Mode of action of bacterial killing by quinolinones, Bacterial resistance to quionolinones, Mode of action of non – antibiotic antimicrobial agents. Penetrating defenses – How the antimicrobial agents reach the targets (cellular permeability barrier, cellular transport system and drug diffusion).

UNIT-II

Microbial production and Spoilage of pharmaceutical Products

Microbial contamination and spoilage of pharmaceutical products (sterile injectibles, non injectibles, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and in process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (Streptokinase, Streptodornase).New vaccine technology, DNA vaccines, synthetic peptide vaccines, multivalent subunit vaccines. Vaccine clinical trials.

UNIT-III

Regulatory practices, biosensors and applications in Pharmaceuticals

Financing R&D capital and market outlook. IP, BP, USP. Government regulatory practices and policies, FDA perspective. Reimbursement of drugs and biologicals, legislative perspective. Rational drug design. Immobilization procedures for pharmaceutical applications (liposomes). Macromolecular, cellular and synthetic drug carriers. Biosensors in Pharmaceuticals. Application of microbial enzymes in pharmaceuticals.

UNIT-IV

Quality Assurance and Validation

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in

pharmaceutical industry.Regulatory aspects of quality control.Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification.Sterilization control and sterility testing (heat sterilization, D value, z value, survival curve, Radiation, gaseous and filter sterilization).Chemical and biological indicators.Design and layout of sterile product manufacturing unit.Designing of Microbiology laboratory,Safety in microbiology laboratory.

Course Learning Outcomes

1. Be able to acquaint with antibiotics
2. Be able to know antimicrobials action.
3. Be able to understand the production of pharmaceuticals
4. Be able to understand the quality assurance.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	1	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	2	2	1	1	-	-	-	1	1
CO_3	3	2	2	2	3	2	2	-	-	-	1	1
CO_4	3	1	2	2	2	2	1	-	-	-	1	1

MB - 403: b) INDUSTRIAL BASED MICROBIAL CELAN TECHNOLOGY

Course Learning Objective

1. To provide overview of organic wastes.
2. To give in-depth information biomining
3. To give knowledge biopesticides.
4. To provide information bioremediation

UNIT – I

Scope of microbial agents in industry - regarding clean environment – waste water and effluent treatment – aerobic biological treatment, carbon oxidizers, filamentous carbon oxidizers, nitrifiers, dinitrifiers. Anaerobic waste-water treatment – hydrolytic bacteria, acetogenic bacteria, methanogenic bacteria.

Compositing of solid organic wastes – *Agaicus bisporus, Bacillus stearothermophilus, Thermus sp., Fungi – Rhizomucor Pusillus.* Ensiling – to preserve the material with a minimum loss of nutritional value, commercial, microbial inoculants, *Pediococcus sp.,Sstreptococcus sp.,* some *Lactobacillus sp.* Biodegradation of Xenobiotics, Bioremediation – basic principle, biodegrade or detoxify contaminating compounds in situ, metal sequester – *Geobacter metallireducens,* radiation resistance bacteria – *Deinococcus radiodurans.*

UNIT – II

Biomining (mineral leaching) – conventional mineral mining – metal ores, *Thiobacillus ferroxidans, Leptosirillum ferroxidans,* Microbial desulphurization of coal – S*ulfolobus acidocaldarium.*

Bioinsecticides – control of insects by use of microbial pathogens - bacteria, fungi, protozoa and viruses – *Bacillus thuringiensis, Pythium, Oligandrum, Ampelomyces quiqualis,* Baculo viruses.

UNIT – III

Biopesticides – Introduction and importance of biopesticides, types of biopesticides, bioinsecticides – biofungicides – biobactericides – bionematicides – bioherbicides. Important bioinsecticides- Bt, NPV, fungal bioinsecticides (Beauveria, Metarhizium, Verticillium, Paecilomyces, Nomuraea. Mass production – formulation – application for the control of insect pests. Important biofungicides – Trichoderma, Gliocladium, *Pseudomonas fluorescens*, mass production – formulation – use in agriculture for the control of crop diseases. Biobactericide - *Agrobacterium radiobacter*, use in control of crown gall disease. Bionematicides- Verticillium, Trichoderma, control of root knot nematodes. Bioherbicides - Phytophthora , Colletotricum, advantage for the use of biopesticides – Problems in commercialization and efficacy – commercial products of biopesticides.

UNIT – IV

Bioremediation – Bioremediation definition, concept – rationale – kinds of pollution – organic, inorganic in soil, water and air – remediation by bacteria, fungi and green plants. Processes of bioaccumulation and biomagnification – microbial remediation by natural attenuation – biostimulation – bioaugmentation – application of immobilized microbes in soil decontamination.Use of genetically engineered microorganisms and bioremediation – Biodegradation of organic compounds – humification and polymerization reaction – biotransformation of metal and metal compounds – phyto-remediation use of green plants to remove pollutants – Phyto-extraction – induced phyto-extraction and continuous phyto-extraction – phyto-degradation – rhizofiltration – phyto-stabilisation – phytovolatisation of metals – phyto-remediation of organic – bioavailability and uptake – biotransformation and compartmentalization.

Course Learning Outcomes

1. Be able to acquaint various bacteria involved in composting
2. Be able to know about mineral leaching.
3. Be able to understand the production of bioinsecticides and bio fungicides
4. Be able to understand the biomagnification.

Suggested Books :

1. Microbial Technology by J.H. Peppler and D. Perlman.
2. Microbial Enzymes & Biotechnology by W.M. Fogarty and C.T. Kelly.
3. Industrial Microbiology, 1999 by L.E. Casida, Jr. New Age International Publ.
4. Industrial Microbiology. 1984. A.H. Patel. Macmilan India Limited.
5. Industrial Microbiology by B.M. Miller and W. Litsky.
6. Microbial Biotechnology – Fundamentals of Applied Microbiology. 1995. by Alexander N.

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	1	2	1	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	1	2	2	3	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB – 404: PRACTICAL: MOLECULAR CELL BIOLOGY & CELL TECHNOLOGY AND ENVIRONMENTAL MICROBIOLOGY.

Course Learning Objective

1. To provide hands on experience with the techniques used in molecular cell biology.
2. To give hands on experiments techniques used in Environmental Microbiology.

1. MTT assay
2. Trypan blue dye exclusion test
3. Agrobacterium mediated transformation
4. Culturing of HeLaS3 cells insuspension.
5. Humus estimation in the soil
6. Determination of organic matter of soil
7. Contact slide technique
8. Ammonification in soil
9. Nitrification in soil

10. Denitrification in soil
11. Isolation of antibiotic producing microorganisms from soil
12. Most Probable Number Test for coliforms
13. Quantitative analysis of water for microbial numbers (SPC)
14. Membrane filter method for detection of coliforms in water
15. Effect of heavy metals on the growth of bacteria
16. Microbial interrelationships (Synergism and Antagonism)

Course Learning Outcomes

1. Be able to perform techniques in molecular cell biology independently.
2. Be able to perform techniques in environmental microbiology.

MB - 405: Project

Course Learning Objective

1. To acquatic themselves to identify and collect scientific Research Problem formula in microbiology.

Practical experience in locating, collecting and interpreting the scientific information for the purpose of M.Sc., Microbiology project work. Students work individually under faculty / scientist supervision in Laboratories, Research labs, National Institutions to perform the procedures and record the results and present the project work at the end of the fourth semester. The project work of the student will be evaluated by seeing the performance of presentation and interpretation of the results.

Course Learning Outcomes

1. Be able to design and a research problem analyzes the results.

MB-406: a) BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

Course Learning Objective

1. To give information on ethics.
2. To give in-depth information about containment.
3. To give knowledge about regulatory affairs of pharmaceuticals.
4. To provide information about Intellectual rights .

UNIT – I

Bioethics – Introduction to Bioethics, solid and ethical issues related industrial genetically manipulated microorganisms (GMM).

UNIT – II

Biosafety – Definition, biosafety consideration, types of containments, personal practices, primary and secondary containment barriers (biosafety levels 1, 2, 3, 4), containment for production activities, practical consideration, possible hazards from industrial production and use of pathogens.

UNIT – III

Biosafety for human health and environment - Use of genetically modified microorganisms and their release in to the environment, special procedures for recombinant DNA based products. Regulatory affairs – regulatory requirements for drugs and biologics.

UNIT – IV

Intellectual property rights – Importance of Intellectual property, history of patent concept, composition of a patent, general patent information – patent laws, patentable subject matter, apply for patent, requirements for patentability, issuance of a patent, infringement of a patent. Obtain patent protection – applying for patent protection, patent prosecution, appeals and interference proceedings, applying for foreign patent protection. Patent laws in US, India and other countries.

Course Learning Outcomes

1. Be able to acquaint various ethical issues related to recombinant bacteria
2. Be able to know about various biosafety levels
3. Be able to understand the production of GMO is use
4. Be able to understand about patenting

Suggested Books :

1. Intellectual property rights on Biotechnology. K. Singh BCII, New Delhi.
2. Biotechnologies in developing countries present and future. 1993. A. Sasson. UNESCO Publishers.

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CO_2	3	1	2	1	2	2	1	-	-	-	1	1
CO_3	3	2	2	2	3	1	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	2	-	-	-	1	1

MB-406: b) MICROBIAL PRODUCTION OF ALCOHOLIC BEVERAGES

Course Learning Objective

1. To give information on role of microorganisms in brewing
2. To give in-depth information about fermentation process
3. To give knowledge about various types of whiskies.
4. To provide information about vinegar production process

UNIT – I

History, scope and Industrial important of Beverages. Types of Beverages and their significance in the society. Brewing microbiology – Microorganisms related to Beverages, their isolation, identification and small scale culturing, pure culture techniques, Microbial metabolism and nutrition, genetics of Microbial organisms, magnitude of the brewing industry.

UNIT – II

Elements of the Brewing process – Ingredients – Malt, Adjuncts, water, Hops, yeast, miscellaneous additives. Different process of Bear Brewing – Malting, Brewing, Mashing, Hop addition. Fermentation – Primary, continuous fermentation, aging and finishing. Pure culture of yeast – quality, source, maintenance of pure culture, pure culture propagation, evaluation of yeast produced, microscopic and serological tests, test fermentations, recycled yeast, separation, collection and storage. Microbial contamination. Fermentation requirements – Carbohydrates, nitrogen compounds, inorganic ions, vitamins, polyphenols, Hop compounds, lipids oxygen, yeast.

UNIT – III

Distilled Beverage Alcohol – commercial Important of alcohol, whiskey – Raw materials, mashing and conversion, fermentation, distillation, types of whiskey – Bourbon whiskey, Rye whiskey, corn whiskey, Light whiskey, Tennessee whiskey. Canadian whiskey, scotch whiskey, Irish whiskey,

Vodka, Gin, By-product recovery in whiskey synthesis, Rum, Tequila, Cordials and Liqueurs, Congeners.

Wine production – production of grape must, wine fermentation, traditional spontaneous wine fermentation, use of starter cultures, continuous wine fermentation, secondary wine fermentation, post – fermentation treatments.

UNIT – IV

Cider production – apple juice extraction, composition of apple juice, cider fermentation, cider maturation. Vinegar production – Vinegar fermentation, alcohol fermentation, acetic acid fermentation, methods of acetification in vinegar manufacture, traditional surface method trickle generators, submerged methods, finishing processes, process developments.

Course Learning Outcomes

1. Be able to acquaint with various bevarges
2. Be able to know about various beverage production process
3. Be able to understand the production of bevarages
4. Be able to understand about cidar productions

Suggested Books:

1. Molecular Biotechnology : Principles and Applications of recombinant DNA. 1994. by B.R. Glick and J.J. Pastermak. Panima Publ. Corporation.
2. Microbial Biotechnology; Fundamentals of Applied Microbiology. 1995. A.N. Glazer and H. Nikaido. W.H. Freeman and Company.
3. Biotechnology : A test Book of Industrial Microbiology. Second edition, 2000. Ed. W.Crueger & A.Crueger.Panima Publishing corporation.
4. Industrial Microbiology : An Introduction by M.J. Waites et al. Blackwell Science. 2001.
5. Microbial Technology by J.H. Peppler and D. Perlman.
6. Manual of Industrial Microbiology and Biotechnology, Second edition. 1999. A.L. Demain, Editor in Chief, ASM Press

CO-PO Mapping Matrix/Programme Articulation Matrix

	PO_1 Know ledge	**PO_2** Analysis	**PO_3** Design	**PO_4** Development	**PO_5** Modern Tools	**PO_6** Society	**PO_7** Environment	**PO_8** Ethics	**PO_9** Team work	**PO_{10}** Communication	**PO_{11}** Programme Management	**PO_{12}** Lifelong Learning
CO_1	3	2	2	2	2	2	2	-	-	-	1	1
CO_2	3	2	2	2	2	2	1	-	-	-	1	1
CO_3	3	2	1	2	1	2	2	-	-	-	1	1
CO_4	3	2	2	2	2	2	1	-	-	-	1	1