

Department of Microbiology

Syllabus

M.Sc Microbial Biotechnology



Maharshi Dayanand University
Rohtak 124001

DEPARTMENT OF MICROBIOLOGY**Credit Matrix for M.Sc. Microbial Biotechnology Program w.e.f. 2016-17**

| Semester | Core Paper | Discipline specific elective | Open elective | Foundation course | Total |
|--------------|------------|------------------------------|---------------|-------------------|------------|
| I | 28 | - | - | - | 28 |
| II | 20 | 4 | 3 | 2 | 29 |
| III | 16 | 8 | 3 | - | 27 |
| IV | 28 | - | - | - | 28 |
| TOTAL | 92 | 12 | 6 | 2 | 112 |

REQUIRED CREDITS FOR M.SC MICROBIAL BIOTECHNOLOGY TWO**YEAR COURSE: TOTAL=112****CORE PAPER=92****DISCIPLINE SPECIFIC ELECTIVE=12****OPEN ELECTIVE=6****FOUDATION COURSE=2****INSTRUCTION FOR THE STUDENTS****Course Types:**

- **Core papers (C):-** There are Core Courses in every semester. These courses are to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.
- **Discipline specific elective (E):-** Soft core is a course which can be chosen from a pool of papers. It will be supportive to the discipline of study & mandatory as per course curriculum.
- **Open Elective (OE):-**Open elective course may be from an unrelated discipline. It is Interdisciplinary/Open Elective & mandatory as per course curriculum.
- **Foundation Course (F):-** The Foundation Course is based upon the content that leads to Knowledge enhancement. It is mandatory as per course curriculum.

Choice Based Credit System
Examination scheme of M.Sc. Microbial Biotechnology (Semester system) w.e.f. the academic session 2016-17

| FIRST SEMESTER | | | | | | | | | |
|------------------------|--------------------------------|---|------------------------------------|------------|---|----|---------|-------|----------|
| S No. | Course No. | Title | Type | L | T | P | Credits | Marks | |
| | | | | | | | | Th. | Int.Ass. |
| 1 | 16MBB21C1 | Principles of Microbial Biotechnology | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 2 | 16MBB21C2 | General Microbiology | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 3 | 16MBB21C3 | Fundamentals of Biochemistry | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 4 | 16MBB21C4 | Biostatistics & Bioinformatics | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 5 | 16MBB21C5 | Techniques in Microbial Biotechnology | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 6 | 16MBB21CL1 | Lab Course I (Based on 16MCB21C1,C2) | Core | 0 | 0 | 8 | 4 | 100 | |
| 7 | 16MBB21CL2 | Lab Course II (Based on 16MCB21C3,C4,C5) | Core | 0 | 0 | 8 | 4 | 100 | |
| Sub Total | | | | 28 | | | | - | |
| SECOND SEMESTER | | | | | | | | | |
| 8 | 16MBB22C1 | Microbial Energetics and Biosynthesis | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 9 | 16MBB22C2 | Biochemical Engineering | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 10 | 16MBB22C3 | Fundamentals of Microbial Bioremediation | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 11 | 16MBB22D1 or 16MBB22D2 | Fundamentals of Infection and Immunity or Agriculture and Soil Microbiology | Discipline Specific Elective | 4 | 0 | 0 | 4 | 80 | 20 |
| 12 | | | | 4 | 0 | 0 | 4 | 80 | 20 |
| 13 | ---- | To be selected from the pool of open elective of university basket | Open Elective | 3 | 0 | 0 | 3 | 80 | 20 |
| 14 | ----- | To be selected from the pool of foundation elective of university basket | Foundation Elective | - | - | - | 2 | - | - |
| 15 | 16MBB22CL | Lab Course III (Based on 16MBB22C1 & C2) | Core | 0 | 0 | 8 | 4 | 100 | |
| 16 | 16MBB22DL | Lab Course IV (Based on 16MBB22C3 & D1/D2) | Core | 0 | 0 | 8 | 4 | 100 | |
| Sub Total | | | | 29 | | | | - | |
| THIRD SEMESTER | | | | | | | | | |
| 17 | 17MBB23DA1 OR 17MBB23DA2 | Production of Microbial Metabolites or Downstream Processing | Discipline Specific Elective | 4 | 0 | 0 | 4 | 80 | 20 |
| 18 | | | | 4 | 0 | 0 | 4 | 80 | 20 |
| 19 | 17MBB23C1 | Molecular Biology | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 20 | 17MBB23C2 | Fermented Food | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 21 | 17MBB23DB1 OR 17MBB23DB2 | Biomass, Bioenergy and Biomaterials or Bacterial Diversity | Discipline Specific Elective | 4 | 0 | 0 | 4 | 80 | 20 |
| 22 | | | | 4 | 0 | 0 | 4 | 80 | 20 |
| 23 | -- | To be selected from the pool of open elective of university basket | Open Elective | - | - | - | 3 | - | - |
| 24 | 17MBB23CL | Lab Course V (Based on 17MBB23C1, 17MBB23C2) | Core | 0 | 0 | 8 | 4 | 100 | |
| 25 | 17MBB23DL | Lab Course VI (Base on 17MBB23DA1/DA2 & DB1/DB2) | Core | 0 | 0 | 8 | 4 | 100 | |
| Sub Total | | | | 27 | | | | - | |
| FOURTH SEMESTER | | | | | | | | | |
| 26 | 17MBB24C1 | Genetic Engineering of Microorganisms | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 25 | 17MBB24C2 | Bioprocess Plant design | Core | 4 | 0 | 0 | 4 | 80 | 20 |
| 26 | 17MBB24C3 | Dissertation | Core | 0 | 0 | 20 | 20 | 300 | |
| Sub Total | | | | 28 | | | | - | |
| G. Total | | | | 112 | | | | - | |

*One paper to be opted from the choices amongst soft core papers per semester

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
16MBB21C1 Principles of Microbial Biotechnology

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Introduction and Historical developments in industrial microbiology; industrially important microbes and metabolic pathways; Various Microbial metabolites and their Overproduction; Isolation and selection of industrially important microorganisms; Preservation and maintenance of microbial cultures.

Unit II

Microbial substrates and Media formulation; Components of microbial fermentation process; Types of fermentation processes- Solid state, Static and submerged fermentations; Design of laboratory bioreactor; Types of Bioreactor: Stirred tank reactor, bubble column etc.; Downstream processing.

Unit III

Production of Microbial Biomass - Baker's Yeast, Mushroom; Production of fermented foods; Alcoholic beverages- wine, beer, etc.; Production of Ethanol, Citric acid; Amino acids and vitamins; Microbial enzymes for food, detergent and pharma industry; Biopesticides and biofertilizers

Unit IV

Production of Antibiotics; penicillin and other antibiotics; Bioweapons and Bioshields; Pigments, Microbial transformation, Production of Insulin, Interleukin, growth hormones, etc using rDNA technology.

Suggested readings:

1. Stanbury P. F., A. Whitaker, S. J. Hall. Principles of Fermentation Technology Publisher: Butterworth-Heinemann
2. W. Crueger and A. Crueger: Biotechnology. A Textbook of Industrial Microbiology, Publisher: Sinauer Associates Gerald Reed.
3. Casida L. E. J. R: Industrial Microbiology by Publisher: New Age (1968).
4. Shukla P. and Pletschke, Brett I. (Eds.) (2013) Advances in Enzyme Biotechnology, Springer-Verlag Berlin Heidelberg. ISBN 978-81-322-1094-8 (ebook); ISBN 978-81-322-1093-1 (Softcover)[URL: <http://link.springer.com/book/10.1007%2F978-81-322-1094-8>]

M.Sc. (Microbial Biotechnology)

(SEMESTER-I)

16MBB21C2 General Microbiology

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History of development of Microbiology; Development of fields of Microbiology in 20th century; The spontaneous generation controversy; Germ theory of disease; Microbes and fermentation; Physical and chemical methods of sterilization, Microscopy.

Unit II

Binomial nomenclature; Haeckel's three kingdom classification; Woese's three kingdom classification systems and their utility – Archaea, Eubacteria, Eukarya; Organization of prokaryotic and eukaryotic cell; Different groups of acellular microorganisms-Viruses, Virioids.

Unit III

General characters of microorganisms- Bacteria, Algae, Fungi and Protozoa. Classification of bacteria; Bacterial growth and metabolism. Microbes in Extreme Environment – Special features of the thermophilic, methanogenic and halophilic archaea; Photosynthetic bacteria, Cyanobacteria; microbes in other extreme conditions – Deep Ocean, and space.

Unit IV

Scope of Microbiology- Cycle of matter in nature. Microbial interactions- mutualism, symbiosis, commensalisms, predation, parasitism, amensalism, competition, bioluminescence, biodegradation, biofilms. Cleaning oil spills, microbes in composting, landfills, biopesticides, bioremediation, bioleaching; SCP; Microbial enzymes and fermented foods. Human diseases and their causative agents. Definition of aeromicrobiology, air-borne pathogens and allergens Phytopathogenic bacteria: Angular leaf spot of cotton, crown galls, bacterial cankers of citrus. Diseases caused by Phytoplasmas: Aster yellow, citrus stubborn.

Suggested readings:

1. Brock TD., Milestones in Microbiology, Infinity Books.
2. Pelczar M.J., Chan E.C.S. & Kreig N.R., Microbiology: Concepts and Application.,Tata McGraw Hill.
3. Stainier RY, Ingraham JL, Wheelis ML & Painter PR General Microbiology. Publisher: MacMillan.
4. adigan M.T., Martinko J.M. and Parker J., Brock Biology of Microorganisms: Prentice-Hall ,Inc USA.
5. Atlas R.M., Principles of Microbiology, Wm C. Brown Publishers.
6. Vandenmark P.V. and Batzing B.L., The Microbes – An Introduction to their Nature and Importance: Benjamin Cummings. Microbiology.

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
16MBB21C3 Fundamentals of Biochemistry

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Scope and importance of biochemistry; Fundamental principles governing life; Structure of water; Acid base concept and buffers; pH; Hydrogen bonding; Hydrophobic, Electrostatic and Van der Waals forces. General introduction to physical techniques for determination of structure of biopolymers.

Unit II

Classification, structure and function of carbohydrates; Biomembranes and lipids. Structure and function of amino acids and vitamins; Structure and function of proteins; protein folding; Types of nucleic acid-their structure and functions.

Unit III

Enzymes classification, mechanism of action; Factors affecting enzyme action; Immobilized enzymes; Thermodynamic principles and biological processes; Bioenergetics.

Unit IV

Metabolism of carbohydrates; photosynthesis and respiration; Oxidative phosphorylation; Lipids; Proteins and Nucleic acids; DNA replication; Transcription and Translation in Prokaryotes and Eukaryotes; Recombinant DNA technology.

Suggested readings:

1. Mathews C.K., VanHolde K.E. and Ahern K.G., Biochemistry, Benjamin /Cummings.
2. Stryer L., Biochemistry. ,W.H. Freeman and Company.
3. Devlin's Textbook of Biochemistry with Clinical correlations. John Wiley and Sons Inc.
4. Lehninger A.L., Nelson D.L., Principles of Biochemistry, M.M. Cox. Worth Publishing.
5. Robert K., Murray M.D., Granner D.K., Mayes P.A. and Rodwell V.I. Harper's Biochemistry. McGraw-Hill/Appleton and Lange.

M.Sc. (Microbial Biotechnology)
(SEMESTER-1)
16MBB21C4 Biostatistics and Bioinformatics

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Principles and practice of statistical methods in biological research; Samples and Populations; Probability distributions- addition and multiplication theorems, Baye's theorem, Binomial, Poisson, and Normal distribution; Data presentation- Types of data, Methods of data representation.

Unit II

Measures of central tendency- Mean, Median, Mode; Measures of dispersion- Range, Mean deviation and Coefficient of variation, Standard deviation, Standard error; Correlation and regression; Statistical inference- Hypothesis testing, Significance level, Test of significance for large and small samples; Parametric tests; Non parametric tests; Experimental design, Use of biostatistics softwares.

Unit-III

Bioinformatics basics; Application and research; Present global bioinformatics scenario. Databases- characteristic of bioinformatics databases, navigating databases, information retrieval system and database collaboration; Sequence databases- nucleotide sequence databases, protein sequence database, information retrieval system e.g. Entrez and SRS; Structure databases- Structure file format, Protein structure database collaboration, PDB, MMDB, FSSP, SCOP, BRENDA, AMENDA and FRENDA, Pathway databases e.g. CAZy.

Unit-IV

Tools- Need for tools, data mining tools, data submission tools e.g. nucleotide submission tools and protein sequence submission tools; Data analysis tools- nucleotide sequence analysis and protein sequence analysis tools e.g. BLAST & FASTA. Prediction tools- multiple nucleotide alignment, phylogenetic tree, gene prediction, protein structure & functions prediction. Modelling tools: 2D and 3D protein modelling.

Suggested Readings:

1. Casella G. and Berger R. L., Statistical Inference (The Wadsworth and Brooks/Cole Statistics/Probability Series) b, Brooks/Cole Pub Company.
2. Grant G. R., Ewens W.J. ,Statistical Methods in Bioinformatics: An Introduction. Springer Verlag.
3. Jagota A. Data Analysis and Classification for Bioinformatics, Bioinformatics By The Bay Press.
4. Spiegel M. R., Schiller J.J., Srinivasan R. A. , A. Srinivasan Schaum's Outline of Probability and Statistics. McGraw-Hill Trade.

M.Sc. (Microbial Biotechnology)**(SEMESTER-I)****16MBB21C5 Techniques in Microbial Biotechnology****Time: 3hrs****Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Microscopy (light microscopy and electron microscopy), Types of PCR, Metagenomics for the isolation of genes for novel enzymes; Spectrophotometry: Principles and applications of UV-Visible; Mass Spectrometry; MALDI-TOF; Atomic Absorption Spectrometry.

Unit II

Purification of microbial protein; Electrophoresis separation of protein; Characterization using- PAGE/ gel filtration method, native and SDS-PAGE; 2D-PAGE; capillary electrophoresis; IEF. Differential centrifugation and purification by density gradient centrifugation. Chromatographic methods of separation: Principles and applications of Paper; Thin layer; Gas-liquid; HPLC and FPLC.

Unit III

Antisense and RNAi technology; Protein and DNA sequencing techniques: Maxam– Gilbert sequencing, Chain-termination methods, next generation sequencing, Pyrosequencing; Genomic and cDNA library preparation; RFLP; RAPD and AFLP techniques.

Unit IV

Tracer techniques in biology: Concept of radioactivity; radioactivity counting methods with principles of different types of counters; Concept of α , β and γ emitters, scintillation counters; γ -ray spectrometers; autoradiography; applications of radioactive tracers in biology, FACS.

Suggested Readings:

1. Friefelder. D. (1982) Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2nd ed. W.H. Freeman and Company, San Fransisco.
2. Griffiths, O. M. (1983). Techniques of Preparative, Zonal and Continuous Flow Ultracentrifugation.
3. William, B.L. and Wilson, K. (1986). A Biologist Guide to Principles and Techniques Practical Biochemistry, 3 rd ed., Edward Arnold Publisher, Baltimore, Maryland (USA).
4. Slater, R.J. (1990).Radioisotopes in Biology-A Practical Approach, Oxford University Press, NewYork.

M.Sc. (Microbial Biotechnology)**(SEMESTER-I)****16MBB21CL1: Lab Course I (Based on 16MBB21C1, C2)
(Principals of Microbial Biotechnology and General Microbiology)****Time: 6 hrs****Marks: 100**

Principles of Microbial Biotechnology: Design and Preparation of Media for Bioprocesses; Isolation of industrially important microorganism from different sources using specific substrates; To study the various methods of biomass measurement; Production of ethanol from sucrose by yeast; Determination of yield coefficient and Monod's constant and metabolic quotient of *E. coli* culture on glucose.; To study the design of fermenter and its working; Production of extracellular enzymes; Ethanol production using immobilized yeast culture.

General Microbiology: Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa; Differential staining methods; Study of shape and arrangement of bacterial cells; Preparation of microbiological media; Sterilization: principles & operations; Preparation of specific media for isolation of bacteria, actinomycetes and fungi from natural sources; Sampling and quantification of microorganisms in air, soil and water; Isolation of thermophiles from compost.

M.Sc. (Microbial Biotechnology)**(SEMESTER-I)****16MBB21CL2: Lab Course II (Based on MBTC16MBB21C3, C4, C5)
(Fundamentals of Biochemistry; Biostatistics and Bioinformatics; Techniques in Microbial Biotechnology)****Time: 6 hrs****Marks: 100**

Biochemistry: Preparation of standard and buffer solutions; Use of simple techniques in laboratory (spectrophotometry-verification of Beer's law, relation between O.D. and percentage transmission; Centrifugation) Estimation of sugars, Estimation of Proteins by Lowry's method; Estimation of DNA and RNA by diphenylamine and orcinol methods; Determination of enzyme activity and study of enzyme kinetics; Separation of biomolecules by electrophoresis.

Techniques in Microbial Biotechnology: Isolation of industrially important microorganism from different sources using specific substrates; Design and Preparation of Media for Bioprocesses; Growth curve studies of bacteria/Yeasts in batch culture and calculation of maximum specific growth rate; To study the various methods of biomass measurement; Production of ethanol from sucrose by yeast; Determination of yield coefficient and Monod's constant and metabolic quotient of *E.coli* culture on glucose.; To study the design of fermenter and its working; Production of citric acid using sucrose and molasses; Production of extracellular enzymes ; Ethanol production using immobilized yeast culture.

Biostatistics and Bioinformatics: Software handling, BLAST: finding scores and E values; Sequence alignment, nucleotide restriction-site determination.; Dendrogram making (both rooted and unrooted); gene prediction, primer and oligos development using different softwares; Retrieval of gene, finding specific gene from whole-genome sequence; Developing protein structure using Ras Mol; Finding hydrophobicity in protein sequence e.g. Kitte & Doolittle; Developing a vector map using a software.

Suggested readings

1. Benson H. J. Microbiology Applications – (A Laboratory Manual in General Microbiology), Wm C Brown Publishers.
2. Cappuccino J.G. and Sherman N., A Laboratory Manual, Addison-Wesley.
3. Work T.S. and Work R.H.E., Laboratory Techniques in Biochemistry and Molecular Biology.

Elsevier Science.

**M.Sc. (Microbial Biotechnology)
(SEMESTER-II)**

16MBB22C1 Microbial Energetics and Biosynthesis

Time: 3hr**Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Basic aspects of bioenergetics– laws of thermodynamics, free energy reactions, role of ATP in metabolism, electron carriers. Microbial Nutrition, Metabolite Transport- Passive and facilitated, Primary and secondary active transport, Group translocation (phosphotransferase system), symport, antiport and uniport, transport of Iron. Microbial Growth- Definition balanced and unbalanced growth, growth curve, the mathematics of growth, Generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve.

Unit II

Respiratory metabolism: Breakdown of glucose to pyruvate: Embden-Mayer Hoff pathway, Pentose phosphate pathway; Entner-Doudroff pathway; Krebs cycle, Glyoxalate pathway, Oxidative and substrate level phosphorylation, Reverse TCA cycle, gluconeogenesis, Pasteur effect; Fermentation of carbohydrates, homo and heterolactic fermentations.

Unit III

Brief account of photosynthetic and accessory pigments - chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins; Carbohydrates- anabolism. Autotrophy, oxygenic, anoxygenic photosynthesis – autotrophic generation of ATP; fixation of CO₂, Calvin cycle, C₃, C₄ pathway. Chemolithotrophy: sulphur, iron, hydrogen, nitrogen oxidations, methanogenesis, luminescence.

Unit IV

Biosynthesis of peptidoglycan, polysaccharides, major amino acids, polyamines, Lipids, Nucleotides: Purines and Pyrimidines; Assimilation of nitrogen; Dormancy and germination; Microbial Differentiation, sporulation and morphogenesis, Cell division cycle in *E.coli* and yeast.

Suggested Readings

1. Doelle H.W. 1969. Bacterial Metabolism. Academic Press.
2. Gottschalk G. 1979. Bacterial Metabolism. Springer Verlag. Moat A.G. 1979. Microbial Physiology. John Wiley & Sons.
3. Sokatch J.R. 1969. Bacterial Physiology and Metabolism. Academic Press.
4. Moat A.G., Foster J.W., Spector M.P. Microbial Physiology, 4th Ed: Wiley India Pvt Ltd 2009

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
16MBB22C2 Biochemical Engineering

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Introduction; Engineering Units; Material Balances; Energy Balances; Growth Stoichiometry; Kinetics of enzyme catalyzed reactions: Simple enzyme kinetics- Michaelis-Menten approach, Briggs-Haldane approach, Estimation of Enzyme kinetics parameters, Enzyme Inhibition, Effects of Physicochemical factors on enzyme catalyzed reactions, Statistical approach for Medium optimization.

Unit II

Microbial Growth Kinetics: Growth parameters, Monod's model of substrate limited growth kinetics, other models of growth kinetics, Substrate and product growth inhibition, Environmental factors affecting microbial growth, Colony growth, growth of filamentous organisms in submerged culture, Growth and product formation kinetics in Fed-batch culture and continuous culture; Sterilization of air and medium: Kinetics of heat killing, Designing of Batch sterilization, Scale-up of batch sterilization, Design of continuous sterilization, Filter sterilization: Types of air filter, Theory and design of depth filters.

Unit III

Heat Transfer: Basic principle, Modes of heat transfer: Conduction, Convection, Radiation; Thermal resistance, over all heat transfer coefficient, Heat exchangers; Mass transfer: Fluid Flow and Momentum and Molecular Diffusion, Laminar versus Turbulent Flow, Aeration and agitation in bioreactor, Measurement of K_{la} value, Power requirements for mixing, Mass and heat transfer in Biological reactions; Scale-up Principles.

Unit IV

Bioprocess considerations and types of bioreactors for Microbial Culture, Animal Cell Culture, Enzymatic reactions and Waste treatment; Instrumentation and control of bioprocess: Basic structure of stirred tank bioreactor, various sensors and controls; Design of Bioprocess; Downstream process.

Suggested Readings:

1. Principles of Fermentation Technology by P. F. Stanbury, A. Whitaker, S. J. Hall. Publisher: Butterworth-Heinemann
2. Biochemical Engineering by S. Aiba, A.E. Humphrey and N.F. Millis. Publisher: University of Tokyo Press.
3. Bioreaction Engineering Principles by J. Nielson and J. Villadsen Publisher: Plenum Press.
4. Bioprocess Engineering Basic Concepts by M.L. Shuler and F. Kargi. Publisher: Prentice Hall.
5. Bioprocess Engineering Principles by P. Doran. Publisher: Academic Press.
6. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.
7. Chemical Engineering by J.M. Coulson, and J.F. Richardson. Publisher: Butterworth Heinemann.
8. Introduction to Chemical Engineering by W.L. Badger, and J.T. Banchero, Publisher: Tata McGraw Hill
9. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications

M.Sc. (Microbial Biotechnology)

(SEMESTER-II)

16MBB22C3 Fundamentals of Microbial Bioremediation

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit-I

Bioremediation- process and organisms involved; Constraints and priorities of bioremediation. Biostimulation and Bioaugmentation; Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Major pollutants and associated risks; organic pollutant degradation- Microbial aspects and metabolic aspects; Factors affecting the process; Recent developments.

Unit-II

Microbes involved in aerobic and anaerobic processes; physico-chemical properties of waste water; aerobic and anaerobic waste water treatments; use of membrane bioreactor; aquaculture effluent treatment; Aerobic sludge and landfill leachate process; aerobic digestion. Biosorption; Microbial biosorption; Mechanisms of biosorption & bioaccumulation; Chemical and physical aspects of sorption process.

Unit-III

Anaerobic digestion: methane production and important factors involved, Pros and cons of anaerobic process, biodegradation of hydrocarbons (halogenated, nitroaromatic and polycyclic aromatic hydrocarbons), Aerobic and anaerobic digesters: design; various types of digester for bioremediation of industrial effluents (distillery, pharmaceutical, textiles, paper and pulp industries)

Unit-IV

Microbial leaching of ores- process, microorganisms involved and metal recovery with special reference to copper and iron, Biotransformation of heavy metals and xenobiotics, reductive and oxidative dechlorination. Biodegradable plastics and super bug; Bioinformatics and molecular biology in bioremediation

Suggested readings:

1. Pandey A, Lasroche C, Soccol C. R and Dussop C. G. Advances in Fermentation technology (2008). Asiatech publishers Inc.
2. Mathuriya A. S. Industrial Biotechnology (2009) Ane Books Pvt. Ltd.

**M.Sc. (Microbial Biotechnology)
(SEMESTER-II)**

16MBB22D1 Fundamentals of Infection and Immunity

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Discovery of pathogenic microorganisms and development of medical microbiology & immunology as a discipline. Definitions of invasion, pathogen, parasite, pathogenicity, toxigenicity, virulence, carriers and their types, nosocomial infections, opportunistic infections, septicemia, transmission and spread of infection. Role of aggressins, depolymerizing enzymes, organotrophism. Normal microbial flora of the human body and their importance. Transmission and spread of infection. Emerging and reemerging pathogens.

Unit II

Innate and adaptive immunity; Cells and organs involved in immune system; Antigens and Antibodies- Properties and types; Haptens and Adjuvants. antigenic determinants on antibodies (isotype, allotype and idiotype), Major histocompatibility complex, antigen processing and presentation, Complement system.

Unit III

Principle of different diagnostic tests (ELISA, Immunofluorescence, agglutination based tests). Modern approaches for diagnosis of infectious diseases: Basic concepts of gene probes, dot hybridization and PCR assays. Mechanism of action of various chemotherapeutic agents (antibacterial, antifungal and antiviral). Various methods of drug susceptibility testing. Principle of drug resistance, passive and active immunization.

Unit IV

Study of important diseases with reference to symptoms, pathogenesis, transmission, prophylaxis and control. *Bacillus anthracis*, *E. coli*, *Salmonella typhi*, *Vibrio cholerae*, *Mycobacterium tuberculosis*, *Treponema palladium*, Malaria & Giardiasis; Superficial, subcutaneous, systemic and opportunistic mycoses, Hepatitis, influenza, rabies, polio, herpes, dengue fever and AIDS

Suggested Readings

1. Goldsby RA, Kindt TJ, Osborne BA. (2007). *Kuby's Immunology*. 6th edition W.H. Freeman and Company, New York.
2. Ananthanarayanan R. and C.K. Jayaram Panicker Orient Longman Text of Microbiology, 1997.
3. Mackie and McCartney Medical Microbiology Vol.1: Microbial Infection. Vol.2: Practical Medical Microbiology Churchill Livingstone, 1996.
4. Shanson D.C., Wright PSG, Microbiology in Clinical Practice., 1982.
5. Baron EJ, Peterson LR and Finegold SM Mosby, Bailey and Scott's Diagnostic Microbiology, 1990.
6. Smith, C.G.C. "Epidemiology and Infections" (1976): Medowfief Press Ltd., Shildon, England.

M.Sc. (Microbial Biotechnology)

(SEMESTER-II)

16MBB22D2* Agriculture and Soil Microbiology

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit – I

Development of soil microbiology; Distribution of microorganisms in soil; Quantitative and qualitative microflora of soils; general description of soil, types of soil, soil profile, Role of microorganisms in soil fertility; Influence of soil and environmental factors on microflora: moisture, pH, temperature, organic matter; Distribution of microorganisms in manure and composts; Influence of soil amendments on soil microflora.

Unit – II

Microorganisms in soil processes: biogeochemical cycles, Nitrogen fixation: symbiotic, non symbiotic, associative symbiotic and endophytic organisms, process of nitrogen fixation, Molecular biology of Nitrogen fixation; Microbial transformation of phosphorus, iron, sulphur and micronutrients in soil; phosphorus solubilization by phosphobacteria; sulphur; iron bacteria and their importance.

Unit – III

Interrelationships between plants and microorganisms -Rhizosphere concept - quantitative and qualitative studies – R : S ratio - Rhizoplane -spermosphere - phyllosphere microorganisms - their importance in plant growth. PGPR (plant growth promoting rhizobacteria), siderophores and antimicrobials, microbial interactions.

Unit –IV

Biofertilizer: Mass cultivation of microbial inoculants; green manuring; Microbial products and plant health; Microbial Pesticides: development and their significance; Source Organisms: Bacteria-*Bacillus thuringiensis*, Bt based commercial products, other Bacilli producing pesticides.

Suggested readings:

1. Subba Rao, N.S. (1999). Soil Microorganisms and Plant Growth. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
2. Alexander, M. (1985). Introduction to Soil Microbiology, 3rd Edition. Wiley Eastern Ltd., New Delhi.
3. Rangaswami, G. 1979. Recent advances in biological nitrogen fixation. Oxford and IBH. New Delhi.

4. Subba Rao, N.S. (1995) .Soil Micro organisms and plant growth, Oxford and IBH publishing Co. Pvt. Ltd.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
Open Elective: Microbial World: Diversity and applications

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit – I

Systematics&Biodiversity:Classification and nomenclature of microorganism.Salient featuresof different groups: Acellularmicroorganisms (Viruses,Viroids, Prions) and Cellular microorganisms (Bacteria, Algae, Fungi andProtozoa) in reference to their distribution and occurrence, morphology, mode ofreproduction and economic importance.

Unit – II

Characteristics of extremophiles:Thermophiles, Methanophiles, Alkalophiles, Acidophiles, Halophiles and Barophiles: Classification, habitats, ecological aspects andapplications.

Unit – III

Microbiological techniques:Preparation of culture media, Pure culture isolation; cultivation,maintenance and preservation/stocking of pure cultures; cultivation of anaerobicbacteria, and accessing non-culturable bacteria. Physical and Chemical methods for the control of microorganisms

Unit – IV

Scope of Microbiology:Role of microorganisms in Food industry, Pharmaceutical industry, Production ofIndustrial enzymes, Agriculture: bio-fertilizers, bio-pesticides. Environment:bioremediation, bioleaching

Suggested readings:

1. Brock TD., Milestones in Microbiology, Infinity Books.
2. Pelczar M.J., Chan E.C.S. & Kreig N.R., Microbiology: Concepts and Application.,Tata McGraw Hill.
3. Stainier RY, Ingraham JL, Wheelis ML & Painter PR General Microbiology, Publisher: MacMillan.
4. Madigan M.T., Martinko J.M. and Parker J., Brock Biology of Microorganisms: Prentice-Hall , Inc USA.
5. Atlas R.M., Principles of Microbiology, Wm C. Brown Publishers.
6. Vandenmark P.V. and Batzing B.L., The Microbes – An Introduction to their nature and Importance: Benjamin Cummings. Microbiology

M.Sc. (Microbial Biotechnology)

(SEMESTER-II)

Foundation Course: Communication Skills for Science & Technology

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

UNIT I

Basics of Technical Communication: Introduction and Structure of Communication, The Process of communication, Language as a Tool of Communication, Levels of communication, The Flow of Communication, Communication Networks, The Importance of Technical Communication.

UNIT II

Oral/visual Communication: Active Listening, Speech Structure, The Art of Delivery, Effective Presentation Strategies, Use of audio visual Aids, ICTs, Handling the Audience, Body Language, Conducting Meetings, Interviews, Group Discussion, Negotiation, Small Talk.

UNIT III

Reports: Informal and Formal: Characteristics of a Report, Types of Reports, The Importance of Reports, Formats, Prewriting, Structure of Reports, Writing the Report, Revising, Editing and Proofreading.

Writing Journal Articles: Word choice and Syntax style, Number use, References, Plagiarism.

UNIT IV

Technical Proposal and Thesis Writing Methodology

M.Sc. (Microbial Biotechnology)**(SEMESTER-II)****16MBB22CL: Lab Course III (Based on 16MBB22C1, C2)
(Microbial Energetics and Biosynthesis; Biochemical Engineering)****Lab Time: 6 hrs****M. Marks: 100**

Microbial Energetics and Biosynthesis: Determination of viable number of Bacterial cells in a given sample. Determination of bacterial growth by turbidity measurements (Bacterial growth curve). To study the microscopic measurements. To study the types of growth (synchronous, diauxic, batch). Effects of incubation temperature on the growth of microorganisms. To study the lethal effect of temperature. Effects of different pH on the growth of microorganisms. To study the bacterial growth under aerobic, microaerophilic and anaerobic conditions. Effect of salt concentration on the growth of microorganisms. Preparation of selective and differential media for the growth of microorganisms. Fermentation of different carbohydrates. Morphological, Physiological and Biochemical tests of selected bacterial cultures.

Biochemical Engineering: Study of the Rheology of Fermentation Fluids and determining their flow parameters, Production of biomass in a bioreactor (Batch/ fed batch/ continuous mode), to study the product synthesis kinetics, To study the mixing and the residence time in bioreactor. Determination of K_{La} value of fermenter, to study effects of Physicochemical factors on microbial growth, Determination of thermal death rate constant and decimal reduction time for *E. coli*. Cell disruption for endoenzymes by sonication, Preservation of industrially important bacteria by lyophilization, Extraction of Citric acid/Lactic acid by salt precipitation.

M.Sc. (Microbial Biotechnology)**(SEMESTER-II)****16MBB22DL: Lab course IV (Based on 16MBB22C3 & D1/D2)
(Fundamentals of Microbial Bioremediation Remediation, Fundamentals of Infections and Immunity)****Lab Time: 6 hrs****Marks: 100**

Fundamentals of Microbial Bioremediation: Isolations of nitrogen fixing bacteria; nitrogen fixing activity, indoleacetic acid (IAA), siderophore production etc; Bioinoculant production and quality control. Cultivation of mushrooms. Isolation of xenobiotic degrading microorganisms, Anaerobic waste water treatment of industrial dyes and effluent; Estimation of BOD & COD levels of different water systems; Bacteriological analysis of water by presumptive, confirmatory and completed tests

Fundamentals of infections and immunity: Fixation of smears for microscopy by different methods, Different staining techniques, Simple staining, Negative staining, Gram's staining, Ziehl Leishman's stain, Giemsa's staining, Drug susceptibility testing by various methods. Determine total leucocyte count (TLC) of a given blood sample, To perform differential leucocyte count (DLC) of the blood sample, Separation of serum from the blood sample, Identification of human blood groups – ABO and Rh factor, Immunodiffusion by Ouchterlony method, Immunoelectrophoresis with a given antigen, antibody system, Dot- ELISA; Demonstration of Western blotting.

M.Sc. (Microbial Biotechnology)

(SEMESTER-III)

17MBB23DA1 * Production of Microbial Metabolites

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Microbial products as primary and secondary metabolites; trophophase- Ideophase relationships in production of secondary metabolite; Role of secondary metabolites in physiology of organisms producing them; Pathways for the synthesis of primary and secondary metabolites of commercial importance; Metabolic control mechanisms: substrate induction; catabolic regulation; feedback regulation; amino acid regulation of RNA synthesis; Energy charge regulation and permeability control; Bypassing/disorganization of regulatory mechanisms for overproduction of primary and secondary metabolites

Unit II

Organic feedstock: ethanol; Acetone; Ethanol Organic acids: Production of Citric acid; Acetic acid; Lactic acid; Gluconic acid; Kojic acid; itaconic acid; Amino acids: Use of amino acids in industry; methods of production; Production of individual aminoacids (L-Glutamic acid; L Lysin; L-Tryptophan).

Unit III

Enzymes: commercial applications; production of Amylases; Glucose Isomerase; L Asparaginase Proteases Renin; Penicillin acylases; Lactases; Pectinases; Lipases; Structure and biosynthesis Nucleosides Nucleotides and related compounds.

Unit IV

Vitamins- Vitamin B12; Riboflavin; B carotene; Antibiotics: beta-Lactam antibiotics; aminoacid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and antracyclines; Nucleoside antibiotics; Aromatic antibiotics; bioplastics (PHB; PHA); biotransformation of steroids.

Suggested Readings:

1. Biotechnology. A Textbook of Industrial Microbiology, by W. Crueger and A. Crueger. Publisher: Sinauer Associates.
2. Industrial microbiology by G. Reed, Publishers: CBS
3. Biology of Industrial microorganisms By A. L. Demain.
4. Stanbury P.F.A. Whitaker and Hall. Principles of fermentation technology
5. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.
6. New Products and New Areas of Bioprocess Engineering (Advances in Biochemical Engineering/Biotechnology, 68) by T. Scheper. Publisher: Springer Verlag.

M.Sc. (Microbial Biotechnology)

(SEMESTER-III)

17MBB23DA2* Downstream processing

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Role and importance of downstream processing in biotechnological processes. An overview of bioseparation; Problems and requirements of bioproduct purification; Characteristics of biological mixtures; Downstream process economics.

UNIT-II

Physico-chemical basis of bio-separation processes. Removal of particulate matter; biomass; and insolubles: flocculation and sedimentation; centrifugation and filtration methods; Cell disruption methods; Enrichment Operations: precipitation methods (with salts; organic solvents; and polymers; extractive separations; aqueous two-phase extraction; supercritical extraction); adsorption method.

Unit III

Membrane separations: Membrane based separation theory; Types of membranes; Types of membrane processes (Dialysis; Ultrafiltration; microfiltration and Reverse Osmosis). Chromatographic separations: Paper; TLC; Adsorption; Ion exchange; Gel filtration; affinity chromatographic separation processes; GC; HPLC; FPLC; Electrophoretic separation.

Unit IV

Final product polishing and Case studies: Products polishing: Crystallization and drying; Purification of cephalosporin; Glutamic acid; Recombinant Streptokinase; Monoclonal antibodies; Tissue plasminogen activator; Taq polymerase; Insulin.

Suggested readings:

1. Chromatographic and Membrane Processes in Biotechnology by C.A. Costa and J.S. Cabral. Publisher: Kluwer Academic Publishers
2. Bioseparations: Downstream Processing for Biotechnology by P.A. Belter et al. Publisher: John Wiley and Sons Inc
3. Bioseparations by P.A. Belter, E.L. Cussler and W.S. Hu. Publisher: John Wiley and Sons Inc.
4. Biochemical Engineering Fundamentals by J.E. Bailey and D.F. Ollis. Publisher: McGraw-Hill.
5. Downstream Processing by J.P. Hamel, J.B. Hunter and S.K. Sikdar. Publisher: American Chemical Society.

M.Sc. (Microbial Biotechnology)

(SEMESTER-III)

17MBB23C1 Molecular Biology

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History of molecular biology; Nucleic acids as hereditary material; Structure of nucleic acid; Secondary and tertiary structure of nucleic acids; Types of RNA- rRNA, tRNA and mRNA; structure of ribosomes; Nucleases; Restriction and modification; Nucleic acid sequencing; DNA replication and DNA polymerases of *E. coli*.

Unit II

Transcription; RNA polymerases; Types of promoters; Reverse transcriptase and RNA replicase; Genetic code; Translation; Gene regulation at transcriptional and translational level; Operon- positive and negative control; Attenuation; Molecular mechanism of mutation; Mechanism of DNA repair.

Unit III

Molecular organization of eukaryotic genome- Structure of genomes, Chromatin; Types of DNA polymerases, Types of RNA polymerases- Transcription, Structure of primary transcript; Ribozyme, RNA processing and alternate splicing; Structure of ribosomes and translation in eukaryotes; Molecular evolution.

Unit IV

Cell division cycle- Check points in cell cycle; apoptosis and its pathways; Oncogenes-Retroviruses, Tumor suppressor p53, Telomere shortening, Ras oncogenes; Oncoproteins and gene expression; Genetic instability and cancer.

Suggested readings:

1. Lewin, B. Gene X, Oxford University Press.
2. Brown, T.A. Genomes, John Wiley and Sons Inc.
3. Brown. T.A. Molecular Biology LabFax, Bios Scientific Ltd. Oxford.
4. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. Molecular Biology of the Cell, Garland Publishing.
5. Watson, J.D, Weiner, A.M and. Hopkins, N.H Molecular Biology of the Gene Addison-Wesley Publishing.
6. Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J.E Molecular Cell Biology, W.H. Freeman and Company.

M.Sc. (Microbial Biotechnology)

(SEMESTER-III)

17MBB23C2 Fermented Food

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History and scope of fermented foods; definition and importance of fermented foods; Organisms used for production of fermented food products; Environmental parameters for fermentation process; Classification of fermentation processes for fermented foods.

Unit II

Fermented beverages- production of different types of wine and beer; Fermented foods of vegetables and fruits- Processing, microbiology, starter cultures, biochemistry, food safety of sauerkraut, pickles, Kimchi; Cereal and legume based fermented products-bread, Soya Sauce, Koji, Tempeh, Miso, Natto, Tofu, Angkkak; Indian products like Idly, Dosa, Bada.

Unit III

Microbiology of Fermented Dairy Products (Product Characteristics, Processing, Starter culture, Growth, Genetics) Buttermilk; Yogurt (probiotics, prebiotics, synbiotics); Acidophilus Milk; Bifidus Milk; Bulgarian milk; acidophilus milk; Kefir; Kumiss; Cheeses; Properties and beneficial effects of probiotic and prebiotic.

Unit IV

Fermented meat and fish products; Microbial fermentation of tea, coffee and cacao. health aspects of fermented foods.

Suggested readings

1. Kosikowski, F.V. 1997. Cheese and fermented milk foods. Frank Kosikowski and Vikram Mistry, Brooktondale, N. Y.
2. Fox, P.F. 1993. Cheese : chemistry, physics, and microbiology, London ; New York: Chapman & Hall,.
3. Wood, J. B. 1985. Microbiology of fermented foods. Volumes I and II. . Elsevier Applied Science Publishers. London, England
4. Joshi, V.K. and Pandey, A. Ed. 1999. Biotechnology. Food Fermentation, (2 Vol. set). Education Publ. New Delhi
5. R.C. Dubey and D.K. Maheshwari. Practical Microbiology
6. Jay, J.M. (2008) Modern Food Microbiology (Sixth Edition).Aspen Publishers, Inc. Gaithersburg, Maryland

M.Sc. (Microbial Biotechnology)**(SEMESTER-III)****17MBB23DB1* Biomass, Bioenergy & Biomaterials****Time: 3hrs****Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Microbial cells as products for commercial use; Selection and Improvement of Strains for biomass production; Formulation of medium for Biomass Production; Characteristics of Single-Cell Biomass-Composition; Nutritional Value and Toxicological Status.; Types of fermentation system for Biomass Production. Baker's yeast; Production of probiotic biomass; and mold cultures. Mushroom production: cultivation of different types of mushroom;

Unit II

Microbial inoculants- Selection and establishment of nitrogen fixing bacteria. Production of *Rhizobium*, *Azotobacter*, *Azospirilla*, cyanobacteria and other nitrogen fixing bacterial cultures. Quality control of bio inoculants; Phosphate solubilising bacteria; mycorrhiza; plant growth promoting rhizobacteria (PGPR); Biocontrol microbial inoculants.

Unit III

Production of Ethanol, butanol etc. by microorganisms using plant biomass; strategies for pretreatment of plant biomass for release of lignin, cellulose and hemicellulose; Saccharification of pretreated plant biomass using enzymes from fungi and bacteria- Separate hydrolysis and fermentation process (SHF), Simultaneous saccharification and fermentation process (SSF), Consolidated Bioprocess (CBP, simultaneous hexose and Pentose fermentation by yeast and bacteria; Anaerobic digestion of plant biomass for biogas production; hydrogen production by microorganism; Oleogenic yeasts and algal cultures for biodiesel production.

Unit IV

Use of Microorganisms in Producing Biomaterials, bioplastics;; restriction enzymes etc, Cyanobacterial cultures for Polyhydroxyalkanoates (PHAs); Microbial synthesis of nanoparticles and their applications, Biomineralisation by microorganisms.

Suggested reading:

1. Robert A Andersen. 2005. *Algal Culturing Techniques*. Academic Press.
2. L. M. Prescott, J. P. Harley and D. A. Klein. Microbiology-, McGraw Hill
3. N. J. Pelczar, S. Chand, R. Krieg. Microbiology- Tata McGraw Hill
4. Casida, Industrial microbiology-, L.E. New age international Ltd, Publishers. New Delhi:
5. Frazier, Food microbiology. W.C. Tata McGraw Hill.
6. Carr NG & Whitton BA. 1982. The Biology of Cyanobacteria. Blackwell
7. Bergerson F J. 1980. Methods for Evaluating Biological Nitrogen Fixation. John Wiley & Sons.

M.Sc. (Microbial Biotechnology)**(SEMESTER-III)****17MBB23DB2 * Bacterial Diversity****Time: 3hrs****Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Bacterial Classification- Basis of Bacterial classification; conventional; molecular and recent approaches to polyphasic bacterial taxonomy; evolutionary chronometers; rRNA oligonucleotide sequencing; signature sequences; and protein sequences. Differences between eubacteria and archaeobacteria.

Unit II

Organization of Bacterial Cell- Structure and function of Cell Wall; Cell Membrane; Cytoplasm; Flagella; Endoflagella; Fimbriae; Glycocalyx; Capsule; Endospore; Growth and Nutrition- Cultivation of aerobic; anaerobic and accessing non-cultureable bacteria. Maintenance and preservation of bacterial cultures; Components of media and different types of culture media. Bacterial nutrition: Transport of nutrients; Salient features of bacterial growth curve.

Unit III

Important archaeal groups- According to Brock's 2009 and Bergey's Manual of Systematic Bacteriology. Archaeobacteria: General characteristics; phylogenetic overview; genera belonging to Nanoarchaeota (*Nanoarchaeum*); Crenarchaeota (*Sulfolobus*; *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*; *Methanocaldococcus*); thermophiles (*Thermococcus*; *Pyrococcus*; *Thermoplasma*); and Halophiles (*Halobacterium*; *Halococcus*)]

Unit IV

Eubacteria- Non Proteobacteria and Proteobacteria: Morphology; metabolism; ecological significance and economic importance of following groups:

Gram Negative- Non proteobacteria (*Aquifex*, *Thermotoga*, *Deinococcus*, *Thermus*, *Chlorobium*, *Chloroflexus*, *Chlamydiae*, *Spirochaete*), Alpha proteobacteria (*Rickettsia*, *Coxiella*, *Caulobacter*, *Rhizobium*, *Hyphomicrobium*, *Agrobacterium*), Beta proteobacteria (*Neisseria*, *Burkholderia*, *Thiobacillus*), Gamma proteobacteria (*Enterobacteriaceae* family, Purple sulphur bacteria, *Pseudomonas*, *Vibrio*, *Beggiatoa*, *Methylococcus*, *Haemophilus*), Delta proteobacteria (*Bdellovibrio*, *Myxococcus*), Epsilon proteobacteria (*Helicobacter*, *Campylobacter*).

Gram Positive-Low G+C or Firmicutes (*Mycoplasmas*, *Clostridium*, *Heliobacterium*, *Lactobacillus*, *Lactococcus*, *Staphylococcus*, *Streptococcus*, *Leuconostoc*, *Bacillus*), High G+C or Actinobacteria (*Arthrobacter*, *Bifidobacterium*, *Corynebacterium*, *Frankia*, *Mycobacterium*, *Nocardia*, *Streptomyces*, *Thermomonospora*, *Propionibacterium*, *Cyanobacteria*).

Suggested readings:

1. Salle A.J., Fundamental Principles of Bacteriology.
2. Pelczar M.J., Chan E.C.S. & Kreig N.R., Microbiology: Concepts and Application, Tata McGraw Hill.
3. Stainier RY, Ingraham JL, Wheelis ML & Painter PR General Microbiology. Publisher: MacMillan.
4. Madigan M.T., Martinko J.M. and Parker J., Brock Biology of Microorganisms: Prentice-Hall, Inc USA.
5. Atlas R.M., Principles of Microbiology, Wm C. Brown Publishers.
6. Vandemark P.V. and Batzing B.L., The Microbes – An Introduction to their nature and Importance: Benjamin Cummings. Microbiology

M.Sc. (Microbial Biotechnology)

(SEMESTER-III)

Open Elective: Microbial Technology for Entrepreneurship

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Commercial Microbial Products; Introduction to bioprocess development- upstream development, downstream process, Preservation and improvement of industrially important microorganisms, Strain development by mutagenesis, protoplast fusion and Genetic engineering.

Unit II

Raw materials and media formulation for microbial culture; batch, fed batch and continuous mode of bioprocess, Types of Bioreactors and their applications: Stirred tank bioreactor & Specialized bioreactors.

Unit III

Downstream process, Choice of bioprocess plant location; Methods of estimation of Capital Cost and Operational costs of bioprocess plant, Good Lab Practices (GLP) and Good Manufacturing Practices (GMP).

Unit IV

Introduction to Bioentrepreneurship; Factors necessary for Entrepreneurship; Attributes in an Entrepreneur; Market Assessments; Managing Technology transfer and Intellectual property in biotechnology in India, Licensing of Biotechnological invention, Funding agencies in India, Basics of Patents- Types of patents; Filing of a patent application.

Suggested readings:

1. Handbook of Bioentrepreneurship by **Patzelt**, Holger, **Brenner**, Thomas (Eds.) Publisher:
2. SpringerBiotechnology. A Textbook of Industrial Microbiology, by W. Crueger and A. Crueger. Publisher: Sinauer Associates.
3. Industrial microbiology by G. Reed, Publishers: CBS
4. Bioprocess Engineering Principles by P. Doran. Publisher: Academic Press.
5. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.

**M.Sc. (Microbial Biotechnology)
(SEMESTER-III)**

**17MBB23CL: Lab Course V (Based on 17MBB23C1, C2)
(Molecular Biology, Fermented Food)**

Time: 6 hrs

Marks: 100

Molecular Biology: To study agarose gel electrophoresis of genomic DNA, To study genomic DNA isolation from bacteria and fungi, DNA isolation from humus rich soil samples and diversity study using 16s rDNA primers, To study restriction profile of isolated DNA and plasmid samples, Isolation of plasmids from E.coli DH5 α cells, Isolation of DNA fragments which carry promoter sequence, Synthesis and codon modification of bacterial hemoglobin gene, Agrobacterium mediated gene transformation studies in fungi, To prepare chemically competent cells of E. coli DH5 α and determine their transformation efficiency, To amplify the laccase/phytase/xylanase gene by Polymerase Chain Reaction, To clone the laccase/cellulase/phytase/xylanase amplicon into the TA cloning vector pGEM-T.

Fermented Food: Production of fermented milk by Lactobacillus acidophilus, Cheese fermentation, Microbial production of alcohol, acetic acid and lactic acid. Production of Traditional fermented foods such as idli and dosa and Cake.

(SEMESTER-III)

**17MBB23DL: Lab Course VI (Based on 17MBB23DA1/DA2 & DB1/DB2)
(Production of Microbial Metabolites/Downstream Processing and Biomass, Bioenergy and Biomaterials/Bacterial Diversity)**

Time: 6 hrs

Marks: 100

Production of Microbial Metabolites: Primary and secondary metabolites, Production of citric acid, acetic acid, amino acids and vitamins by microbial cultures using sucrose and molasses; Production of extracellular enzymes; Ethanol production using immobilized yeast culture. Production of antibiotics and pigments by microbial cultures.

Downstream Processing: Separation of microbial biomass from culture medium, Isolation of cell bound and intracellular product, Cell lysis and different methods, Isolation and purification of a protein by salt and solvent precipitation, Study the application of dialysis in downstream processing of a product, Product recovery and purification by different chromatography techniques such as gel filtration, ion exchange and other chromatography, Determination of molecular mass of a protein using SDS-PAGE and gel filtration chromatography, Ultrafiltration and its application in purification.

Biomass, Bioenergy and Biomaterials: To evaluate the production of alcohol from molasses & ligno-cellulosics biomass, Microbial biomass production (fungi/bacteria/yeast) in batch and fed batch cultures, To compare production of citric acid using sucrose and molasses as carbon source. Isolation of thermophilic microbes from environmental samples and screen them for hydrolytic enzymes.

Bacterial Diversity: Methods of isolation, purification and maintenance of microorganisms from different environments e.g. air, water, soil, milk and food. Staining of bacteria and actinomycetes, Use of selective media, Enrichment culture technique – isolation of asymbiotic nitrogen fixing bacteria; Isolation of symbiotic nitrogen fixing bacteria from nodules, Isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of isolated bacterial cultures. To study bacterial diversity using metagenomic techniques.

Suggested Readings:

1. Molecular Cloning : A Laboratory Manual (3-Volume Set) by J. Sambrook, E.F. Fritsch and T.

Maniatis. Publisher : Cold spring Harbor Laboratory Press

2. Introduction to Practical Molecular Biology by P.D. Dabre. Publisher:: John Wiley and Sons Inc.

M.Sc. (Microbial Biotechnology)

(SEMESTER-IV)

17MBB24C1 Genetic Engineering of Microorganisms

Time: 3hrs

Marks: 80

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit-I

Value addition in industrially important microorganisms using recombinant DNA technology; Basic techniques involved; Essential enzymes used in recombinant DNA technology; Cloning vectors; Cloning strategies. Cloning and selection of individual genes, gene libraries: cDNA and genomic libraries; Design of vectors for the over expression of recombinant proteins: selection of suitable promoter sequences, fusion protein tags, protease cleavage sites and enzymes, inducible expression systems; organelle specific expression of cloned gene.

Unit-II

Mutagenesis and directed evolution of microbes. Different expression systems- Cloning in bacteria other than *E. coli*; cloning in *Saccharomyces cerevisiae*; cloning in GRAS microorganism; Gene regulation- RNA interference: antisense RNA technology. Bioethics, Biosafety and IPR issues.

Unit-III

PCR methods, PCR optimization, PCR cloning, real-time PCR, and PCR application in diagnostics; DNA sequencing methods. *In vitro* mutagenesis of cloned gene; Proteomics- basic concept and importance. Metagenome: DNA isolation from diverse sources, library formation, screening of clones: functional screening, sequence based and high-throughput screening.

Unit-IV

Nucleic acid sequences as diagnostic tools: Detection of sequences at the gross level, single nucleotide polymorphisms (SNPs), importance of SNPs, forensic applications of VNTRs. New drugs and new therapies for genetic diseases: recombinant proteins for therapeutic use. Recombinant bacterial vaccines, Recombinant viruses as vaccines, Plants as edible vaccines, DNA vaccines, selecting targets for new antimicrobial agents, *In vivo* expression technology (IVET), and signature-tagged mutagenesis.

Suggested Reading:

1. Nicholl D. S. T. 2008. An Introduction to Genetic Engineering, Cambridge University Press.
2. Glick BR, Pasternak JJ. 2003. Molecular Biotechnology. ASM Press Washington D.C.
3. Old and Primrose 2008. Principles of Gene Manipulation. Blackwell Scientific Publication.
4. Brown T.A. 2010. Gene Cloning. Blackwell Publishing.

M.Sc. (Microbial Biotechnology)**(SEMESTER-IV)****17MBB24C2 Bioprocess Plant Design****Time: 3hrs****Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Introduction and plant layout plan: Material and energy balance calculations; Facilities design: General design information; Site Selection- factors influencing the selection, rural and urban locations of sites, optimum decision on choice of site and analysis; Process Flowsheeting; Plant Layout- Types of production, types of layouts, advantages and disadvantages of layout, factor affecting layout, systematic layout planning.

Unit II

Selection and Specification of bioprocess equipments (upstream and downstream); Piping and Valves for Biotechnology; Pressure Relief System; Material handling: Significance, Principles of material handling; various utilities for bioprocess plant. Bioprocess validation: Introduction, Validation of Systems and Processes including SIP and CIP

Unit III

Development of Bioprocess; Bioreactor design; Analysis and Stability of Bioreactors; Bioprocess Optimization: Full factorial, partial factorials experimental designs, Response Surface Methodology, Pontryagin's Maximum Principle, Optimization of biomass production; optimization of metabolite production.

Unit IV

Bioprocess modelling: equation models, non equation models -Neural network model and Fuzzy modelling. Bioprocess Economics: General fermentation process economics; Capital Investment estimation; Operating Cost estimation; Environmental Assessment of Bioprocess: Structure of Method, Impact Categories and Groups, Calculation of Environmental Factors; Case studies: Traditional Products and Recombinant Products; Introduction to Good manufacturing practices and GLP; Intellectual Property Right .

Suggested Readings

1. Perry, R.H. and Green, D.W., Chemical Engineers Handbook, McGraw-Hill.
2. Meyers, F.E. and Stephens, M.P., Manufacturing Facilities Design and Material Handling, Prentice Hall.
3. Peter, Max S. and Timmerhaus, Klaus D, Plant Design and Economics for Chemical Engineers, McGraw Hill.
4. Sinnott, R.K., Coulson, J.M. and. Richardsons, J.F Chemical Engineering, Butterworth-Heinemann.
5. Peters M. and Timmerhaus K, Plant Design and Economics for Chemical McGraw-Hill.
6. Process Plant Layout and Piping Design by E. Bausbacher and R. Hunt. Publisher:Prentice Hall PTR.

M.Sc. (Microbial Biotechnology)

(SEMESTER-IV)

17MBB24C3 Dissertation in Microbial Biotechnology

Marks: 300

Note: The Dissertation will be based upon research and actual bench work. It will be carried out IVth Semester, but review of literature etc. will be initiated in the IIIrd Semester in order to give maximum time for working of students. The dissertation will be submitted at the end of semester and will be evaluated by external and internal examiners. The dissertation topics and date of submission will be decided by Departmental committee.