Department of Microbiology

Syllabus and Scheme of Examination

M.Sc Microbial Biotechnology

Maharshi Dayanand University
Rohtak 124001

Students who graduate with MSc. (Microbial Biotechnology) will,

PSO1: Have significant knowledge on various aspects of Biotechnology with special reference to microbes and their products.

PSO2: Expertise in laboratory techniques of basic microbiology, especially with regard to isolation, characterization of industrially important microbes.

PSO3: Deeper understanding of fermentation technology, up-scaling and downstream processing for production of microbial metabolites.

PSO4: Have insights into the various aspects of bioprocess plant design and biochemical engineering

PSO5: Acquire technical skills especially in regard to industrially important metabolites and their production.

PSO6: Have ability to plan and execute experiments as well as to analyze & interpret data for any rese.

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:-** 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:-** 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**:-Open elective course may be from an unrelated discipline. It is Interdisciplinary/Open Elective & mandatory as per course curriculum.
- **Foundation Course**:- 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

S.No.	Course No.	Title	Type	L	T	P	Credits	Marks Th.	Marks Int.Ass.
FIRST SEMESTER									
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 on16MBB21C1, C2)	Core	0	0	8	4	100	
7.	16MBB21CL2	Lab Course II (Based on 16MBB21C3, 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	Fundamentals of Infection and Immunity	Discipline Specific Elective	4	0	0	4	80	20
12.	16MBB22D2	Agriculture and Soil Microbiology		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	0	0	2	-	
15.	16MBB22CL1	Lab Course III (Based on16MBB22C1, C2)	Core	0	0	8	4	100	
16.	16MBB22CL2	Lab Course IV(based on16MBB21C3 & 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.			CP(Hard)	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	0	0	3	80	20
24.	17MBB23CL	Lab Course V (Based on17MBB23C1, C2)	Core	0	0	8	4	100	
25.	17MBB23DL	Lab Course VI(Based on17MBB23 DA1/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
27.	17MBB24C2	Bioprocess Plant design	Core	4	0	0	4	80	20
28.	17MBB24C3	Dissertation	Core	0	0	20	20	300	
Sub Total			**28**						
G. Total			**112**						

L- Lecture, T- Tutorial, P- Practical

M.Sc. (Microbial Biotechnology)

(SEMESTER-I)
16MBB21C1 - Principles of Microbial Biotechnology

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course outcomes:

CO1: This course is designed to develop an understanding of an applied aspect of microbes in industry.
CO2: The course gives insight into the development of bioprocess strategy including different phases of the bioprocess: Upstream development, production and downstream.
CO3: The course focuses on techniques used in industry for production of microbial products thus it enables the students to enter the industry with essential knowledge of Microbiology and fermentation 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

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, Interluekin, 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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
On the completion of this course students will learn the following:
CO1: Basic instrumentation in microbiology and historical details about the development of microbiology.
CO2: The characteristics of bacteria, fungi and viruses and details about classification of these.
CO3: Scope of microbiology in diversified areas.

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, Viriods.

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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
On the completion of this course students will be able to learn the following:
CO1: The significance of physical forces and chemical reactions in the biomolecules.
CO2: The student gets the basic understanding about the universal biochemical reaction in a basic unit of life i.e., Cell.
CO3: They will also understand the reason of metabolic disorders at molecular level.
CO4: Structure and functions of different biomolecules (e.g. DNA, RNA, Proteins & Carbohydrates)

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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
Students who complete this course will be able to learn:
CO1: The roles biostatistics and general principles of biostatistics
CO2: Practical importance of key concepts from probability and inference, inductive versus deductive reasoning, including related biostatistics techniques
CO3: Experimental design and use of biostatistics softwares
CO4: Bioinformatics databases, perform text- and sequence-based searches.
CO5: Multiple sequence alignment, sequence alignment the secondary and tertiary structures of protein sequences.

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., EwensW.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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
On completion of the course, students are able to understand:
CO1: Microscopy (light microscopy and electron microscopy),
CO2: Gene cloning and PCR allow students to make a large amount of DNA from only a small fragment. They also understand how do these technologies work?
CO3: Students learn the Purification of microbial protein and their electrophoretic separation and characterization.
CO4: They learn the analytical techniques like Gas-liquid; HPLC and FPLC. Students will learn the application of antisense and RNAi technology;
CO5: They also understand about DNA sequencing technique, Radioactivity: and about molecular markers after completion of this course

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. Freemen 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 & 16MBB21C2)

Total Marks: 100
Time: 4 hours

Course Outcomes
On completion of the course, students are able to:
CO1: Prepare media and isolate and cultivate microbes from various sources
CO2: Learn the microscopic characteristic features of microbes.
CO3: Isolate and quantify various groups of microorganisms
CO4: Learn various methods of biomass measurement
CO5: Produce various metabolites and Learn the design of fermenter and its working

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 16MBB21C3, 16MBB21C4 & 16MBB21C5)

Total Marks: 100
Time: 4 hours

Course Outcomes

On completion of the course, students are able to learn:

CO1: The basis and working of simple techniques in laboratory like spectrophotometry, centrifugation etc.
CO2: Estimation of various macromolecules like sugar, protein , DNA and RNA
CO3: Isolate of industrially important microorganisms
CO4: Steps in the production of citric acid, enzymes and ethanol
CO5: Software handling, BLAST,Sequence alignment, nucleotide restriction-site determination prier design, Developing protein structure, a vector map, Phylogenetic analysis using Dendrogram

Biochemistry: Preparation of standard and buffer solutions; Use of simple techniques in laboratory (spectrophotometery-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/Yeast*s* 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 an; E values; Sequence alignment, nucleotide restriction-site determination,; Dendrogram making (both rooted and unrooted); gene prediction, primer and oligos development using different softwares; Retrival 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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcome

On completion of the course, students are able to understand

CO1: Nutritional requirements and nutritional grouping of microorganisms, Mechanism involved in transport of nutrient.
CO2: Types of culture media, isolation of pure cultures and salient features of microbial growth
CO3: Photosynthetic and Respiratory metabolism and the Concept of Chemolithotrophy
CO4: Metabolic pathways of Biomolecules
CO5: Microbial Differentiation and Cell division cycle in *E. coli* and yeast

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;EntnerDoudroff 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 CO_2, 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 AG. 1979. Microbial Physiology. John Wiley & Sons.
3. Sokatch JR. 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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes

CO1: Develop the ability to operate lab-scale bioreactor and also upscale the bioprocess.
CO2: Develop the ability to model growth and product formation kinetics.
CO3: To develop an understanding of Kinetics of Enzymatic reaction.
CO4: To teach various statistical methods of optimization of the bioprocess.
CO5: It enables the students to enter the industry with required knowledge of concepts related to Fermentation 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

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 Physiochemical 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 Kla 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. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.
6. Chemical Engineering by J.M. Coulson, and J.F. Richardson. Publisher: Butterworth Heinemann.
7. Introduction to Chemical Engineering by W.L. Badger, and J.T. Banchero, Publisher: Tata McGraw Hill
8. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
16MBB22C3 - Fundamentals of Microbial Bioremediation

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcome
On the completion of the course students are able to understand

CO1: Microbial and metabolic aspects of bioremediation
CO2: Microbiology and processes involved in the bioremediation of waste water
CO3: Various types of digester for bioremediation of industrial effluents
CO4: Microbial leaching of ores, microorganisms involved in metal recovery. Biotransformation of heavy metals and xenobiotics

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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes

On completion of the course, students are able to understand

CO1: Basis of host-parasite relationship

CO2: Concept of antigen and antibodies and overview of development of immune response

CO3: Principals of different diagnostic tests and Modern approaches for diagnosis of infectious diseases

CO4: Few important bacterial, viral and fungal diseases with regard to causative agent, pathogenesis, symptoms, transmission, control measures, epidemiology and diagnosis

CO5: Various means of prevention and treatment of infectious diseases

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 typhii, 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

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
On the completion of the course students are able to understand

CO1: Process of nitrogen fixation and its molecular biology.
CO2: Microbial transformation of phosphorus, iron, sulphur and other micronutrients in soil.
CO3: The role of plant growth promoting rhizobacteria
CO4: Different types of plant-microbes interactions.
CO5: Study of biopesticides and biofertilizers.

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)
16MBB22CL -: Lab Course III (Based on 16MBB22C1 & 16MBB22C2)

Total Marks: 100
Time: 4 hours

Course outcomes

CO1: To study the types of growth (synchronous, diauxic, batch).
CO2: Effects of various parameters on the growth of microorganisms.
CO3: Morphological, Physiological and Biochemical tests of selected bacterial cultures
CO4: Production of biomass in a bioreactor (Batch/ fed batch/ continuous mode), to study the product synthesis kinetics,
CO5: Preservation of industrially important bacteria

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. Ferrmentation 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 KLa value of fermenter, to study effects of Physiochemical 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 & 16MBB22D1 or D2)

Total Marks: 100
Time: 4 hours

Course outcomes

CO1: Isolations of nitrogen fixating bacteria and studying their activity, Bio-inoculant production and quality control.
CO2: Isolation of xenobiotic degrading microorganisms,
CO3: Bacteriological analysis of water by presumptive, confirmatory and completed tests
CO4: Isolation of medically important organisms and their characterization and drug susceptibility testing by various methods
CO5: Various immunodiagnostic techniques like agglutination, precipitation, ELISA and molecular diagnostic techniques like PCR

Fundamentals of Microbial Bioremediation: Isolations of nitrogen fixating 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, ZiehlLeishman'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)
16MBB23DA1 - Production of Microbial Metabolites

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course outcome:
On completion of the course, students are able to understand

CO1: Microbial metabolites, their synthesis and types
CO2: Relationship between Primary and Secondary metabolites and the role of secondary metabolites in physiology of organisms producing them
CO3: Pathways for the synthesis of primary and secondary metabolites
CO4: Industrial production and applications of important metabolites
CO5: Concept of Bioplastics (PHB; PHA) and Biotransformation of steroids

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)
16MBB23DA2 - Downstream processing

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Objectives:
On the completion of this course students will be able to learn the following:
CO1: To learn about the basic principles involved in the purification of metabolites of commercial importance.
CO2: To learn the improvements in the downstream processing of existing commercial products like insulin, Taq polymerase etc.
CO3: To learn different cost-cutting strategies in the downstream processing of products.

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)
16MBB23C1 - Molecular Biology

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes
On completion of the course, students are able to understand:
CO1: Structure and types of Nucleic acids, also students will learn about Restriction and modification system.
CO2: The process of Transcription and enzymes involved in replication and DNA repair.
CO3: The mechanism of Gene regulation at transcriptional and translational level, Operon concept
CO4: Molecular organization of eukaryotic genome- Structure of genomes, Chromatin; Types of DNA polymerases
CO5: Students will learn about the Cell division cycle- Check points in cell cycle; apoptosis and its pathways and complete cancer biology.

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)
16MBB23C2 -Fermented Food

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes:
On the completion of the course students are able to understand
CO1: Study of different types of fermented foods, their production, importance and scope.
CO2: Environmental parameters and classification of fermentation processes for fermented foods.
CO3: Isolation of microorganisms from different fermented foods e.g. curd, idli and dosa batter etc.
CO4: Screening of various lactic acid bacteria for bacteriocin production and their antimicrobial activity.
CO5: Production of sauerkraut, wine, citric acid etc. and the role of bread yeast in bread making.

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)
16MBB23DB1 -Biomass, Bioenergy & Biomaterials

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course outcomes:
On the completion of this course students will be able to learn the following:
CO1: To learn about the basic principles involved in the production of single cell protein, biopesticides and biofertilizers.
CO2: To learn the process for the production of renewable energy from lignocellulosic biomass using microorganisms.
CO3: To learn the production of different materials (nanomaterials, bioplastics) using microorganisms.

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)
16MBB23DB2- Bacterial Diversity

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes
On completion of the course, students are able to understand
CO1: Basis of Bacterial classification: conventional; molecular and recent approaches
CO2: The Organization of Bacterial Cell
CO3: Cultivation, maintenance and preservation of bacterial cultures.
CO4: General characteristics of Archaebacteria and their phylogenetic overview
CO5: Overview of Bacterial Diversity: Morphology, Metabolism, Ecological Significance and Economic importance

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 archaebacteria.

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. Archaebacteria: 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, PropionibacteriumCyanobacteria*).

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. 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.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
16MBB23CL: Lab Course V (Based on 16MBB23C1 And 16MBB23C2)

Total Marks: 100
Time: 4 hours

Course outcomes
On completion of the course, students are able to understand various techniques for:
CO1: Study of DNA, RNA and protein
CO2: Diversity analysis
CO3: Cloning of a gene
CO4: Cloning, Screening and selection of a protein
CO5: Production and microbiology of various fermented food

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 DH5α 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 DH5α 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.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
16MBB23DL: Lab Course VI (Based on 16MBB23DA1/DA2 & 16MBB23DB1/DB2)

Total Marks: 100
Time: 4 hours

Course outcomes
On completion of the course, students are able to understand various techniques for:
CO1: Production of primary and secondary metabolites
CO2: Downstream processing of a product
CO3: Production and separation of microbial biomass from culture medium
CO4: Microbial biomass production (fungi/bacteria/yeast) in batch and fed batch cultures
CO5: Isolation, purification and maintenance of microorganisms from different environments

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)
16MBB24C1 - Genetic Engineering of Microorganisms

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes
On completion of the course, students are able to understand
CO1: Different tools and techniques of gene manipulation
CO2 The techniques to clone genes
CO3: Learn to produce recombinant protein
CO4: The application of molecular biology for product development.

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)
16MBB24C2 - Bioprocess Plant Design

Theory Marks: 80
Internal assessment: 20
Time: 3 hours

Course Outcomes
CO1: The course gives insight into various concepts used in the industry such as Bioprocess plant layout, site selection, Analysis of economics for predicting capital Investment. bioreactor engineering, relief system, material handling and bioprocess validation, economic and environmental assessment of bioprocess.
CO2: It makes the student familiar with the concept such as Intellectual property right, Good lab Practices, Good manufacturing practices.
CO3: The course gives knowledge of the key elements used in industry and also develops technical skills to succeed as an entrepreneur.

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.

Unit IV
Bioprocess modelling: equation models, non equation models. 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)
16MBB24C3 -Dissertation in Microbial Biotechnology

Total Marks: 300

Course Outcomes

On completion of the course, students will acquire

CO1: In-depth knowledge of the current research and development work in microbiology
CO2: The ability to plan and carry out tasks in given framework of thesis
CO3: The capability to clearly present and discuss the planned work/task both in written and spoken English.
CO4: Capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.

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.