Gujarat University, Ahmedabad 380 009, Gujarat, India.
M.Sc. MICROBIOLOGY SYLLABUS
From June 2022

- 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 hundred marks and each practical shall carry hundred marks.

- The candidate is required to show article to faculty in/before interpreting his/her experimental work.

- Two typed/computerised 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 weightage while setting question paper. Question or its sub question including the options will be set from the same unit.

- There shall be one microbiological study tour / field work during fourth or any semester of P.G. study. It will pertain to different microbiological / environmental industries / research institute / various ecosystems even outside Gujarat State. The microbiological tour is highly essential for studying microbiological process and technology.

- Assignments and group discussions / industrial training accomplished with the bound copy of report are necessary for evaluation.

- At-least two seminars should be delivered during fourth semester.

- Practical batch will be consisting of maximum 10 students.

- Student can select any one paper from the three elective papers given in semester III.

PROGRAMME OUTCOMES (POs)

The programme of master's in microbiology focuses in-depth 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 pertaining to pharmaceuticals, bioprocess technology, environmental protection, in the domains of 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 commercial level.

- **PSO3** Significant portion of this programme is dedicated to food, agriculture and environmental microbiology along with focus on monitoring control of various products and process in synchrony with the guidelines of 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 all round development of students and to develop an urge of research dissertation work with interactive seminars, assignments, group discussions along with ethical and biosafety training.

M.Sc. MICROBIOLOGY SYLLABUS
SEMESTER 1 & 2

Paper no.	Title	No. of Hours per Week				Course Credits
		Lecture	Others	Practi-cals	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 11 PR	Lab 3	-	-	12	12	4
MIC 412 PR	Lab4	-	-	12	12	4
	Total	**12**	**4**	**24**	**40**	**24**

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 microbes impacting health, environment and industries.
- **CO2** Identifying importance of microbial diversity and Bacterial systematics.
- **CO3** Understanding and distinguishing various genera of Yeasts, molds and extremophiles.
- **CO4** Knowing the Ecological importance and economic uses of microbes as a whole.

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 microbial diversity

Unit 2: Bacterial Systematics

- Green phototrophic bacteria/cyanobacteria,
- Proteobacteria: α, β, γ, δ, ε
- Gram-positive bacteria, High G+C bacteria, actinomycetes, Spirochetes & Bacteroids, 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 of important 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 and molecular strategies to life at high salinity, biotechnological applications

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.	Moulds and filamentous fungi in technical microbiology	O. Fassatiova

WEBLINKS

1. Strategies and challenges for the development of industrial enzymes using fungal cell 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

MIC 402: Microbial Biochemistry and Enzymology

COURSE CODE: MIC 402
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Conveying understanding of biomolecules, microbial metabolism and enzymes.

- **CO2** Identifying biological importance of biomolecules-carbohydrates, lipids, proteins and enzymes.

- **CO3** Appreciating the knowledge of biological metabolism of carbohydrates, lipids, amino acids and nucleotides.

- **CO4** Imparting the knowledge on working of 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 under anaerobic condition
- PHA and PHB in cells; degradation of fatty acids by beta-oxidation
- Metabolism of C 1 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 and functions
- 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
- Immobilisation of Enzymes
- Biotechnological applications of enzymes
- Abzymes and ribozymes

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. etl.
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

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 is imparted along with emphasis on modern advancements.
- **CO2** Promulgating the information on Fungal and bacteriophage genetics.
- **CO3** Implementing the learning on in-age concepts of on molecular biology and genetic engineering.
- **CO4** Familiarizing the concept of biological data management and its analysis using statistics.

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 detail emphasis on T4.
- Bacteriophage genetics of T-odd phages with detail emphasis on T7.
- M13 phage genetic assembly and function with emphasis for 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 test and their role in biostatistics
- F test and Student's t-test in hypothesis testing
- Normal distribution curve, characteristics and uses with computation

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 bio statistics

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 immunology is provided that enables students to understand the impact pathogenic microbes on human health.
- **CO2** Imparting the in-depth knowledge in microbial growth and physiology.
- **CO3** Understanding the interplay of various components on immune system during infection.
- **CO4** Learning the deficiencies and disorders of 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 and idiophase, diauxic growth, maximum growth rate, specific growth rate, yield co-efficient
- Continuous growth and its kinetics: continuous culture, dilution rate, residual substrate concentration
- Factors affecting growth: temperature, pH, oxygen, salt concentration, pressure, water activity, 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

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.	Text book 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

MIC 405: Practicals

COURSE CODE: MIC 405
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** Laboratory skills to cultivate microbes, characterize them and identify their use for betterment of humanity is provided to the students with practical exercises.

- **CO2** Acquiring skills in isolating and cultivation of 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 standardisation
3. Microbial Diversity : Cultural, Morphological (Spore, Capsule, Flagella and inclusion bodies) 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, 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 reciprocal curve) 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

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 industry of fermentation, pharmaceutical, food and environment are inculcated to the students in depth.
- **CO3** Processes in the fermentation industries are explained in depth.
- **CO4** Economics and ethics of environmental safety is 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, secondary metabolites, 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 Fermenter
- 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, K_La and factors affecting K_La, rheological and fluid-flow properties
- Fundamentals of scale up

Unit 4 Downstream processing & Fermentation economics

- Methods of cell separation and product recovery: Filtration, Centrifugation, Membrane processes, Extraction, Chromatography
- Methods of cell disruption: Mechanical and non-mechanical
- Fermentation economics: Expenses for industrial organism, strain improvement, media sterilization, heating, cooling, aeration, agitation, Batch process cycle time and continuous culture

- Fermentation economics: Cost of fermenter plant and other equipment, product recovery and effluent treatment, Cost due to recovery, waste usages 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.

WEBLINKS

e-PGPathshala:

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

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 in microbes are taught.
- **CO3** Tools such as to identify and analyze Molecular markers are explained to students.

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
- c-DNA formation and c-DNA library and genomic library
- Cohesive and blunt end ligation
- CRISPER-Cas9

Unit 3: Vectors and Probes

- Cloning and expression vectors
- Methods of introduction of r-DNA into 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

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

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 on 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 is taught.

- **CO4** Use of computers to retrieve data from biological databases and their analysis is learnt by students.

Unit 1: Bio-nanotechnology

- Introduction to 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 and environment

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 sequence alignment

- Phylogeny
- Application of bioinformatics in Proteomics, Genomics, Transcraptomics

Unit 4: Bioinformatics-II

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

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

MIC 410: Advances in Microbial Technology

COURSE CODE: MIC 410
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

- **CO1** in depth knowledge on the development of microbially derived products such as antibiotics, organic acids, therapeutic agents, enzymes, vitamins.

- **CO2** Role of microbes at industrial scale for developing beverages food and are taught to the students with special emphasis on entrepreneurship.

- **CO3** In-age knowledge pertaining for the use of microbes in developing chemicals alternatives 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 (B_2)
- 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

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 gum
Paper-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 biomass
Paper-11 Module-01 & 02 Nutraceuticals

MIC 411: Practical

COURSE CODE: MIC 411
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Use of computational tools in retrieving and analyzing biological data from the domains of genomics and proteomics is learnt by students.

CO2 Skills for the techniques used in genetic manipulation is imparted.

1. Bioinformatics:
   - Data base 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 are learnt and imparted.

CO2 Various industrial microbial products like enzymes, alcohol, antibiotics, organic acids are produced by students during this course.

CO3 Students get through with the procedures to develop commercially important fermentation derived products.

1. Fungal spore/Yeast cells count
2. Isolation, screening and optimization of conditions for production:
   - Solid state fermentation: enzymes, alcohol
   - Submerged fermentation: enzymes, exopolysaccharide, alcohol, organic acids and antibiotics
3. Ammonium sulphate 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 immobilisation of cells and enzymes
8. Scale up study

M.Sc. MICROBIOLOGY SYLLABUS
SEMESTER 3 & 4

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 Presentation and assignments	-	-	6	6	4
	Total	**-**	**-**	**12**	**28**	**24**

SEMESTER 3

MIC 501: Agriculture Biotechnology

COURSE CODE: MIC 501
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 The knowledge on the role of microbes in sustainability of agriculture is imparted.

CO2 Fine influence of microbes in development of Biofertilizers and Biopesticides is exemplified and is learnt by students.

CO3 Knowledge on developing transgenic crops using molecular biology is imparted.

CO4 Skills and knowledge for the use of Plant Tissue Culture (PTC) technology is inculcated.

Unit 1: Agriculturally Important Microorganisms

- Free living (Azotobacter), symbiotic (rhizobial, actinorhizal), associative and endophytic nitrogen fixers, cyanobacteria, etc.
- Phosphate solubilizing microorganisms, mechanism of action of P-solubilization and plant growth promotion.
- Plant growth promoting rhizobacteria; active biomolecules (Phytohormones, HCN, siderophores, ACC deaminase etc) and mode of growth promotion.
- Mycorrhizae: classification and significance
- Vermicomposting

Unit 2: Biofertilizers and Biopesticides

- Technologies used for biofertilizers production: screening, selection, establishment, competitiveness, crop productivity, soil and plant health,
- Mass scale production and quality control of bio inoculants, BIS standards recommendation for biofertilizers (nitrogenous/phosphatic biofertilizers) production
- Biocontrol agents and their scope, concept and component of Integrated Pest Management (IPM)
- Bacterial pesticides – *Bacillus thuringinesis*, structure of BT toxin and their mode of action, advantages and limitations of biopesticides.
- Fungal and viral based biopesticides
- Production technology for BT and Baculovirus based pesticide.

Unit 3: Molecular Biology approaches for crop improvement

- Genetic Engineering: Agrobacterium-plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer; disarmed Ti plasmid; Genetic transformation - Agrobacterium-mediated gene delivery
- Direct gene transfer - PEG-mediated, electroporation, particle bombardment
- Molecular pharming - concept of plants as biofactories, production of industrial enzymes and pharmaceutically important compounds.
- Molecular markers - hybridization and PCR based markers RFLP, RAPD, STS, SSR, AFLP, SNP markers; DNA fingerprinting-principles and applications
- Introduction to mapping of genes/QTLs; Marker-assisted selection - strategies for introducing genes of biotic and abiotic stress resistance in plants

Unit 4: Plant Tissue Culture- Techniques and Methodology

- Introduction to plant tissue culture and its techniques
- Plant tissue culture media and composition
- Callus and suspension cultures, cloning and regeneration Micropropagation and applications of plant tissue culture
- Applications of Plant Tissue Culture
- Plant cell cultures for secondary metabolite production

REFERENCE

No.	Name	Author
1.	Agriculturally Important Microorganisms: Mechanisms and Applications for Sustainable Agriculture	Bibhuti Bhusan Mishra, Suraja Kumar Nayak and Avishek Pahari
2.	Biofertilizers and Biopesticides	S. Kannaiyan
3.	Agriculturally Important Microbes for Sustainable Agriculture	Vijay Singh Meena
4.	Handbook of Microbial Biofertilizers	M.K. Rai
5.	Bioprocess Engineering	P.K. Ghosh
6.	Principles of Plant-Microbe Interactions: Microbes for Sustainable Agriculture	Ben Lugtenberg
7.	Molecular Biology Techniques: A Classroom Laboratory Manual	Heather Miller et al.
8.	Plant Biotechnology and Genetics: Principles, Techniques, and Applications	C. Neal Stewart Jr.
9.	Plant Tissue Culture: Theory and Practice	S.S. Bhojwani and M.K. Razdan
10.	Plant Cell Culture Protocols	M. Loyola-Vargas and Felipe Vázquez-Flota
11.	Introduction to Plant Biotechnology	H.S. Chawla

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1. Agriculturally Important Microorganisms**;** Biopesticides and Biofertilizers

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

- Paper-05 Module-19 Biopesticides; biofertilizers
- Paper-05 Module-20 Composting; vermiculture

2. Molecular biology approaches for crop improvement

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

- Paper-05 Module-26 Agrobacterium mediated transformation
- Paper-05 Module-27 Direct DNA transfer to plants (particle gun, electroporation, Silicon carbide fibres, PEG mediated, in-planta)
  Paper-05 Module-31 Detection, characterization and expression of transformants (Genetic markers, reporter genes, transgene stability and gene silencing)
- Paper-05 Module-32 GM technology for: Conferring resistance to biotic stresses (pests, viruses, fungi)

- Paper-05 Module-33 GM technology for conferring resistance to Abiotic stresses (tolerance to salt, cold, drought)

3. Plant Tissue culture: Techniques and Methodology

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

- Paper-12 Module-02 Setup tissue culture laboratory
- Paper-12 Module-04 Medium constituents (macro and micro elements, hormones, other growth regulators) and preparation
- Paper-12 Module-05 Cell and tissue culture
- Paper-12 Module-06 Micropropagation
- Paper-12 Module-07 Micropropagation Shoot multiplication
- Paper-12 Module-18 Production of secondary metabolites

MIC 502: Environment Microbiology

COURSE CODE: MIC 502
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 The course emphasizes on environmental problems and monitoring.

CO2 The students are learnt about the environmental laws and policies in India.

CO3 Strategies such as bioremediation, biodegradation and biodeterioration is taught involving microbes for developing sustainable environment is learnt.

Unit 1: Environmental problems and monitoring

- Environmental monitoring: environmental impacts and their assessments
- Bio-indicators (Keystone species), biomarkers,
- Biosensors, toxicity testing, and DNA based technologies in Environmental monitoring.
- Environment Conservation strategies, Environmental laws, and policies in India

Unit 2: Waste treatment

- Classification and characterization of waste
- Principles and mechanisms of waste treatment
- Biological methods of liquid waste treatment
- Biological methods for solid waste management

Unit 3: Biodegradation

- Principles of biodegradation and mechanism of detoxification
- Role of key enzymes, Monooxygenases, Dioxygenases, Cytochrome P440s in the biodegradation of compounds
- Biodegradation of detergents and lignin
- Biodegradation, bio-decolourization and bio-detoxification of dyes
- Biodegradation and detoxification of Pesticide and Hydrocarbons with suitable examples

Unit4: Biodeterioration

- Principles and mechanisms of biodeterioration
- Methodology to assess biodeterioration
- Prevention and control of biodeterioration
- Biodeterioration of selected materials of economic value

REFERENCE

No.	Name	Author
1.	Environmental Monitoring	G. Bruce Wiersma
2.	Environmental Monitoring Handbook	Frank R. Burden et al.
3.	Environmental Monitoring and Characterization	Janick F. Artiola et al.
4.	Waste Treatment in the Process Industries	Lawrence K. Wang et al.
5.	Biological Wastewater Treatment	C.P. Leslie Grady Jr. et al.
6.	Waste Treatment and Disposal	Paul T. Williams
7.	Biodegradation and Bioremediation	Martin Alexander
8.	Biodegradation: Natural and Synthetic Materials	S.J.L. Roffey
9.	Biodegradation of Organic Pollutants in Natural Waters	E.M. Perdue
10.	Biodeterioration of Stone Surfaces: Lichens and Biofilms as Weathering Agents of Rocks and Cultural Heritage	Larry St.Clair and Mark Seaward
11.	Biodeterioration Research 4: Mycotoxins, Wood Decay, Plant Stress, Biocorrosion, and General Biodeterioration	Gerald C. Llewellyn et al.
12.	Biodeterioration 7: Proceedings of the Seventh International Biodeterioration Symposium	D.R. Houghton et al.
13.	Biodeterioration of Stone Surfaces: Lichens and Biofilms as Weathering Agents of Rocks and Cultural Heritage by	Larry St.Clair and Mark Seaward
14.	Environmental Microbiology, Second Edition	Ralph Mitchell, Ji-Dong Gu
15.	Manual of Environmental Microbiology, Fourth Edition	Marylynn V. Yates et al.
16.	Brock Biology of Microorganisms, Fifteenth Edition	Michael T. Madigan et al.
17.	Environmental Microbiology, Third Edition	Ian L. Pepper et al.

e-PGPathshala:

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

- Paper-05 Module-05 Methodology of environmental management
- Paper-05 Module-06 waste water treatment
- Paper-05 Module-09 Bioremediation and Biodegradation
- Paper-05 Module-11 Bioremediation of Soil and Water Contaminated with Pesticides and Toxic
- Substances
- Paper-05 Module-12 Biodegradation of lignin and cellulose

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=0Xvq9yUM2ILDrJ07FvlArQ==

- Paper 15 Module 24 Biosensors: An introduction
- Paper 13 Module-02 Constitutional Provisions relating to Environment Protection in India

MIC 503: Green and Blue Biotechnology

COURSE CODE: MIC 503
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Infer the use of microbes in developing Biofuels.

CO2 Discuss the rile of microbes in environmental sustainable strategies such as acid mine drainage formation and control, biogeohydrotechnology of sulphidic minerals and biobeneficiation.

CO3 Inculcate knowledge of marine microbes as treasure house of industrial, therapeutic, cosmetics, pharmaceuticals and nutraceuticals agents.

Unit 1: Fuel Biotechnology

- Types of energy resources and their uses
- Biotechnology for biogas, bioethanol, biodiesel and biohydrogen production
- Desirable and undesirable features of biofuels
- Energy crops
- MEOR
- Mode of utilization of biomass

Unit 2: Microbiology of Minerals

- Biogeohydrotechnology of sulphidic minerals
- Bioleaching methods and factors affecting bioleaching
- Biobeneficiation
- Acid mine drainage formation and control

Unit 3: Bioremediation

- Bioremediation principles
- Strategies and techniques of bioremediation: in situ and ex situ
- Bioremediation of metals
- Phytoremediation
- GMOs and their impact on bioremediations

Unit 4: Marine Biotechnology

- Introduction to Marine environments and marine biotechnology
- Marine microbial enzymes, antimicrobial peptides and exopolysaccharides
- Marine therapeutics, cosmetics, pharmaceuticals and nutraceuticals agents
- Microbial Bioprospecting in Marine Environments

REFERENCE

No.	Name	Author
1.	Environmental Microbiology, Second Edition	Ralph Mitchell, Ji-Dong Gu
2.	Manual of Environmental Microbiology, Fourth Edition	Marylynn V. Yates et al.
3.	Brock Biology of Microorganisms, Fifteenth Edition	Michael T. Madigan et al.
4.	Environmental Microbiology, Third Edition	Ian L. Pepper et al.
5.	Biotechnology: An Introduction, Second Editions	Susan R. Barnum
6.	Environmental Biotechnology: Principles and Applications	Bruce E. Rittmann and Perry L. McCarty
7.	Fungi in Fuel Biotechnology, edited	Gholamreza Salehi Jouzani et al.
8.	Industrial Biotechnology: Products and Processes	Christoph Wittmann and James C. Liao
9.	Geomicrobiology	Henry Lutz Ehrlich et al.
10.	Environmental Microbiology: From Genomes to Biogeochemistry	Eugene L. Madsen
11.	Bioremediation: Principles and Applications	Ronald L. Crawford et al.
12.	Environmental Biotechnology: Principles and Applications	Bruce E. Rittmann
13.	Marine Biotechnology I and II	Yves Le Gal et al

e-PGPathshala:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=0Xvq9yUM2ILDrJ07FvlArQ==

- Paper-15 Module-13 Role of microbes and plants in remediation - Phytoremediation
- Paper-15 Module-30 Biogas Production from Biomass and Its Applications
- Paper-15 Module-37 Bioremediation: Processes and Techniques
- Paper-15 Module-40 Bioremediation of heavy metals
- Paper-05 Module-10 Biofuel-gaseous biofuel (Biogas); Biohydrogen and biomethane
- Paper-15 Module-17 Microbial biohydrogen production
- Paper-15 Module-29 Biomineralization

MIC 504 E1: Concept of Bio-business

COURSE CODE: MIC 504 E1
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 This course infers the knowledge on ethical use of eukaryotic animal cell lines for therapeutic used.

CO2 The knowledge on economic management for fermentation industry is imparted.

CO3 In-depth knowledge on intellectual property rights for microbiological and biotechnological interventions is imparted.

CO4 Wisdom on Regulatory affairs, Biosafety and bioethics is inculcated.

Unit 1: Bio-entrepreneurship

- Introduction and Significance of the Bio-Entrepreneur
- Skill sets in Science-Business
- Forms of business organizations & Source of funds, investments
- The Biotechnology Sector, Start-up ecosystem and BT policy of Gujarat (2022-2027)

Unit 2: Intellectual Property rights

- Types of IPR
- Patent types and process, Inclusions, and exclusions in various IPRs Overview on Rules and sections of Indian Patent act 1970
- Benefits, problems, and management of IPR
- National and International harmonization of patent law
- Patents of biotechnological process and their protection
- Case Study of Diamond v. Chakrabarty on patenting engineered microbes

Unit 3: Regulatory affairs

- Introduction to pharmacopoeia, good microbiological techniques and good laboratory practice (GLP)
- Basic principles of quality control (QA) and quality assurance (QC)
- Guidelines for QA and QC: raw materials, sterilization, media, stock cultures and products
- Validation study and toxicity testing
- Role of culture collection centre, public health laboratories and regulatory agencies

Unit 4: Biosafety and bioethics

- Biosafety guidelines
- Risk and risk assessment
- Biosafety levels, laboratory biosecurity concepts
- Introduction to drug design
- Pre-clinical and clinical trials
- Basics of bioethics principles, international codes and guidelines in India Ethics in post-genomic era

REFERENCE

No.	Name	Author
1.	Animal Cell Culture: A Practical Approach	John Mastersv
2.	Animal Cell Culture and Technology	Michael Butler
3.	Introduction to Pharmaceutical Biotechnology, Volume 1-4	Saurabh Bhatia et al.
4.	Pharmaceutical Biotechnology: Fundamentals and Applications, Fifth Edition	Daan J.A. Crommelin et al.
5.	Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies	Craig Shimasaki
6.	Bioentrepreneurship and Transferring Technology Into Product Development	Swati Agarwal et al
7.	Intellectual Property Rights: Legal and Economic Challenges for Development	Mario Cimoli et al

e-PGPathshala:

Unit 1: Bio-entrepreneurship
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=JVkwqv+HM+natE9SiF7CZA==

- Paper-03 Module-01 Understanding Business and Entrepreneur
- Paper-03 Module-06 BUSINESS ECOSYSTEM: DIFFERENT FORMS OF ECOSYSTEMS

Unit 2: Intellectual Property rights
https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=t5vt4STquHRj94mcOBMr5g==

- Paper-05 Module-36 Intellectual Properties
- Paper-05 Module-37 Implication of IPRS on commercialization of biotechnology products
- Paper-05 Module-38 Copyrights, Trademarks, Trade secrets, Patents, Geographical Indications

Unit 3: Regulatory affairs

- Paper-05 Module-25 General principles for the laboratory and biosafety

Unit 4: Biosafety and bioethics

- Paper-05 Module-26 National Biosafety Policies and Regulatory Framework
- Paper-05 Module-28 Biosafety and risk assessment issues and Risk management issues
- Paper-09 Module-39 Animal cell culture, Tissue culture, Biosafety level, Different level of Biosafety, Good Laboratory Practice
- Paper-09 Module-40 Ethical Issues in Animal Cell Culture
- Paper-10 Module-02 Biosafety and Biocontainment I
- Paper-10 Module-03 Biosafety and Biocontainment I

MIC 504 E2: Recombinant DNA Technology

COURSE CODE: MIC 504 E2
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Genetic manipulation of microbes for biotechnological innovations is conveyed with their use under ethical wisdom.

CO2 Techniques used for genetic manipulation in microbes are taught.

CO3 Tools to identify and analyze genes for their mapping are explained to students.

Unit 1: Fundamentals of rDNA Technology

- Core techniques and essential enzymes used in rDNA.
- Restriction digestion, ligation and transformation.

Unit 2: Cloning strategies-1

- Cloning vectors-plasmids, phages and cosmids.
- Cloning strategies. Cloning and selection individual genes, gene libraries: cDNA and genomic libraries.

Unit 3: Cloning strategies-2

- Specialised cloning stratifies. Expression vectors, Promoter probe vectors,
- vectors for library construction-artificial chromosomes.

Unit 4: Methods and Techniques in rDNA Technology

- PCR methods and application.
- DNA sequencing methods; dideoxy and chemical method.
- Sequence assembly. Automated sequencing. Genome sequencing and physical mapping of genes.

REFERENCE

No.	Name	Author
1.	Gene Cloning And DNA Analysis: An Introduction, Seventh Edition	T A Brown
2.	Principles Of Gene Manipulation And Genomics, Eighth Edition	Sandy B Primrose et al.
3.	Recombinant Gene Expression: Reviews And Protocols	Paulina Balbas et al.
4.	Recombinant DNA: Genes and Genomes - A Short Course	James D Watson et al.
5.	Molecular Biotechnology: Principles and Applications of Recombinant DNA	Bernard J Glick et al.
6.	Basic Concept of Recombinant DNA Technology	Somnath De
7.	Recombinant Dna Technology and Genetic Engineering	Rajagopal K

e-PGPathshala:

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

- Paper-04 Module-02 DNA modifying enzyme (Nomenclature, Type I-IV)
- Paper-04 Module-03 Restriction Endonucleases, Isoschizomers
- Paper-04 Module-04 Classification of Restriction enzymes
- Paper-04 Module-05 DNA Topoisomerases
- Paper-04 Module-06 DNA Methyltransferases
- Paper-04 Module-07 DNA polymerases
- Paper-04 Module-011Polymerase Chain Reaction (PCR)
- Paper-04 Module-15 Generalized cloning schemes and strategies
- Paper-04 Module-19 Insertion vectors, replacement vectors, cosmids, phasmids
- Paper-04 Module-32 Sanger's Di-deoxy Chain termination method (Use of M13 based ssDNA vectors to cycle sequencing
- Paper-12 Module-24 Cloning Strategies

MIC 504 E3: Biopharmaceuticals and Drug Development

COURSE CODE: MIC 504 E3
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Therapeutic signaling factors and their industrial production is explained.

CO2 Strategies for development of vaccines and their improvement is conveyed to combat novel challenges is addressed.

CO3 Sensitization to pharmacopeia and ethical manufacturing practices are inculcated.

CO4 Approaches of Rational drug design with special emphasis on clinical trial is discussed at length.

Unit 1: Basics of Biopharmaceuticals

- Introduction to pharmaceuticals of animal, plant and microbial origin
- Haematopoietic growth factors and coagulation factors
- Interferons and cytokines for anti-infective and cancer therapy
- Insulin and growth hormones
- Vaccine: genetically improved vaccines, synthetic peptide based and nucleic acid vaccines

Unit 2: Products and therapies based on Biopharmaceuticals

- Recombinant thrombolytic agents: tissue type plasminogen activator, first and second generation of thrombolytic agents
- Concept and approaches for gene therapy, ex vivo and in vivo gene therapy
- Potential target diseases for gene therapy (inherited disorders and cancer)
- Antigene and antisense therapy

Unit 3: Xenotransplantation, Forensic Sciences and Toxicity Estimation

- Xenotransplantation in pharmaceutical biotechnology
- The role of biotechnology in forensic sciences
- Estimation of toxicity: LD50 and ED50
- Pre-clinical and clinical trails

Unit 4: Pharmaceutical Quality Assurance

- Introduction to pharmacopoeia, guide to good manufacturing practice
- Manufacturing facility
- Final product fills and analysis
- Validation study

REFERENCE

No.	Name	Author
1.	Biopharmaceutical Drug Design and Development	Susanna Wu-Pong et al.
2.	Development of Biopharmaceutical Drug-Device Products	Feroz Jameel et al
3.	Biopharmaceutics and Pharmacokinetics Considerations	Rakesh K. Tekade et al.

e- PGPathshala:

https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=WR+tSjp4YS3g7BIFEffOcw==

- Paper-06 Module-16 Good Manufacturing Practice

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

- Paper-10 Module-07 Fundamentals of Gene therapy
- Paper-10 Module-16 Cytokine therapy
- Paper-10 Module-19 Biotherapy of cancer
- Paper-10 Module-28 Recombinant Protein therapeutics
- Paper-10 Module-34 Vaccines and vaccinology-1
- Paper-10 Module-35 Vaccines and vaccinology-2

MIC 505: Practicals

COURSE CODE: MIC 505
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Use of microbes in Bioremediation of pollutants in practically learnt.

CO2 Skills in the domain of microbial assessment of water, soil and environment is implicated.

CO3 Developing acumen in Microbial assessment for the quality of fermented food.

1. Bioremediation of inorganic pollutants and phytoremediation of metals
2. Characterization of waste water:
    a. Physical: odour, colour, turbidity, temperature, salinity, Volatile Solids (VS), Dissolved Solids (DS), Suspended Solids (SS) and Total Solids (TS)
    b. Chemical: acidity, alkalinity, chloride, phosphate, sulphate, copper and hardness
3. Water Analysis:
    a. Bacteriological characterization of potable water: MTT and MFT
    b. Biochemical characterization of waste water: BOD and COD
4. Estimation of phosphatase activity of soil: acid and alkaline
5. Isolation of probiotic culture from various sources
    a. Evaluation and efficacy of probiotic culture
6. Production of fermented food and characterization of acidity, alkalinity and its microbial profile

MIC 506: Practicals

COURSE CODE: MIC 506
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Practical learning on environmental assessment for contamination of toxic metals and dyes with its biodegradation.

CO2 Skills are inculcated to develop bio fertilizers.

CO3 Environmental rehabilitating using microbes in inculcated.

1. Bio-oxidation and determination of oxidation rate: Fe and S
2. Bioleaching of Cu from sulphidic ore
3. Biocatalyst from marine microbes
4. Microbial load determination
5. Decolourization of dye
6. Biodeterioration of lignocellulosic waste and pharmaceutical products:
    a. Determination of microbial load
    b. Characterization of biodeteriorating microorganisms
7. Isolation of Plant growth promoting bacteria (PGPR)
    a. Nitrogen fixers
    b. Phosphate solubilizers
    c. Phytohormone (IAA and Gibberellic Acid) procedures
8. Tissue culture: Plant and animal
9. Antioxidant activity of pigment

SEMESTER 4

MIC 507: Project / Dissertation Work theory

COURSE CODE: MIC 507 PT
NO. OF CREDITS: 16

COURSE OUTCOMES (COs)

CO1 Enables the student to develop aptitude to carry out research independently.

CO2 Acquire skills to plan and execute experiments individually as well as in groups.

CO3 The student imbibes necessary skills to represent scientific data in form of scientific report.

CO4 The course intends to inculcate individual research methodology skill sets.

- The candidate is required to show article to faculty in/before interpreting his/her experimental work.
- Two typed/computerised 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.
    - Thesis experimental work: conducting and reporting experiments in labs or other settings with quality, safety and ethics considerations
    - Thesis evaluation: assessing and comparing experimental work with existing literature and suggesting future research directions.
    - Presentation and viva-voce: presenting and defending dissertation to examiners who test research skills and knowledge.
- Students have to provide Project Proposal: A project proposal is a document that outlines the objectives, methods, expected outcomes of selected dissertation topic.
- Students have to give a seminar on Classical Research Paper Presentation: A research paper presentation-seminar is an oral presentation of a research paper to an audience of peers and experts. It is usually accompanied by slides or other visual aids and followed by a question-and-answer session. The purpose of a research paper presentation-seminar is to share the findings to demonstrate their concept understanding of the topic.
- Student has to either choose to study Concepts in Research Methodology or undergo Industrial Training of seven (07) days and submit a report.
    - Concepts in research methodology are the principles and techniques that guide the design and conduct of a research project. They include topics such as research paradigms, research questions, literature review, data collection methods, data analysis methods and ethical issues.
    - Industrial training with report is a practical learning experience in an industry-related setting that requires students to write a report on their activities, achievements and challenges. The purpose of industrial training with report is to expose students to real-world problems and solutions in their field of study and enhance their professional skills.

- **Students opting to study Concepts in Research Methodology must learn the following:**
  - Searching interest of research, Defining the research question, Approaches and Methodology, objectives, significance and techniques of research
  - Introduction to kinds of scientific documents: research paper, review paper, book reviews, theses, and project reports (for the scientific community and for funding agencies).
  - Ethics in research: Honesty and integrity, Misconducts: Falsification, fabrication, plagiarism. Best/ standard practices of research.
  - Redundant publication: duplication and overlapping of publications, selective reporting and misinterpretation of data. Conflict of interest, Violation of publication ethics: authorship and contributorship.
  - Introduction to spreadsheet applications, features
  - Generating charts / graph and other features, Tools – Microsoft Excel or similar.
  - Using formulae and functions, Data storage, Standard deviation, standard error
  - Web Search: Use of Publication search engines and libraries (PubMed, PubMed central, CrossRef, Google scholar).
  - Use of automated referencing softwares (Mendley, Zotero, EndNote, etc.)
  - Presentation tools: Introduction, features and functions, slide presentation
  - Key aspects of research presentations

MIC 508: Conference report writing and Study tour

COURSE CODE: MIC 508
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Students will be able to learn Conference report writing by collecting, evaluating information on that elaborates on a scientific topic using facts, charts, and graphs to support its arguments and findings.

CO2 Study tours will let student to reflect the educational value of a trip, including any objectives the student might have and unexpected learning experiences.

CO3 Students will learn to highlight the impact of the trip on the student's chosen discipline, and will serve to develop inspiration.

- Students have to (i) attend conference and write a report on it and (ii) participate in study tour and provide its report
- Conference report writing:
  - A summary of the main themes, topics and outcomes of a conference attended by the writer

    - A critical reflection on the relevance, quality and impact of the conference for the writer's research or professional development
- Study tour:
    - A visit to a place or an institution related to the field of study or interest of the participants
    - An opportunity to observe, learn and interact with experts, practitioners and peers in a different cultural and academic context

MIC 509: Review Paper Presentation and assignments

COURSE CODE: MIC 509
NO. OF CREDITS: 04

COURSE OUTCOMES (COs)

CO1 Enables the student to present a scientific topic of subject relevance thereby developing oral presentation and oratory skills.

CO2 The students are familiarized to the opportunities that lie in the commercial avenues pertaining to microbiology & biotechnology.

CO3 Sensitize students with the standard operational procedures employed in the industrial setup.

Students have to give a Presentation on Review Paper and submit two assignments of which one should be on Instrument or Technique, while the other assignment should be on either of Process or Product or Technology.

- Presentation on Review Paper:
    - A critical analysis and synthesis of the literature on a specific topic or research question.
    - A demonstration of the current state of knowledge, gaps and controversies in the field.
    - A communication of the main findings, implications and recommendations for future research.
- Assignment-1 on Instrument or Technique:
    - A description and evaluation of a tool or a method used for data collection or analysis in research project.
    - A comparison and contrast of the advantages and disadvantages of different instruments or techniques for a given purpose.
    - An application and demonstration of an instrument or a technique to a relevant research problem or question.
- Assignment-2 on Process or Product or Technology:
    - A description and explanation of a sequence of actions, an outcome or an innovation related to the field of study or interest.
    - A discussion and assessment of the benefits, challenges and impacts of the process, product or technology for society, environment and economy.

An identification and suggestion of potential improvements, alternatives or extensions for the process, product or technology.