M. G. Science Institute (Autonomous)
Ahmedabad 380 009, Gujarat, India.

Proposed Syllabus

M.Sc. MICROBIOLOGY SYLLABUS
Effective From June 2024

Preamble:

In pursuit of academic excellence and the advancement of knowledge in the field of microbiology, the Master of Science (MSc) program is designed to equip students with a comprehensive understanding of microbiological principles, techniques, and applications. Rooted in a commitment to scientific inquiry, critical thinking, and ethical practice, these programs aim to cultivate a new generation of professionals capable of contributing to the diverse realms of microbiology, including healthcare, biotechnology, environmental science, and beyond.

Through a rigorous curriculum encompassing fundamental microbiological concepts, laboratory methodologies, and interdisciplinary perspectives, students will be empowered to explore the intricate microbial world and its significance in various contexts. Emphasizing both theoretical knowledge and practical skills, the syllabus is structured to foster intellectual curiosity, problem-solving abilities, and a holistic understanding of microbial processes and their implications.

Furthermore, recognizing the dynamic nature of microbiology and the continuous evolution of scientific knowledge, these programs are designed to instill adaptability, innovation, and a lifelong commitment to learning. By engaging with cutting-edge research, technological advancements, and real-world challenges, students will be prepared to navigate the complexities of the microbial world and make meaningful contributions to scientific discovery and societal well-being.

In alignment with global standards of excellence and guided by principles of inclusivity and diversity, the MSc program in microbiology is dedicated to nurturing a supportive learning environment that values collaboration, integrity, and respect for all individuals. Aspiring to cultivate leaders and scholars who are poised to address the complex microbiological issues of the 21st century, these programs uphold a steadfast dedication to excellence, innovation, and ethical conduct in all aspects of microbiological practice and scholarship.

Goyal

PROGRAMME OUTCOMES (POs)

The programme of master's in microbiology focuses in-depth on the study of microorganisms by imparting classical and modern knowledge and skillsets to the students which makes them competent to thrive in research and industries pertainingto pharmaceuticals, bioprocess technology, environmental protection, in the domainsof intellectual property rights and bioethics.

- **PO1** Imparting theoretical and experimental skills in microbiology.

- **PO2** Enabling young minds to grasp effective communicational skills in the domain of microbiology with scientific writing and communication.

- **PO3** This programme, with dissertation projects, imparts competent skills to thrive in research institutions and industries.
- **PO4** Sensitizes students to pursue scientific advancements in microbiology while embracing ethics and environmental safety.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

- **PSO1** The knowledge of microbes including prokaryotes, eukaryotes, and archaea is provided in depth with their diversity, health benefits, and hazards with their industrial and environmental use.

- **PSO2** The programme emphasizes for development of potential recombinant microorganisms under ethical guidelines to produce industrial products at the commercial level.

- **PSO3** Significant portion of this programme is dedicated to food, agriculture, and environmental microbiology along with the focus on monitoring control of various products and processes in synchrony with the guidelines of the government,international norms, and of control agencies.

- **PSO4** In-depth knowledge and skillsets are addressed with respect to bioethics, environmental safety, biosafety, and intellectual property rights in the domain of microbial technology.

- **PSO5** The programme also involves activities for the round development of students and to develop an urge of research dissertation work with interactiveseminars, assignments, and group discussions along with ethical and biosafetytraining.

Goyal

- There shall be four theory papers each of four hours (3+1) duration and two practicals each of eight hours' duration.
- Each theory paper shall carry a hundred marks and each practical shall carry a hundred marks.
- The candidate is required to show the article to the faculty /before interpreting his/her experimental work.
- Two typed/computerized bound copies of the dissertation shall be submitted to the University during the final M.Sc. at least fifteen days before the commencement of the final examination.
- Each theory paper is divided into four units. Each unit will have equal weightagewhile setting the question paper. The question or its sub-question including the optionswill be set from the same unit.
- There shall be one microbiological study tour/fieldwork during the fourth or anysemester of P.G. study. It will pertain to different microbiological/environmental industries/research institutes / various ecosystems even outside Gujarat State. The microbiological tour is highly essential for studying microbiological processes and technology.
- Assignments and group discussions / industrial training accomplished with thebound copy of the report are necessary for evaluation.
- At least two seminars should be delivered during the fourth semester.
- The practical batch will consist of a maximum of 10 students.
- Students can select any one paper from the three elective papers given in semesterIII.

Examination Scheme (Marks)			
	CE	**SEE**	**Total**
Theory	50	50	100
Practical			
LAB 1	30	70	100
LAB 2	30	70	100

Uyoyal

Annexure 1

M.Sc. MICROBIOLOGY SYLLABUS

Paper no.	Title	No. of Hours per Week				Course Credits
		Lecture	Others	Practicals	Total	
Semester 1						
MIC 401	Diversity of Prokaryotic and Eukaryotic Microorganisms	3	1	-	4	4
MIC 402	Microbial Biochemistry and Enzymology	3	1	-	4	4
MIC 403	Microbial Genetics and Biostatistics	3	1	-	4	4
MIC 404 E	Microbial Physiology and Immunology	3	1	-	4	4
MIC 405 PR	Lab 1	-	-	12	12	4
MIC 406 PR	Lab 2	-	-	12	12	4
	Total	**12**	**4**	**24**	**40**	**24**
Semester 2						
MIC 407	Fermentation technology	3	1	-	4	4
MIC 408	Gene regulation and recombinant DNA technology	3	1	-	4	4
MIC 409	Techniques in synthetic microbiology and Bioinformatics	3	1	-	4	4
MIC 410 E	Advances in Microbial Technology	3	1	-	4	4
MIC 411 PR	Lab 3	-	-	12	12	4
MIC 412 PR	Lab4	-	-	12	12	4
	Total	**12**	**4**	**24**	**40**	**24**

Paper no.	Title	No. of Hours per Week				Course Credits
		Lecture	Others	Practi-cals	Total	
Semester 3						
MIC 501	Agriculture Biotechnology	3	1	-	4	4
MIC 502	Environment Microbiology	3	1	-	4	4
MIC 503	Green and Blue Biotechnology	3	1	-	4	4
MIC 504 E	Concepts of Bio-business	3	1	-	4	4
MIC 505 PR	Lab 1	-	-	12	12	4
MIC 506 PR	Lab 2	-	-	12	12	4
	Total	**12**	**4**	**24**	**40**	**24**
Semester 4						
MIC 507	MIC 507 PT: Project / Dissertation Work theory	-	-	-	16	16
MIC 508	Conference report writing and Study tour			6	6	4
MIC 509	Review Paper Presentations and assignments	-	-	6	6	4
	Total	**-**	**-**	**12**	**28**	**24**

Jyoyal

Annexure 2

SEMESTER 1

MIC 401: Diversity of Prokaryotic and Eukaryotic Microorganisms

COURSE CODE: MIC 401
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Imparting knowledge of microbial diversity including important microbesimpacting health, environment, and industries.
- **CO2** Identifying the importance of microbial diversity and Bacterial systematics.
- **CO3** Understanding and distinguishing various genera of Yeasts, molds, andextremophiles.
- **CO4** Knowing the Ecological importance and economic uses of microbes as awhole.

Unit 1: Principles of Microbial Diversity

- History of microbial diversity, concepts of the Tree of Life
- Principles of Microbial Diversity and Taxonomy: Morphological, Biochemical, Chemical and Numerical
- Methods of studying microbial diversity: Classical and Molecular approaches,Microbial phylogeny
- Concept of Metagenomics and methods of assessment non-cultivable microbialdiversity

Unit 2: Bacterial Systematics

- Green phototrophic bacteria/cyanobacteria,
- Proteobacteria: α, β, γ, δ, ε
- Gram-positive bacteria, High G+C bacteria, *Actinomycetes*, *Spirochetes &Bacteroides*, *Deinococci*, *Chlamydiae*, *Planctomycetes*
- Bacterial phyla and non-cultivable species

Unit 3: Diversity of yeast and molds

- Structure, Reproduction, classification of molds and yeast, life cycle ofimportant examples
- Fungal cell factories: pharmaceuticals and enzymes
- Fungal diseases in plants and animals
- Mycotoxins and their significance
- Environmental Importance of Fungal Associations: Mycorrhizal fungi and lichens

Unit 4: Diversity of Archaea

- Systematics occurrence, diversity, and classification of archaea
- Characteristics features of different groups of archaea
- Alkaliphiles: alkaline environments, genera of alkali-tolerant and alkaliphilic microorganisms, homeostasis of the pH, adaptation mechanisms, biotechnological applications
- Acidophiles: diversity of acidic environments, phylogenetic relationship, energy metabolism, cellular and molecular adaptation mechanisms, biotechnological applications
- Thermophiles: distribution, physiological, biochemical, and molecular adaptations to life at high temperature, biotechnological applications
- Halophiles: occurrence and ecosystem, cell architecture, biochemical andmolecular strategies to life at high salinity, biotechnological applications

lyoyal

REFERENCE

No.	Name	Author
1.	A guide to identifying and classifying yeast	Burnet et.al
2.	Agricultural statistics-techniques and procedures	Mandal & Nambiar
3.	Analytical biochemistry	D.J. Holme & H.Peck
4.	Annual review of microbiology	Volumes
5.	Bacteria in their natural environment	Fletcher
6.	Bacterial metabolism	Gottschalk, G.
7.	Bacterial respiration and photosynthesis	C.W. Jones
8.	Bergey's Manual of Systematic Bacteriology vol.: I-V	Krieg & Holt
9.	Biodiversity of microbial life	Ed. J. T. Staley & A.L. Reysenbach
10.	Bioinformatics databases, tools, and algorithms	O. Bosu & S. K. Thukral
11.	Biology of the conidial fungi	Cole & Kendrick
12.	Biology of the fungi	I.K. Ross
13.	Brock's Biology of the Microorganisms 8th edition	M.T.Madigan, T.M.
14.	Microbial diversity	Colwd. D
15.	Microbial ecology	Bartha and Atlas, Pearson Edu
16.	Molds and filamentous fungi in technical microbiology	O. Fassatiova

WEBLINKS

1. Strategies and challenges for the development of industrial enzymes using fungalcell factories:
https://link.springer.com/chapter/10.1007/978-3-030-29541-7_7
2. Growing a circular economy with fungal biotechnology: a white paper:
https://fungalbiolbiotech.biomedcentral.com/articles/10.1186/s40694-020-00095- z
3. Fungal biology. Deacon, J. W. (2013). John Wiley & Sons:
https://yeastwonderfulworld.files.wordpress.com/2016/10/fungal-biology.pdf
4. Fungi: Biology and applications:
https://www.wiley.com/en-us/Fungi%3A+Biology+and+Applications%2C+3rd+Edition-p-9781119374275
5. Yeast biotechnology: teaching the old dog new tricks:
https://link.springer.com/article/10.1186/1475-2859-13-34
6. Yeast as a Versatile Tool in Biotechnology. In A. Morata, & I. Loira (Eds.), Yeast - Industrial Applications:
https://www.intechopen.com/chapters/56515

Uyoyal

MIC 402: Microbial Biochemistry and Enzymology

COURSE CODE: MIC 402
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Conveying understanding of biomolecules, microbial metabolism, andenzymes.
- **CO2** Identifying biological importance of biomolecules-carbohydrates, lipids,proteins and enzymes.
- **CO3** Appreciating the knowledge of the biological metabolism of carbohydrates,lipids, amino acids, and nucleotides.
- **CO4** Imparting the knowledge of the working of the enzyme along with portraying their clinical, analytical, and industrial applications**.**

Unit 1: Biochemistry of Carbohydrates and Lipids

- Carbohydrates, types, structure and function
- Lipids: Fatty acids, simple lipids, phospholipids, and cholesterol
- Glycoconjugates- glycoproteins, proteoglycans, and glycolipids
- Central metabolic pathways, feeder pathways, and Fate of pyruvate underanaerobic condition
- PHA and PHB in cells; degradation of fatty acids by beta-oxidation
- Metabolism of C1 compounds

Unit 2: Biochemistry of Proteins and Nucleic Acids

- Amino acids and proteins, structure, classification, and properties
- Structure and function of Nucleic acids, Nucleotides- types, derivatives andfunctions
- Nitrogen metabolism: Nitrate and Ammonia Assimilation, Nitrogen fixation and Nitrogenase
- Biosynthesis and regulation of amino acids
- Biosynthesis and regulation of nucleotides

Unit 3 Enzymology 1

- Extraction and purification enzymes
- Protein folding and denaturation
- Enzyme Kinetics
- Mechanism of enzyme action-catalysis mechanisms and lysozyme
- Enzyme regulation

Unit 4 Enzymology 2

- Enzyme inhibition
- Enzyme turnover
- Immobilization of Enzymes
- Biotechnological applications of enzymes
- Abzymes and ribozymes

Goyal

REFERENCE

No.	Name	Author
1.	Biochemistry and molecular biology	W. H. Elliott & D. C. Elliott
2.	Biochemistry Stryer 5th edition	W.H. Freeman
3.	Biochemical methods	Pingoud A. et al.
4.	Enzymes and immobilized cells in biotechnology	A. L. Laskin
5.	Enzymes, biochemistry, biotechnology, clinical chemistry	Trevor Palmer
6.	Principle of Biochemistry 3rd edition	Lehninger Nelson & Cox
7.	Biotechnology	U. Satayanarayan

WEBLINKS

1. Carbohydrates:
https://www.presentica.com/doc/11089287/module-11-carbohydrates-lecture-29-carbohydrates-i-pdf-document

2. e-PGPathshala:
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==

- Paper-11 Module-17 Nitrogen fixation and cycles
- Paper-04 Module-06 Entry of fructose and galactose
- Paper-04 Module-08 Fate of pyruvate
- Paper-04 Module-23 Gluconeogenesis
- Paper-14 Module-10 Enzyme kinetics
- Paper-14 Module-11 Enzyme inhibition
- Paper-14 Module-26 Enzyme immobilization

Goyal

MIC 403: Microbial Genetics and Biostatistics

COURSE CODE: MIC 403
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Classical concepts of molecular biology and microbial genetics are imparted alongwith the emphasis on modern advancements.
- **CO2** Promulgating the information on fungi and bacteriophage genetics.
- **CO3** Implementing the learning on in-age concepts of molecular biology and geneticengineering.
- **CO4** Familiarizing the concept of biological data management and its analysis usingstatistics.

Unit 1: Bacterial genetics and plasmid

- Methods of gene exchange in bacteria: Transformation, Conjugation and Transduction
- Application and use of gene exchange processes
- Plasmid biology: Types, Replication, Compatibility, Control of copy number and segregation
- Plasmid designing and application

Unit 2: Genetics of microorganisms

- Ordered tetrad analysis and mitotic recombination of *Neurospora.*
- Unordered tetrad analysis in yeast.
- Bacteriophage genetics of T-even phages with detailed emphasis on T4.
- Bacteriophage genetics of T-odd phages with detailed emphasis on T7.
- M13 phage genetic assembly and function with emphasis on its role in genetic engineering.

Unit 3: Concepts of molecular biology

- Organization of eukaryotic chromosome
- Enzymes involved in prokaryotic DNA replication
- Molecular mechanism of prokaryotic DNA replication
- Introduction to eukaryotic DNA replication.
- Structure of RNA Polymerase and molecular mechanism of transcription
- Molecular mechanism of translation
- Mutation and DNA damage
- Repair mechanisms

Unit 4: Biostatistics

- Meaning of data and their representation in biostatistics
- Measures of central tendency with computation and their application in biostatistics
- Measures of dispersion with computation: Standard deviation and Variance
- Correlation: meaning, types, and methods of correlation
- Chi-squared tests and their role in biostatistics
- F test and Student's t-test in hypothesis testing
- Normal distribution curve, characteristics, and uses with computation

Goyal

REFERENCE

No.	Name	Author
1.	Biotechnology and genomics	P. K. Gupta, Rastogi Publication
2.	Cell and molecular microbiology	Garald Karp
3.	Gene function	Robert Glass
4.	Gene V- VII	Benjamin Lewin
5.	General genetics	L. Snyder et. al
6.	Genetics 3rd edition	Peter J. Russel
7.	Genetics as a tool in microbiology	Gloover & Hopwood
8.	Genetics of bacteria	Scaife et.al
9.	Growth of bacterial cell	Ingraham et. al
10.	Molecular biology and biotechnology	Robert A., Meyers Eds.
11.	Molecular biology of gene	J.D.Watson
12.	Molecular biomethods handbook	Rapley & Walker
13.	Molecular biotechnology	Primrose
14.	Molecular cell biology	Lodish et.al
15.	Molecular genetics of bacteria	Snyder & champnes
16.	Biostatistics	Lewis A.E.
17.	Statistical Methods in Biology	N. T. J. Bailey
18.	Elements of biostatistics	S. Prasad
19.	Introduction to biostatistics	R. N. Forthofer & Lee

WEBLINKS

e-PGPathshala:

1. Genetics and Molecular Biology
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==

- Paper-04 Module-08 DNA Replication in Prokaryotes
- Paper-04 Module-09 DNA Replication in Eukaryotes
- Paper-04 Module-05 DNA Topoisomerase
- Paper-04 Module-06 DNA Methyltransferase
- Paper-04 Module-07 DNA Polymerases

2. Biostatistics
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=31BI+Y/JyQo+vtlwaZoj+g==

- Paper-02 Module- Introduction to statistics and biostatistics

Goyal

MIC 404: Microbial Physiology and Immunology

COURSE CODE: MIC 404
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Interactions of microbes with humans with knowledge in the field of immunologyis provided that enables students to understand the impact of pathogenic microbes on human health.
- **CO2** Imparting the in-depth knowledge in microbial growth and physiology.
- **CO3** Understanding the interplay of various components of the immune system during infection.
- **CO4** Learning the deficiencies and disorders of the immune system.

Unit 1: Principles of Physiology

- Nutrient transport in prokaryotic cell
- Signal transduction in bacteria
- Mechanism of drug resistance
- Quorum sensing
- Bacterial Bioluminescence
- Bacterial differentiation

Unit 2: Microbial growth

- Batch growth and its kinetics: definition, trophophase, idiophase, diauxic growth,maximum growth rate, specific growth rate, yield co-efficient
- Continuous growth and its kinetics: continuous culture, dilution rate, residual substrateconcentration
- Factors affecting growth: temperature, pH, oxygen, salt concentration, pressure, wateractivity, radiation
- Growth measurement: direct methods and indirect methods
- Control of microbial growth: physical agents and chemical agents

Unit 3: Functioning of Immune System

- Antigen processing and presentation
- MHC: structure and function
- Cytokines and cytokine bias in diseases
- Compliment components and activation
- T cell receptors and activation of T cells
- B cell receptors and activation of B cells

Unit 4: Immune disorders and immunological techniques

- Hypersensitivity (Hypersensitive reactions)
- Autoimmunity and autoimmune diseases
- Transplantation immunology
- AIDS and other immunodeficiency
- Cancer and the immune system

Goyal

REFERENCE

No.	Name	Author
1.	Advances in microbial physiology	Robert K. Poole
2.	Biochemistry Stryer 5th edition	W.H. Freeman
3.	Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology	Wilson, Walker
4.	Biophysical chemistry	A Upadhyay, K Upadhyay
5.	Growth of bacterial cell	Ingraham et. al
6.	Harper's biochemistry	Murray et. al
7.	Microbial cell-cell interaction	Martin
8.	Microbial ecology	Bartha and Atlas, Pearson Edu
9.	Microbial physiology	Dawes & Southerland
10.	Principle of biochemistry 3rd edition	Lehninger Nelson & Cox
11.	Principles of microbiology	RM. Atlas
12.	The microbial cell cycle	C. Edwards
13.	Textbook on principles of bacteriology, virology, and Immunology, IX Edition (5 Volumes), Edward, London, 1995	Topley and Wilson's
14.	Immunology	Janis Kuby
15.	Immunology and immunotechnology	A. K. Chakravarty
16.	Immunology	I. R. Tizard

WEBLINKS

e-PGPathshala:

1. Principles of physiology

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=SbxpZDmQJ9L1h7rf83v6ow==

- Paper-12 Module-19 Active transport
- Paper-12 Module-15, 16 & 17 Diffusion
- Paper-11 Module-26 Signal transduction

2. Microbial Growth:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=SbxpZDmQJ9L1h7rf83v6ow==

- Paper-11 Module-03 & 04 Cell growth and division

3. Immunology:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==

- Paper-16 Module-22 Antigen processing
- Paper-16 Module-20 MHC
- Paper-16 Module-19 & 21 T-Cells
- Paper-16 Module-17 & 23 B-Cells
- Paper-16 Module-27 to 30 Hypersensitivity
- Paper-16 Module-31 Autoimmune diseases
- Paper-16 Module-34 Cancer and AIDS

Goyal

MIC 405: Practicals

COURSE CODE: MIC 405
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Laboratory skills to cultivate microbes, characterize them, and identify theiruse for the betterment of humanity are provided to the students with practical exercises.
- **CO2** Acquiring skills in isolating and cultivating various microbes.
- **CO3** Developing aptitude to perform biochemical characterization of microbes.
- **CO4** Imparting skillsets to quantify various biomolecules like carbohydrates, lipids, proteins, and nucleic acids.
- **CO5** Acclimatizing students with molecular biology experiments.

1. Demonstration of basic laboratory instruments
2. Preparation of standard solutions, Buffers, and their standardization
3. Microbial Diversity: Cultural, Morphological (Spore, Capsule, Flagella, and inclusionbodies), and Biochemical
4. Study of Microbial Diversity Indices
5. Measurement of microbial cell size using Micrometry
6. Isolation and study of Molds, Yeast and Actinomycetes
7. Isolation and characterization of microorganisms from extreme environments
8. Quantification of biomolecules:
    - Carbohydrates: Cole's, DNSA method, Anthrone method
    - Proteins: Folin Lowry's, Bradford's method
    - Nucleic Acids: DNA by DPA; and RNA by Orcinol method
9. Qualitative analysis of biomolecules by chromatography: sugars, amino acids &organic acids

MIC 406: Practicals

COURSE CODE: MIC 406
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Acquiring expertise in experimentation pertaining to microbial physiology,and enzymology.
- **CO2** Implementing training to familiarize sophisticated instruments.
- **CO3** Teaching to acquire and analyze the experimental data using biostatistics.

1. PHB staining by Nile Blue method
2. Study of bacterial growth curve and its kinetics
3. Determination of bacterial growth rate and factors influencing it
4. Study of enzyme kinetics (Determination of Km, Vmax, and Double reciprocalcurve) of amylase
5. Determination of enzyme activity: protease, lipase
6. Immunological interaction between Ag and ab:
    - Immunoprecipitation
    - Agglutination
7. Isolation and titration of bacteriophage
8. Statistical analysis of data: Measures of central tendency, Assessment of Graphs,and standard deviation

Goyal

SEMESTER 2
MIC 407: Fermentation technology

COURSE CODE: MIC 407
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Defining basic principles of fermentation technology.
- **CO2** Use of microbes in the industry of fermentation, pharmaceutical, food, andenvironment are inculcated to the students in depth.
- **CO3** Processes in the fermentation industries are explained in depth.
- **CO4** Economics and ethics of environmental safety are explained in length to students.

Unit 1 Elements of Bioprocess

- Isolation, screening, and preservation of industrially important microorganisms
- Strain Improvement: Isolation of mutants producing primary metabolites, secondarymetabolites, auxotrophic mutants, resistant and revertant mutants
- Media formulation energy sources, antifoams
- Optimization of fermentation medium

Unit 2 Fermenter Design & Control

- Design of Fermenter
- Types of Fermenters
- Instrumentation and control of process variables
- Control systems

Unit 3: Upstream processing

- Sterilization of media, air, and reactor
- Development of inoculum for industrial fermentations
- Aeration-agitation system,
- Heat transfer, mass transfer of oxygen, KLa and factors affecting KLa, rheological andfluid-flow properties
- Fundamentals of scale-up

Unit 4 Downstream processing & Fermentation economics

- Methods of cell separation and product recovery: Filtration, Centrifugation, Membraneprocesses, Extraction, Chromatography
- Methods of cell disruption: Mechanical and non-mechanical
- Fermentation economics: Expenses for industrial organisms, strain improvement, mediasterilization, heating, cooling, aeration, agitation, Batch process cycle time, and continuous culture
- Fermentation economics: Cost of fermenter plant and other equipment, productrecovery and effluent treatment, cost due to recovery, waste usage, and recycling

REFERENCE

No.	Name	Author
1.	Principles of Fermentation Technology	P F Stanbury, A Whitaker, S J Hall
2.	Industrial Microbiology: An Introduction	M J Waites, N L Morgan, J S Rockey
3.	Bioprocess Engineering	P.K. Ghosh
4.	Fermentation Microbiology and Biotechnology	EL-Mansi & C.F.A.Bryce eds
5.	Manual of Industrial Microbiology and Biotechnology	Demain & Davies, 2nd ed.

e-PGPathshala **WEBLINKS**
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=NuAs6SreCGryddEfs4kkBA==

- Paper-06 Module-16 Fermentation Technology Overview
- Paper-06 Module-17 Downstream processing
- Paper-06 Module-18 Bioreactors

Goyal

MIC 408: Gene regulation and Recombinant DNA technology

COURSE CODE: MIC 408
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Genetic manipulation in microbes is conveyed with their use under ethical wisdom.
- **CO2** various components and techniques used for genetic manipulation inmicrobes are taught.
- **CO3** Tools such as identifying and analyzing Molecular markers are explained tostudents.

Unit 1: Gene expression and regulation

- Transcriptional and translational control
- Lac, arabinose, and tryptophan operon circuits
- Regulation of lytic and lysogenic cycle of λ phage

Unit 2: Enzymes in r-DNA Technology and DNA Sequencing

- Extraction, purification, analysis, and size fractionation of nucleic acid
- Enzymes involved in genetic engineering
- cDNA formation and cDNA library and genomic library
- Cohesive and blunt end ligation
- CRISPER-Cas9

Unit 3: Vectors and Probes

- Cloning and expression vectors
- Methods of the introduction of r-DNA into the host cell
- Expression and characterization of cloned genes
- Oligonucleotide probes and labelling of probes

Unit 4: Molecular markers and techniques

- Blotting and hybridization techniques
- DNA sequencing
- DNA fingerprinting
- Molecular markers- RFLP and RAPD
- Microarray technique

Goyal

REFERENCE

No.	Name	Author
1.	Genetic engineering	Rastogi & Pathak, Oxford
2.	Biotechnology and genomics	P. K. Gupta, Rastogi Publication
3.	Biotechnology	U. Satyanarayana
4.	Molecular biology and genetic engineering	P. K. Gupta
5.	Molecular biology of gene	J.D.Watson
6.	Genetics as a tool in Microbiology	Gloover & Hopwood
7.	Genetics of Bacteria	Scaife et.al
8.	Molecular Genetics of Bacteria	Snyder & champnes
9.	Molecular Biotechnology	Primrose
10.	Gene cloning and manipulation	Christopher Howe
11.	Molecular Biology and Biotechnology	Robert A., Meyers Eds.
12.	Principle of Gene Manipulation, An Introduction to Genetic Engineering	R. W. Old & S.B. Primrose
13.	Essential of Molecular Biology	George M. Malacinski
14.	Recombinant DNA Principles and Methodology	James J Greene & Venigalla B. Rao
15.	Molecular Bio methods Handbook	Rapley & Walker
16.	Cell and Molecular Microbiology	Garald Karp
17.	Biotechnology An Introduction	Susan R. Barnum
18.	Recombinant DNA Methodology II	Ray Wu
19.	Molecular biology and genetic engineering	P. K. Gupta

WEBLINKS

e-PGPathshala:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==

- Paper-15 Module-07 Bacterial transcription
- Paper-15 Module-12 Post-transcriptional modification
- Paper-15 Module-15 Prokaryotic translation
- Paper-15 Module-08 Operons
- Paper-15 Module-18 Vectors and Restriction Enzymes
- Paper-15 Module-20 DNA Cloning
- Paper-15 Module-24 Macromolecule Blotting and Probing
- Paper-15 Module-25 DNA sequencing
- Paper-15 Module-26 Microarray technique

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==

- Paper-04 Module-02 DNA modifying enzyme
- Paper-04 Module-18, 19 & 20 Vectors

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=eCJfy23Kjy3c0vICLa6VYg==

- Paper-13 Module-15 & 17 DNA markers
- Paper-13 Module-19 & 20 Blotting

Goyal

MIC 409: Techniques in synthetic microbiology and Bioinformatics

COURSE CODE: MIC 409
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Specialized computational tools needed to retrieve and analyze data of microbes, their genes, and proteins are taught to improve the skillsets of the students.
- **CO2** Knowledge of modern development in biological sciences and in microbiology making use of Nanotechnology is imparted.
- **CO3** Principles, working, and applications of sophisticated instruments used in microbiology and biotechnology are taught.
- **CO4** Use of computers to retrieve data from biological databases and their analysisis learnt by students.

Unit 1: Bio-nanotechnology

- Introduction to the concept and principles of nanotechnology
- Nanomaterial in nanotechnology: Nanoparticles, Quantum Dots, Nanotubes,Nanowires
- Development of nanotechnology-Timelines and Progress
- Techniques and methodology used to study nanoparticles
- Biosensors, Molecular recognition devices, Lab on Chip- concepts and applications
- Biological Nanoparticles- Plant and Microbial
- Application of nanoparticles in molecular biology, industry, agriculture, andenvironment

Unit 2: Advances in Instrumentation

Principle, working, and applications of:

- Atomic absorption Spectrophotometer (AAS)
- Fourier Transformation Infrared Spectroscopy (FTIR), Matrix Assisted LASER Desorption/Ionization Time of Flight (MALDI-ToF), Mass spectrophotometer (MS)
- High-Performance Liquid Chromatography (HPLC), Gas chromatography (GC)
- Nuclear Magnetic Resonance (NMR)

Unit 3: Bioinformatics-I

- Introduction to bioinformatics
- Introduction to computers and bioinformatics
- Biological databases
- Pairwise sequence alignment: Global sequence alignment vs local sequencealignment
- Phylogeny
- Application of bioinformatics in Proteomics, Genomics, Transcriptomics

Unit 4: Bioinformatics-II

- The dot plot, scoring matrices, FASTA, and BLAST algorithms
- Protein Profiles, motifs, and feature identification
- Homology modeling and HMM algorithm
- Bioinformatic drug discovery pipeline

lyoyal

REFERENCE

No.	Name	Author
1.	Bio nanotechnology: Principles and Applications	Anil Kumar
2.	Essential Bioinformatics, Cambridge	Jin Xiong
3.	Bioinformatics: An Introduction 3rd Edition	Jeremy Ramsden
4.	Bioinformatics and Functional Genomics 3rd Edition	Jonathan Pevsner

WEBLINKS

e-PGPathshala:

1. Bio-nanotechnology:
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==

- Paper-11 Module-13 Nanotechnology-based delivery systems for biotechnological applications
- Paper-11 Module-35 Food Nanotechnology: an introduction
- Paper-11 Module-16 Carbon based nanomaterials
- Paper-11 Module-11 Nanotechnology, Nanomedicine and Nanomaterials: Applications in biotechnology
- Paper-11 Module-14 Dendrimers
- Paper-11 Module-15 Quantum dots
- Paper-11 Module-16 Carbon nanotubes
- Paper-11 Module-24 Environment Remediation Using Nanotechnology
- Paper-11 Module-28 Risks associated with nanotechnology
- Paper-11 Module-31 Medical Nanobiotechnology Applications
- Paper-11 Module-38 Nutraceuticals in Nanotechnology

2. Instrumentation:
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=1+p0z2ZbAGSfsyfLITzgZQ==

- Paper-01 Module-28 Atomic absorption spectroscopy
- Paper-10 Module-24 to 26 FTIR
- Paper-06 Module-30 to 35 Mass spectrometry
- Paper-03 Module-09 to 14 HPLC
- Paper-03 Module-04 to 08 Gas chromatography

3. Bioinformatics:
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=MNhNzp1RQlU+6LM40KjY1Q==

- Paper-13 Module-01 Overview of Bioinformatics
- Paper-13 Module-02 & 03 Database
- Paper-13 Module-06, 07 & 19 Sequence Alignment
- Paper-13 Module-09 BLAST

Goyal

MIC 410: Advances in Microbial Technology

COURSE CODE: MIC 410
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** in-depth knowledge of the development of microbially derived products suchas antibiotics, organic acids, therapeutic agents, enzymes, and vitamins.
- **CO2** Role of microbes at the industrial scale for developing beverages food istaught to the students with special emphasis on entrepreneurship.
- **CO3** In-age knowledge pertaining to the use of microbes in developing chemicalalternatives of glues, gums, and plastics is imparted.

Unit 1: Microbial fermentative products

- Organic Acid: Citric Acid, Acetic acid
- Organic Solvent: Acetone-butanol
- Beverage: Beer
- Enzyme: Protease
- Polysaccharide: Xanthan gum
- Biosurfactants
- Biopolymer: Polyhydroxyalkanoates (PHA)

Unit 2: Production of Therapeutic agents

- Antibiotic: Streptomycin
- Amino acid: Glutamic acid
- Vitamin: Riboflavin (B2)
- Anticancer agents
- Vaccines
- Monoclonal antibodies: Hybridoma technology

Unit 3: Dairy Microbiology

- Fermented foods and their microbiology
- Starter cultures, significance, and production
- Steps in Cheese Production
- Evaluation and Role of Probiotics
- Nutraceuticals

Unit 4: Biomass production and applications

- Fungal biomass- baker's yeast and single-cell oil
- Mushroom cultivation
- Use of Algal biomass.
- Microbial production for food and feed
- Carotenoid pigments- B carotene, lycopene

lyoyal

REFERENCE

No.	Name	Author
1.	Principles of Fermentation Technology	P F Stanbury, A Whitaker, S J Hall
2.	Topics in Enzyme & Fermentation Biotechnology	Volumes by Wisemen
3.	Preservation and Sterilisation Methods in Microbiology	Norris & Ribbons
4.	Biology of Industrial Microorganisms	A.L. Duncun
5.	Bioprocess Engineering	P.K. Ghosh
6.	Handbook of Dairy Microbiology	Getachew Osei
7.	Food and Dairy Microbiology	Getachew Osei

WEBLINKS

e-PGPathshala:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=NuAs6SreCGryddEfs4kkBA== Paper-06
Module-20 Production of fatty acids and amino acids
Paper-06 Module-21 Production of Vitamin B12, Riboflavin and Xanthan gumPaper-06
Module-22 Technologies for production of alcoholic beverages Paper-06 Module-23, 24
& 25 Fermentation of food and Milk
Paper-06 Module-36 Microbial biomass
Paper-06 Module-37 Production of Single cell protein
Paper-06 Module-38 Production of yeast and fungal biomassPaper-11
Module-01 & 02 Nutraceuticals

Uyoyal

MIC 411: Practical

COURSE CODE:
MIC 411NO. OF
CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Use of computational tools in retrieving and analyzing biological data from the domains ofgenomics and proteomics is learnt by students.
- **CO2** Skills for the techniques used in genetic manipulation are imparted.

1. Bioinformatics:
   - Database Exploration
   - BLAST
   - Sequence alignment: Multiple and Pair-wise
   - Phylogenetic tree construction
   - Sequence submission
2. Isolation, quantification, and determination of purity: DNA, RNA, and Plasmid
3. Amplification of DNA by thermocycler
4. RE digestion of plasmid
5. Induction of mutants by physical and/or chemical mutagens and its characterization:
   - Auxotrophic mutants,
   - Pigment variants
   - lac⁻ mutants
   - Antibiotic-resistant mutants
6. Determination of oxygen transfer rate (OTR)
7. Determination of MIC and MBC of antibiotics

MIC 412: Practical

COURSE CODE: MIC 412
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Skills that are essential for industrial production microbial production of food, beverages,enzymes, and organic acids are learnt and imparted.
- **CO2** Various industrial microbial products like enzymes, alcohol, antibiotics, and organic acids are produced by students during this course.
- **CO3** Students get through the procedures to develop commercially important fermentation-derived products.

1. Fungal spore/Yeast cell count
2. Isolation, screening, and optimization of conditions for production:
   - Solid-state fermentation: enzymes, alcohol
   - Submerged fermentation: enzymes, exopolysaccharides, alcohol, organic acids and antibiotics
3. Ammonium sulfate precipitation method for enzyme purification
4. Electrophoretic separation of proteins by PAGE: SDS and NATIVE
5. Estimation, recovery, and purification of fermentation products- Antibiotics, Organic acids,Alcohol, Exopolysaccharide
6. Rheological study of culture broth by Brookfield viscometer
7. Influence of different parameters on immobilization of cells and enzymes
8. Scale up study