Gandhinagar Institute of Science (03)

Academic Regulation & Curriculum

for

Master of Science (09)

in

Microbiology Programme (23)

Gandhinagar University

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Gujarat

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(Applicable from 2024 admitted Batch)

Preamble

The Department of Microbiology and Biotechnology at Gandhinagar Institute of Science, Gandhinagar University, is committed to advancing higher education, scientific research, innovation, and ethical practices in the field of Microbiology. The Master of Science (M.Sc.) in Microbiology programme has been designed with an emphasis on multidisciplinary learning, research excellence, skill development, and outcome-based education. The programme aims to provide advanced theoretical knowledge and intensive practical training in various domains of microbiology. The programme integrates advanced laboratory courses, research methodology, dissertation work, internships, industrial training, seminars, scientific communication, and project-based learning to foster innovation, critical thinking, problem-solving skills, and independent research aptitude. The curriculum also incorporates interdisciplinary and Indian Knowledge System (IKS) components to promote holistic development, professional ethics, environmental sustainability, entrepreneurship, leadership qualities, and lifelong learning. The programme encourages students to actively engage in research projects, workshops, conferences, industrial visits, field studies, extension activities, MOOCs, and collaborative learning initiatives with academic and industrial partners. The curriculum has been developed after extensive consultation with academicians, researchers, industry experts, alumni, employers, and other stakeholders to ensure its relevance to current scientific advancements, national priorities, global trends, and workforce requirements. Through this programme, the Department strives to create a vibrant academic and research ecosystem that nurtures excellence, innovation, entrepreneurship, social responsibility, and ethical leadership, preparing graduates to contribute effectively to scientific progress and societal development at national and international levels.

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1. Institutional Vision & Mission

1.1 VISION

Gandhinagar Institute of Science aims to strengthen quality science education and research by fostering innovation, ethical values, and scientific temperament for societal and sustainable development.

1.2 MISSION

- To provide quality education supported by modern infrastructure and an industry- oriented curriculum, while emphasizing ethics and critical thinking.
- To promote an innovative and research-oriented environment that fosters effective problem-solving skills and entrepreneurial development.
- To encourage innovation, entrepreneurship, and scientific ethics for developing responsible and skilled graduates.
- To foster interdisciplinary learning, sustainability, and community engagement for national development.

2. Program Objectives (PO)

PO1: Advanced Microbiological Knowledge

Acquire in-depth knowledge of microbial diversity, physiology, genetics, immunology, molecular biology, environmental microbiology, and industrial microbiology.

PO2: Laboratory Competency

Demonstrate proficiency in advanced microbiological, molecular, biochemical, and analytical techniques for the identification, characterization, and manipulation of microorganisms.

PO3: Research and Innovation

Design, conduct, analyze, and interpret scientific experiments using appropriate methodologies, statistical tools, and modern research instruments.

PO4: Critical Thinking and Problem Solving

Apply scientific reasoning and analytical approaches to address complex biological and microbiological challenges in healthcare, agriculture, environment, and industry.

PO5: Data Analysis and Bioinformatics

Utilize computational tools, bioinformatics resources, and data analysis techniques for interpreting biological data and supporting scientific research.

PO6: Industry and Entrepreneurship

Understand industrial applications of microbiology, quality control practices, bioprocess technology, and entrepreneurial opportunities in biotechnology and microbiology-based enterprises.

PO7: Communication and Teamwork

Communicate scientific concepts, research findings, and technical information effectively through oral presentations, reports, publications, and collaborative activities.

3. Program Educational Objectives (PEOs)

PEO 1:

Demonstrate advanced knowledge and technical expertise in microbiology and its allied disciplines, enabling them to contribute effectively in academia, research, healthcare, agriculture, environmental management, and industrial sectors.

PEO 2:

Apply scientific principles, analytical skills, and modern laboratory techniques to investigate microbiological problems and develop innovative solutions for societal and industrial challenges.

PEO 3:

Engage in independent research, lifelong learning, and professional development through higher studies, interdisciplinary collaborations, and continuous skill enhancement.

PEO 4:

Uphold ethical values, biosafety practices, environmental responsibility, and professional integrity while working in research laboratories, industries, and public health organizations.

PEO 5:

Develop leadership, communication, teamwork, and entrepreneurial skills to successfully function in multidisciplinary and global professional environments.

4. Program Details

4.1 Program structure & Duration

Duration & Intake: 2 Years & 30 Seats

Semesters: 4

Mode: Full Time

Credit Structure: As per UGC/University norms

Medium of Instruction: English

4.2 Eligibility Criteria for Admission

Candidate must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Candidate should have basic knowledge and technical skill for the concern subject.

4.3 Admission Procedure

Admission to the B.Sc. Microbiology program may be granted on the basis of merit obtained in the qualifying examination and/or performance in the Entrance Test, as prescribed by the University from time to time. Candidates seeking admission must have passed the Graduation examination from a recognized board with Microbiology/Biotechnology, fulfilling the minimum eligibility criteria specified by the University.

Credit summary for M.Sc Microbiology in MIBT department with effect from 2024

Sl. No.	Course Type	Credit
1.	Core Courses	54
2.	Discipline Specific Elective	12
3.	Indian Knowledge System (IKS)	4
5.	Internship/Rerearch Project/on the job training (OJT)	16
	Total	**86**

Definition of Credit:

Teaching Component	Credit Definition
1 Hour of Theory (Lecture) per week	1 Credit
2 Hours of Practical/Laboratory Work per week	1 Credit
2 Hours of Field Work/Internship per week	1 Credit = 30 hrs (4 credit = 120 hrs)
2 Hours of Skill/Project Work per week	1 Credit

Semester-wise Credit Structure (M.Sc. Microbiology)

Semester	Total Credits
Semester I	20
Semester II	22
Semester III	22
Semester IV	22
Grand Total	**86 credits**

5. Curriculum Structure

First Year 1st Semester:

Subject Code	Course Type	Subject Name	Credit	Hours per week			
				L	T	P	Total
10230101	Core Course	Physiology of Microorganisms	4	4	-	-	4
10230102	Core Course	Microbial Diversity	4	4	-	-	4
10230103	Core Course Specialization	Cell Biology of Microorganisms	4	4	-	-	4
10230104	Discipline Specific Elective	Fundamentals of Biochemistry	4	4	-	-	4
30230105	Core Course	Laboratory - I	4	-	-	8	8
			20				24

First Year 2nd Semester:

Subject Code	Course Type	Subject Name	Credit	Hours per week			
				L	T	P	Total
10230201	Core Course	Bioinstrumentation	4	4	-	-	4
10230202	Core Course	Enzymology	4	4	-	-	4
10230203	Core Course Specialization	Microbial Technology	4	4	-	-	4
10230204	Discipline Specific Elective	Bioinformatics	4	4	-	-	4
30230205	Core Course	Laboratory - II	4	-	-	8	8
IKS0201	IKS	Indian Ancient History and Cultural Heritage	2	1	-	1	2
			22				30

Second Year 3rdSemester:

Subject Code	Course Type	Subject Name	Credit	Hours per week			
				L	T	P	Total
10230301	Core Course	Genetic Engineering	4	4	-	-	4
10230302	Core Course	Biostatistics	4	4	-	-	4
10230303	Core Course Specialization	Medical Microbiology	4	4	-	-	4
10230304	Discipline Specific Elective	Environmental Biotechnology	4	4	-	-	4
20230305	Core Course	Laboratory-III	4	-	-	8	8
20230306	IKS	Traditional Fermented food and beverages	2	1		1	3
			22				24

Second Year 4th Semester:

Subject Code	Course Type	Subject Name	Credit	Hours per week			
				L	T	P	Total
10230401	Core Course	Research Methodology	4	4	-	-	4
10230402	Core Course	Seminar/Assignment	2	-	-	-	2
10230403	Core Course	Research Project	16	-	-	-	32
			22				36

6. Teaching, Learning & Evaluation

6.1 Teaching Methodology

The program shall adopt:

- Classroom Teaching
- Laboratory Practical and Demonstrations
- Interactive Learning Sessions
- Problem-Based Learning
- Research-Oriented Projects
- Industrial and Laboratory Visits
- Workshops and Hands-on Training
- Internship and Training Programs
- Field Visits and Sample Collection Studies
- AI-based Learning Tools
- Blended Learning Methods
- Assignments, Presentations, and Tutorials

6.2 Attendance Rules

- Minimum 75% attendance shall be mandatory in each course.
- Students below prescribed attendance may not be permitted to appear in examination.
- Additional attendance requirements may apply for practicals, internships, and field work.

6.3 Examination and Evaluation System

6.3.1 Evaluation Components

- The evaluation may consist of Continuous Internal Evaluation (CIE) and End Semester examination (ESE)
- Continuous Internal Evaluation (CIE) may include:
    - Mid-Semester Examination
    - Assignments
    - Presentations
    - Field work
    - Class Test

- AI Quiz & Viva Voce
- Dissertation
- Project work

6.4 Suggested Weightage

- Continuous Internal Evaluation: 30%
- End Semester Examination: 70%

6.5 Passing Standards

- Minimum 50% marks in each component where applicable.
- Minimum 50% aggregate for passing the course/program.
- Separate passing may be required in theory and practical examinations.

6.6 Grading System

The program shall follow Gandhinagar University grading norms.

6.6.1 Grade Table

Grade	Grade Points	From Marks	To Marks
AA	10	80	100
AB	9	75	79
BB	8	70	76
BC	7	65	69
CC	6	60	64
CD	5	55	59
DD	4	50	54
DF	0	0	49

6.7 Dissertation / Project Work

Students shall undertake Research Project/ Internship

Requirements may include:

- Proposal Presentation
- Periodic Review
- Final Report Submission
- Viva Voce Examination

The dissertation shall be evaluated by internal and external examiners.

7. Rules and Regulations

7.1 Rules for Promotion

A student shall be promoted to the next semester as per Gandhinagar University rules subject to fulfilment of academic requirements, minimum attendance and Completion of required credits.

7.2 Maximum Duration for Completion

The maximum duration for completing the program shall be 2 years from the date of admission (or as prescribed by the University).

7.3 Internship Guidelines

7.3.1 Students shall undergo mandatory internship/industrial training/field training in:

- Microbiology and Biotechnology Industries
- Pharmaceutical Companies
- Clinical and Diagnostic Laboratories
- Research and Development Laboratories
- Food and Dairy Industries
- Environmental and Water Testing Laboratories
- Hospitals and Healthcare Laboratories
- Agricultural and Soil Microbiology Laboratories
- Public Health and Government Research Institutes
- Quality Control and Quality Assurance Laboratories

7.3.2 Students must submit:

- Internship Report
- Work Diary/Logbook
- Training Completion Certificate
- Presentation/Viva-Voce on Internship Work

7.4 Discipline Rules

Students shall maintain discipline, professional ethics, laboratory ethics, and proper conduct within the institution, during laboratory practicals, field visits, internships, industrial visits, research activities, examinations, and all academic programs. Students are expected to attend classes and practical sessions regularly, follow institutional rules and laboratory safety guidelines, respect faculty members, staff, fellow students, and institutional property, and maintain academic honesty in assignments, projects, practical records, and examinations. Any form of misconduct, ragging, indiscipline, falsification of laboratory data, misuse of laboratory equipment or microbial cultures, use of unfair means in examinations, damage to institutional property, harassment, or behaviour affecting the academic and research environment shall be treated seriously and may result in disciplinary action including warning, suspension, cancellation of examination, withholding of results, or expulsion from the program as per University rules and UGC regulations. Students shall also comply with all biosafety, ethical, environmental, and professional standards prescribed by the institution from time to time.

7.5 Anti-Ragging Policy

The program shall strictly follow:

- UGC Anti-Ragging Regulations
- Anti-Ragging Affidavit requirements
- Institutional disciplinary procedures
- Ragging in any form is strictly prohibited

7.6 Ethical Use of Technology and AI Tools

Students are encouraged to use:

- Microbiology and Bioinformatics Software
- Statistical and Data Analysis Tools
- AI-based Learning Platforms
- Digital Microscopy and Imaging Tools
- Online Scientific Databases and Research Platforms
- Laboratory Information and Documentation Tools

8. Student Support

8.1 Industry Collaboration

The department shall actively promote collaboration with pharmaceutical industries, biotechnology companies, clinical and diagnostic laboratories, food and dairy industries, environmental testing laboratories, research organizations, healthcare institutions, agricultural industries, and government agencies to enhance practical exposure and industry relevance of the M.Sc. Microbiology program. Such collaborations may include internships, industrial training, laboratory visits, live projects, expert lectures, workshops, research activities, skill development programs, and placement support. The institution may also establish Memoranda of Understanding (MoUs) with industries, research institutes, hospitals, and professional organizations for academic enrichment, technology support, training programs, certification courses, and collaborative initiatives aimed at improving employability, entrepreneurship, innovation, and professional competency among students.

8.2 Research and Consultancy

The department shall encourage faculty members and students to actively engage in research, consultancy, innovation, and applied studies related to microbiology, biotechnology, public health, food microbiology, industrial microbiology, environmental microbiology, agricultural microbiology, molecular biology, and emerging biological technologies. Students may undertake research projects, laboratory-based studies, microbial analysis, environmental monitoring, quality control studies, and data-driven investigations as part of their academic and professional training. The institution may also undertake consultancy assignments for hospitals, industries, food processing units, pharmaceutical companies, environmental agencies, and other organizations in areas such as microbial testing, water and food quality analysis, biosafety practices, industrial fermentation, and laboratory diagnostics. Participation in seminars, conferences, workshops, publications, funded projects, and collaborative research activities shall be encouraged to promote academic excellence, innovation, scientific temperament, and industry-oriented learning.

8.3 Library and Laboratory Facilities

Adequate library, laboratory, and digital learning facilities shall be made available to support effective teaching, practical training, research, and skill development under the M.Sc. Microbiology program. The department shall facilitate access to relevant textbooks, reference books, scientific journals, research publications, e-resources, microbial culture manuals, laboratory protocols, and digital learning platforms related to microbiology, biotechnology, molecular biology, immunology, biochemistry, and allied life sciences. Necessary laboratory

infrastructure including microscopes, incubators, autoclaves, laminar airflow systems, culture media preparation facilities, analytical instruments, computing facilities, internet access, bioinformatics tools, and other technical resources required for practical and project-based learning shall also be provided to enhance scientific knowledge, research capability, laboratory skills, and professional competency among students.

8.4 Student Support and Mentoring

A structured system for student support, academic mentoring, and professional guidance shall be implemented for students enrolled in the M.Sc. Microbiology program. The department shall facilitate academic counselling, mentoring, career guidance, research support, and skill development activities to assist students in their academic progression and professional growth. Students may also be provided opportunities for interaction with scientists, healthcare professionals, industry experts, and researchers through workshops, seminars, industrial visits, laboratory training, conferences, and extracurricular activities aimed at enhancing employability, scientific aptitude, leadership qualities, communication skills, and overall personality development. Necessary support mechanisms for addressing academic and personal concerns shall also be made available as per institutional policies.

8.5 Placement and Career Development

The department shall promote placement assistance and career development activities for students through industry interaction, professional networking, training programs, internships, and campus engagement initiatives. Efforts shall be made to establish linkages with pharmaceutical industries, biotechnology companies, hospitals, clinical laboratories, food industries, environmental agencies, research organizations, and allied sectors to facilitate internships, industrial exposure, research opportunities, and employment avenues for students. Career development activities such as aptitude training, resume preparation, soft skill development, entrepreneurship guidance, laboratory skill enhancement, certification programs, expert sessions, and placement-oriented workshops may also be organized to improve professional competency, research aptitude, and employability of students.

9. Program Credibility

9.1 Executive Summary

The M.Sc. Microbiology program is designed to develop scientifically skilled and industry-ready graduates with strong theoretical knowledge and practical expertise in microbiology, biotechnology, molecular biology, immunology, industrial microbiology, environmental microbiology, food microbiology, and medical microbiology. The program emphasizes laboratory-based learning, research orientation, scientific ethics, and industry relevance aligned with the rapidly growing healthcare, pharmaceutical, biotechnology, food, agriculture, and environmental sectors.

Every subject in the program is delivered by qualified faculty members and subject experts with academic, research, and industrial experience, ensuring that students gain both conceptual understanding and practical exposure to modern microbiological techniques and applications. Laboratory practicals, research-based assignments, case studies, industrial visits, and internships are integrated throughout the curriculum to strengthen analytical ability, technical competency, and problem-solving skills among students.

The program incorporates training in microbial culture techniques, staining methods, sterilization practices, biochemical analysis, molecular biology techniques, immunological methods, bioinformatics tools, and laboratory instrumentation relevant to modern biological sciences and industrial applications. Students are also exposed to emerging areas such as genetic engineering, microbial biotechnology, environmental sustainability, vaccine technology, bioinformatics, and artificial intelligence applications in life sciences.

The department actively promotes academic-industry interaction through collaborations with pharmaceutical industries, biotechnology companies, diagnostic laboratories, research institutes, hospitals, food industries, and environmental organizations. Expert lectures, workshops, seminars, live projects, and research activities are regularly organized to provide exposure to current developments and professional practices in microbiology and allied sciences.

The program is designed to prepare graduates for employment, higher education, entrepreneurship, and research opportunities in diverse sectors including healthcare, pharmaceuticals, biotechnology, food technology, agriculture, environmental management, and scientific research. The curriculum also supports progression towards postgraduate studies, competitive examinations, professional certifications, and advanced research in microbiology and related life science disciplines.

9.2 Scope and Career Opportunities

Graduates of the program may work in:

- Pharmaceutical Industries
- Biotechnology Companies
- Clinical and Diagnostic Laboratories
- Hospitals and Healthcare Organizations
- Food and Dairy Industries
- Environmental and Water Testing Laboratories
- Agricultural and Soil Testing Laboratories
- Research and Development Organizations
- Public Health Laboratories
- Quality Control and Quality Assurance Laboratories
- Vaccine and Fermentation Industries
- Government Research Institutes
- Academic and Educational Institutions

9.3 Potential Job Roles

- Microbiologist
- Research Assistant
- Laboratory Technician
- Quality Control Analyst
- Quality Assurance Executive
- Clinical Laboratory Technologist
- Food Microbiologist
- Environmental Microbiologist
- Industrial Microbiologist
- Biotechnologist
- Medical Laboratory Assistant
- Fermentation Technician
- Scientific Assistant
- Public Health Laboratory Technician
- Laboratory Executive

9.4 Higher Study & Professional Opportunities

Students may pursue:

- M.Sc. in Microbiology and Allied Life Sciences
- Ph.D. in related disciplines

- Biotechnology and Molecular Biology Programs
- Clinical Research and Bioinformatics Courses
- Medical Laboratory Technology Programs
- Industrial and Food Microbiology Specializations
- Research Fellowships and Competitive Examinations
- Professional Certification Courses in Biotechnology and Laboratory Sciences
- Entrepreneurship in Healthcare, Diagnostics, and Biotechnology Sectors

10. Collaborative Field Work / Experimental Work

10.1 Microbial Isolation and Culture Techniques Exercise

During a supervised laboratory session, students will collect samples from soil, water, air, or food sources and perform microbial isolation using serial dilution and streak plate techniques. They will prepare culture media, incubate microbial cultures, and record colony morphology observations. Submission shall include laboratory observations, microbial characterization tables.

10.2 Water Quality and Microbial Analysis Report

Students will collect water samples from assigned localities and perform microbiological analysis using standard methods such as total viable count, coliform detection, and biochemical testing. They will compare results with BIS drinking water standards and prepare a structured report including microbial load data, photographs, and public health interpretation.

10.3 Industrial Visit — Pharmaceutical or Biotechnology Industry

Faculty shall arrange a guided visit to a pharmaceutical, biotechnology, or fermentation industry. Students will observe industrial microbiology practices, sterilization systems, quality control procedures, biosafety measures, and production processes. Submission shall include ten annotated photographs and a 500-word industrial observation report.

10.4 Food Microbiology and Contamination Analysis

Students will collect and analyze food samples such as milk, curd, packaged foods, or street food items for microbial contamination using culture and staining techniques. They shall identify probable contamination sources and compare findings with food safety standards. Deliverables include laboratory records, microbial data sheets.

10.5 Hospital or Diagnostic Laboratory Visit

Students will visit a clinical or diagnostic microbiology laboratory to observe specimen collection, microbial diagnostics, sterilization protocols, culture techniques, and biosafety procedures. Students shall prepare a structured observation checklist and submit a 400-word report on laboratory workflow and infection control practices.

10.6 Environmental Microbiology Field Study

Students will conduct field sampling from soil, wastewater, compost, or polluted environments to study microbial diversity and environmental contamination. They will analyze microbial populations and prepare comparative data tables with ecological interpretations. Final submission shall include sample records, photographs, and a environmental assessment report.

10.7 Microscopy and Staining Techniques Laboratory Exercise

In a supervised practical session, students will perform Gram staining, acid-fast staining, and fungal staining techniques on microbial samples. They shall identify microorganisms microscopically and prepare detailed laboratory records with labeled diagrams and interpretations.

10.8 Comparative Study of Fermented Products

Students will prepare and analyze fermented food products such as curd, bread, idli batter, or fermented beverages to study microbial activity and fermentation processes. They will document preparation methods, microbial observations, and biochemical changes during fermentation.

10.9 Molecular Biology and DNA Isolation Exercise

Students will isolate genomic DNA from bacterial or plant samples using standard laboratory protocols. They will assess DNA quality using spectrophotometric or gel electrophoresis methods and prepare a structured laboratory report with methodology, observations, and interpretation.

10.10 Bioinformatics and Database Exploration Exercise

Students will use online biological databases such as NCBI, PDB, and EMBL to retrieve microbial gene or protein sequences. They will perform sequence alignment and basic bioinformatics analysis using software tools. Submission shall include screenshots, sequence data, and interpretive report.

10.11 Industrial Fermentation Laboratory Exercise

Students will study fermentation processes using yeast or bacterial cultures for production of products such as alcohol, organic acids, or enzymes. They shall monitor growth conditions, pH changes, and product formation during fermentation. Deliverables include laboratory observations and a technical report.

10.12 Biosafety and Laboratory Audit Exercise

Students will inspect laboratory facilities using biosafety guidelines to evaluate sterilization practices, waste disposal methods, chemical handling, and personal protective measures. They shall prepare a structured biosafety audit report with recommendations for laboratory improvement.

10.13 Mandatory Industry Internship (4–8 Weeks)

Students shall complete a mandatory internship in pharmaceutical industries, biotechnology companies, diagnostic laboratories, food industries, environmental laboratories, hospitals, or research institutes. Internship activities may include laboratory assistance, microbial analysis,

documentation, quality control, or research work. Deliverables shall include a structured internship report, laboratory work diary, and supervisor evaluation certificate.

10.14 Research Project and Dissertation

Students shall undertake an independent or group research project related to microbiology, biotechnology, environmental microbiology, food microbiology, industrial microbiology, or public health. The project shall include proposal preparation, literature review, experimentation, data analysis, and report writing. Final submission shall include a dissertation and viva voce presentation before a faculty panel.

10.15 Scientific Seminar and Poster Presentation

Students shall prepare and present scientific seminars or posters on emerging microbiological topics such as antimicrobial resistance, vaccine technology, microbial biotechnology, environmental sustainability, or infectious diseases. Evaluation shall be based on scientific content, presentation skills, and analytical understanding.

10.16 Portfolio Presentation and Exit Viva

The Portfolio Presentation and Exit Viva shall serve as the final capstone assessment of the program. Students shall compile laboratory records, project reports, internship work, field studies, and seminar presentations into a professional portfolio. Students shall deliver a presentation before a faculty panel followed by a viva voce examination assessing practical knowledge, laboratory competency, scientific understanding, and professional readiness.

11. Market Survey

The M.Sc. Microbiology programme has gained significant importance due to the rapid growth of microbiological sciences and their expanding applications in healthcare, pharmaceuticals, biotechnology, agriculture, food industries, environmental management, and research. The increasing prevalence of infectious diseases, antimicrobial resistance, emerging pathogens, and global health challenges has created a strong demand for highly skilled microbiology professionals with advanced scientific knowledge and laboratory expertise. The programme provides comprehensive theoretical understanding and specialized practical training in areas such as Medical Microbiology, Immunology, Virology, Microbial Genetics, Molecular Biology, Industrial Microbiology, Environmental Microbiology, Food Microbiology, Microbial Biotechnology, and Bioinformatics. Through advanced laboratory training, research projects, dissertations, and scientific investigations, students develop analytical abilities, technical competencies, and research skills required for modern scientific and industrial environments.

The healthcare and pharmaceutical sectors have emerged as major employers of microbiology postgraduates due to the growing need for disease diagnosis, pathogen identification, vaccine development, antimicrobial resistance monitoring, infection control, and molecular diagnostic techniques. The global focus on public health preparedness and disease surveillance has further increased the demand for trained microbiologists in hospitals, diagnostic laboratories, pharmaceutical industries, vaccine manufacturing companies, and public health organizations. In addition, advancements in molecular diagnostics, genomics, proteomics, and precision medicine have expanded the role of microbiologists in biomedical research and healthcare innovation.

The industrial relevance of microbiology has also grown substantially with the expansion of biotechnology, pharmaceutical production, food processing, dairy technology, fermentation industries, and biopharmaceutical manufacturing. Microorganisms are extensively utilized for the production of antibiotics, enzymes, vaccines, probiotics, organic acids, biofuels, fermented foods, and other value-added products. Consequently, industries require professionals who possess expertise in fermentation technology, quality assurance, quality control, microbial process optimization, contamination monitoring, and product development. Food and dairy industries depend on microbiologists to ensure food safety, quality management, microbial testing, and compliance with regulatory standards, creating numerous employment opportunities for postgraduate students.

Environmental sustainability has become another important area contributing to the demand for microbiology professionals. Environmental microbiology plays a crucial role in wastewater treatment, waste management, bioremediation, pollution control, renewable energy production, and sustainable agricultural practices. The use of microorganisms in biofertilizer production, biopesticide development, soil health management, and environmental monitoring has created significant opportunities in agricultural and environmental sectors. Government agencies, environmental consulting firms, and industrial organizations increasingly seek microbiology experts to address environmental challenges through sustainable microbial technologies.

Research and innovation have become central to the development of microbiological sciences, leading to increased opportunities in research institutions, universities, biotechnology companies, and government-funded scientific organizations. Emerging fields such as microbial genomics, metagenomics, synthetic biology, vaccine technology, microbial bioinformatics, industrial biotechnology, and antimicrobial resistance research require highly trained postgraduate professionals. The M.Sc. Microbiology programme equips students with advanced research methodologies, scientific communication skills, data analysis techniques, and laboratory competencies necessary for pursuing doctoral studies, research fellowships, and scientific careers at national and international levels.

The programme also offers diverse career opportunities in research and development laboratories, pharmaceutical companies, biotechnology industries, hospitals, clinical laboratories, food and dairy industries, environmental agencies, agricultural biotechnology firms, forensic laboratories, water testing facilities, public health organizations, and academic institutions. Graduates can pursue careers as Microbiologists, Research Associates, Quality Control Officers, Quality Assurance Executives, Clinical Microbiologists, Laboratory Managers, Production Executives, Regulatory Affairs Professionals, Scientific Officers, and Academicians. Furthermore, the programme provides a strong foundation for higher studies such as Ph.D. programmes in Microbiology, Biotechnology, Molecular Biology, Biomedical Sciences, Environmental Sciences, and related interdisciplinary fields.

Considering the continuous expansion of healthcare, biotechnology, pharmaceutical, environmental, and research sectors, the demand for qualified microbiology professionals is expected to increase steadily in the coming years. Industries and research organizations require graduates who possess advanced laboratory skills, critical thinking abilities, scientific temperament, problem-solving capabilities, and research aptitude. Therefore, the

departmental action plan emphasizes curriculum enrichment, advanced laboratory training, industrial internships, collaborative research, workshops, seminars, field visits, skill development programmes, and industry-academia interactions to enhance student employability and professional competence. The market survey clearly indicates that the M.Sc. Microbiology programme is strategically feasible and highly relevant, offering excellent career prospects while contributing significantly to scientific advancement, industrial development, healthcare improvement, environmental sustainability, and societal welfare.

12. Review and Revision of Regulation

The University reserves the right to interpret, modify, revise, amend, or update any provision, rule, regulation, curriculum structure, evaluation pattern, academic requirement, or operational guideline related to the program from time to time in accordance with university regulations, statutory requirements, industry developments, and academic needs.

In case of any ambiguity or dispute regarding interpretation of any provision of this manual, the decision of the University/Competent Authority shall be final and binding on all stakeholders. Any amendments, additions, or revisions approved by the appropriate academic or statutory bodies of the University shall automatically become applicable to the program.

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1

Subject Code: 10230103	**Subject Title: Cell Biology**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective: (1) Differentiate between prokaryotic and eukaryotic cells and understand their functional compartmentalization.
(2) Understanding cell-cell interactions underlying tissue organization and physiological processes.
(3) To develop understanding of cell division cycle and cell death mechanism along with its implications in cancer.
(4) To introduce methods employed to study cell organelles and cellular processes.
(5) To build a fundamental that would enable the understanding of complex molecular basis of cellular mechanisms.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Structural organization of Membrane and Communication of cell:** Introduction, History and General organization of Prokaryotic cell (Mycoplasma, Viruses, Viroids and Bacteria (*E.coli*)), General organization of Eukaryotic cell (Fungal cells), Composition of cell membrane, Molecular models-Unit membrane, Daniely and Dowsoṅs Mode, Fluid mosaic Model, Functions of cell membrane, General principles of cell signaling, G-protein linked receptors, Enzyme linked receptors, Mitosis and Meiosis.	15	25%

2	**Structural organization, functions of Major Cell organelles and Cytoskeleton-1:** Nucleus-Ultrastructure, Nuclear envelop, Pore complex, Mitochondria-Morphology, molecular structure, membranes, molecular organization, Biogene Genetic code, Chloroplast-Morphology, Ultra structure, molecular organization of thylakoids, Biogenesis, DNA-semi-autonomous nature, Golgi complex- Morphology, cytochemistry, Endoplasmic reticulum - Morphology, Biogenesis, protein segregation.	15	25%
3	**Structural organization, functions of Cell organelles and Cytoskeleton-2:** Ribosomes, Structure and functions of Lysosomes, Vacuoles, Peroxisomes. Microtubules-cilia, flagella, & centrioles, Intermediate filaments, Microfilaments and cell motility.	15	25%
4	**Eukaryotic Cell signaling:** Mechanisms of cell signaling, Types of receptors-membrane bound, cytosolic and nuclear receptors, signal transduction pathways, regulation of signal transduction, comparison with prokaryotic cell signaling. **Cell cycle regulation:** Cell cycle and its control, cell death mechanisms, implications in cancer. **Tools and Techniques of Cell Biology:** Methods of cell disruption, subcellular fractionation, microscopic methods, Basic cell culture techniques, Applications of flow-cytometry and cell sorting (FACS), model organisms.	15	25%

Course Outcome: After completion of this course, student will be able to

1) Gain insight into wide range of basic concepts in cell biology.
2) Develop appreciation towards the intricacies of cell structure and function, their dynamic properties and their co-ordination for the functioning of the whole organism and its development.
3) Acquire an understanding of hierarchical organization of cellular interactions and
4) Gain insights into understanding of tools and techniques used to study cell organization and function.

List of Text Books:

- Cell Biology, Genetics, Molecular Biology: Evolution and Ecology P S Verma and V K Agarwal, S Chand publications, 2004.

List of Reference Books:

- Cell and Molecular Biology '8th Edition by E.D.P. De Robertis.
- Cell Biology 2nd Edition, by Seong S. Han, Ruth Ashley, Gary Hann Rastogi publications.
- Essentials of Cell and Molecular Biology: by de Robertis E. D. P. and E. M. F., Holt Saunder's International Edition (new edition).
- G. M. Cooper. 1997. The Cell and Molecular approach. ASM Press. Ed.
- Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
- The Physiology and Biochemistry of Prokaryotes, by White, D (2000) Oxford University Press, Oxford.

Open e-Resource:

- https://onlinecourses.nptel.ac.in/noc22_bt33/preview
- OpenStax: Microbiology - OpenStax.
- https://www.edx.org/learn/cellular-biology
- https://www.coursera.org/courses?query=cell%20biology
- https://www.ibiology.org/online-biology-courses/cell-biology-flipped-course/

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1

Subject Code: 10230104	**Subject Title: Fundamentals of Biochemistry**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective: (1) Biochemistry is, in simplest terms, the study of the chemistry of living things. The general objective of this course, therefore, is to train students to understand biological processes and events by learning the logic of chemistry.
(2) It is far more than simply memorizing structures and metabolism; the fascination of the field is to see how and why biological molecules are built the way they are and how this makes life possible–on many levels and with an amazing degree coordination and control.
(3) To give students the knowledge about the important biomolecules like Protein, Carbohydrates, Lipids, Nucleic acids.
(4) To make students familiar with the vitamins and their structures & functions.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Chemical Bonding:** Introduction to chemical bonds, covalent bonds, ionic bonds, hydrogen bond, coordinate bond, metallic bond, Van der Waals forces. **Protein chemistry:** Amino acids: Properties, structures, functions and classification of common amino acids. Uncommon amino acids. Peptides and proteins: Peptides bond formation, types of peptides, and lengths of peptides chain, conjugated proteins and their classification. Protein structure: Levels of organization of protein structures – primary, secondary, tertiary and quaternary	15	25%

	structures. The three-dimensional structure of proteins, determination of sequence of amino acids in peptides or protein. **Proteins purification and characterization:** Fractionation, Dialysis, Chromatographic techniques, Electrophoresis, Sequencing methods for polypeptide.		
2	**Lipid chemistry:** Storage lipids: fatty acids – nomenclature structure and properties of some naturally occurring fatty acids, Triacylglycerols and their functions as storage lipids. **Structural lipids in cell membranes:** Glycerophospholipids, galactolipids, sulfolipids, sphingolipids, and sterols. Lipids as signals, cofactors and pigments. Phosphatidyl inositol and sphingosine derivatives as intracellular signals Eicosanoids, Prostaglandins, Thromboxanes, Leukotrienes, Vitamins: A, D, E and K. An outline of method of the extraction, separation and identification of cellular lipids.	15	25%
3	**Carbohydrate chemistry:** Nomenclature of carbohydrates, **Types of carbohydrates: (a)** Monosaccharides & disaccharides **(b)** Polysaccharides **(c)** Glycoconjugates Carbohydrate as informational molecules – the sugar code, An outline of methods of carbohydrate analysis. **Vitamins: (Water soluble and fat-soluble vitamins):** **Structure and functions of: (a)** Water soluble Vitamins – Vitamins B1, B2, B6, B12, Folic acid, Pantothenic acid, Niacin and Biotin. **(b)** Fat soluble Vitamins – Vitamins A, D, E and K.	15	25%
4	**Nucleic acid chemistry:** Nucleotides (the building blocks of nucleic acids): components, structures and nomenclature. **Nucleic acid structures: (a)DNA:** Watson – Crick Model, Three-dimensional forms of DNA (Comparison of A, B and Z form of DNA) Unusual DNA structures – palindromes, mirror repeats, inverted repeats, hairpin (or cruciform), Hoagsteen pairing, triplex DNA's, G tetraplex DNA, H - DNA. **(b) RNA:** monocistronic and polycistronic RNA, base – paired helical structure in RNA. **(c)** Denaturation and renaturation of double stranded DNA and RNA, DNA hybridization, DNA sequencing by Sanger method. Chemical synthesis of DNA (Automated)-Principle and major steps involved. Ribozymes- types and therapeutic applications.	15	25%

Course Outcome: After completion of this course, student will be able to

1) Know the chemical structures and chemistry of biological polymers (proteins, carbohydrates, lipids and nucleic acids) and their monomers (amino acids, sugars, fatty acids and other lipid monomers, and nucleotides).
2) Well versed on the fundamental principles of Biochemistry.
3) Understand the roles of these biological molecules in living cells.

List of Text Books:

- "Lehninger Principles of Biochemistry", David L. Nelson & Michael M. Cox. 4th edition, W.H. Freeman & Co.
- "Microbiology", by Prescott, L.M. Harley, J.P.Klein, D.A.," International edition", 5th edition, 2003, McGraw– Hill Publications, New York.

List of Reference Books:

- "Principles of Microbiology", by Atlas R.M., 1st edition, 1995,Mosby–YearBook Inc. St.Louis, Missouri.
- Biochemistry by Jeremy Berg, John Tymoczko and LubertStryer, Fifth Edition, Freeman Company.
- Fundamentals of Biochemistry by Debajyothi Das 11/e, 2002.
- Fundamentals of biochemistry- Life at the molecular level By: Voet, Voet and Pratt, Second edition, 2006.
- Harper's Biochemistry by Robert.KK.Murray 26/e, 2003.
- Human Biochemistry by James.M.Orten&Oho.W.Neuhaus, 10/e, 1983.
- Lehninger Principles of Biochemistry by David Nelson and Michael Cox, Fifth Edition Freeman Company. (2005).

Open e-Resource:

- Swayam Portal: General Microbiology - Course (swayam2.ac.in)
- OpenStax: Microbiology - OpenStax.
- https://pll.harvard.edu/course/principles-biochemistry-1
- https://www.futurelearn.com/courses/biochemistry
- https://www.edx.org/learn/biochemistry

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1

Subject Code: 20230105	**Subject Title:** Laboratory - I
Pre-requisite: Candidate must have achieved regular degree in the 10+2 system from any recognized Board. Candidate must have studied core subjects like Chemistry and Biology at their Higher Secondary level and he/she may have complete Certificate Course (First Year, B.Sc.) with Basic Microbiology and Chemistry subjects.	

Course Objective:

(1) To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.

(2) To provide the students with the current updates in the areas of Analytical Techniques, Instrumentation, Basic knowledge of media preparation.

(3) To generate competent skilled human resource for industries and research organization.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	12	06	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	Preparation of standard solutions.	Approx. 12 hours per week	100 %
2	Demonstration of basic laboratory instruments		
3	**Quantification of biomolecules:** Carbohydrates: Cole's method, Folin's Wu method, Nelson Somogyi method, Anthrone method		
4	**Quantification of biomolecules:** Proteins: Folin Lowry's method, Bradford's method.		
5	**Quantification of biomolecules:** Lipids: Bligh and Dyer's method, Van Handel's method.		

6	**Quantification of biomolecules:** Nucleic Acids: DNA by DPA; and RNA by Orcinol method.		
7	**Qualitative analysis of biomolecules by chromatography:** sugars, amino acids & organic acids by: **(i)** Paper Chromatography **(ii)** Thin layer Chromatography		
8	**Nuclear staining: (i)** Staining of nuclear material (DNA) of bacteria **(ii)** Staining of nuclear material (DNA) of yeast.		
9	Induction of Endospore formation in bacteria.		
10	Preparation of bacterial and yeast protoplasts.		
11	**Morphological Characterization and identification: (i)** Bacteria – Bacillus, Micrococcus, Proteus, Clostridium and Nitrobacter species. **(ii)** Fungi – Aspergillus, Fusarium, Mucor, Penicillium, Rhizopus, Saccharomyces species. **(iii)** Algae – Spirulina species. **(iv)** Protozoa – Euglena, Paramecium species.		
12	Isolation of psychrophilic bacteria.		
13	Isolation of yeast from natural sources (Fruits / Flowers / Honey).		
14	**Isolation and Identification of:** fungi, unknown microorganism from sewage.		
15	Isolation of Halophilic and Halotolerant organisms from Saline soils / Sea water.		
16	Isolation of Candida albicans from clinical specimens.		
17	Enrichment and isolation of Acidophilic and Alkalophilic organisms from Industrial waste / Sewage.		
18	Enrichment and isolation of Chemolithotrophic bacteria (Nitrosomonas and Nitrobacter species) from soils.		
19	Bacterial growth difference depending on media composition.		
20	To Study the metabolic diversity of bacteria especially of *E. coli* **(a)** Particularly on sugar utilization **(b)** Selective pH (optimum) **(c)** Temperature **(d)** Salinity **(e)** Aeration and Agitation.		

Course Outcome: After completion of this course, student will be able to

- Perform analytical techniques for qualitative as well as quantitative analysis of biomolecules.
- Know characteristics and significance of archea, algae, fungi, viruses, their isolation, cultivation and growth pattern.
- Carry out enrichment and isolation of Acidophilic, Alkalophilic, Osmophilic, Thermophilic and Halophilic microorganisms.

List of Text Books:

- "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.1.
- "Laboratory exercises in Microbiology", by Harlcy Prescott, 2002, 6th edition, The MaCraw-Hill.
- "Laboratory manual in Biochemistry", by Jayraman, J., 1998, New age International Publishers, New Delhi.
- "Manual of laboratory techniques", by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.

List of Reference Books:

- "Compendium of soil fungi", by Domsch, K. H., Gams, W. and Anderson, T. H., 1980, Academic Press, London.
- "Experimental Microbiology Vol-1&2", by Rakesh Patel and Kiran Patel, 5th edition, Book Publisher: Delhi Aditya Book Centre 2009 Edition.
- "Experiments in Microbiology, Plant Pathology and Tissue Culture", by Aneja, K. R., 1993, Wishwa Prakashan.
- "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.1.
- "Identification methods for Microbiologists", edited by Gibbs, G. M. and Shapton, D. A., 1968, Academic Press, London.
- "Illustrated genera of imperfect fungi", by Barnett, H. L., and Hunter, B. B., 3rd edition, 1972, Burgess
- "Medical Microbiology", Vol. 2, 12th edition, 1975 by Cruickshank, R. Duguid, J. P. Marriman, B. P. and R. A. Swan, Churchill Livingstone, London.
- "Methods in Microbiology", Vol.3A and Vol.3B edited by Norris and Ribbons, Academic Press,
- "Practical Biotechnology", by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical
- "Standard methods for the examination of water and waste water", 20th edition, edited by Greenberg, *et al.*, 1998, APHA, AWWA, Washington, DC. London.
- Methods in Microbiology", Vol.4 edited by Booth, C., Academic Press, London.
- Methods in Microbiology", Vol.5 edited by Norris and Ribbons, Academic Press, London.
- Microbiological applications", by Benson, H. J., 6th edition, 1994, Wm. C. Brown Publishers, Dubuque, Iowa. Publishers(p) Ltd. New Delhi.
- Publishing Company, Minneapolis, Minnesota.

Open e-Resource:

- http://www.vlab.co.in
- https://vlab.amrita.edu/?sub=3&brch=73
- https://www.futurelearn.com/courses
- https://www.labster.com/explore/microbiology-virtual-labs

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1

Subject Code: 10230101	**Subject Title: Physiology of Microorganisms**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective: (1) To introduce the students with the phenomenon of chemotaxis, phototaxis and magneto taxis.
(2) To give the students' knowledge about the autotrophic mode of microbial metabolism.
(3) To give students the knowledge about the heterotrophic mode of microbial metabolism.
(4) To give students the knowledge of various metabolic reactions and their role/functions.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Chemotaxis, magneto taxis and phototaxis:** **(i)Chemotaxis:** Chemotactic behavior of bacteria, molecular mechanism of chemotaxis. **(ii)Magneto taxis:** Magneto tactic bacteria, mechanism of magnotaxis. **(iii)Phototaxis:** Phototactic organisms, mechanism of phototaxis. **Autotrophic Metabolism:** **Chemoautotrophic metabolism:** Concept of chemoautotrophy Hydrogen oxidation, Autotrophic methanogenesis, sulfur and Iron oxidation Ammonium and nitrite Oxidation – Nitrification.	15	25%

	Photoautotrophic metabolism: Characteristic of photoautotrophic microorganisms, Photophosphorylation, comparison of oxygenic and anoxygenic photosynthesis.		
2	**Heterotrophic metabolism:** **Conversion of carbohydrates to pyruvate** -Glycolytic pathways, Embden Meyerhof pathway, Entner – Doudoroff pathway, Pentose phosphate pathway, methyl glyoxal pathway, Archaebacterial Glycolytic pathways – modified Entner – Doudoroff pathway **The citric acid cycle:** Tri carboxylic acid cycle (TCA) Production of acetyl CoA, reaction of citric acid cycle, energetics, Anaplerotic reactions, regulation of the citric acid cycle, the glyoxylate cycle, coordinated regulation of glyoxylate and citric acid cycle. **Fermentations:** Mixed acid fermentations, Propionic and butyric acid fermentations, Amino acid fermentation, Fermentation of acetate to methane: Methanogenesis.	15	25%
3	**Oxidative Phosphorylation:** **Electron transport chain:** Components (carriers), their organization into large functional complexes, the path of electron flow through them, Proton gradient, Proton motive force. ATP synthesis – Mechanisms: chemiosmotic model proposed by Peter Mitchell, ATP synthase complex of mitochondria, Binding change mechanism (rotational catalysis mechanism) proposed by Paul Boyer, Shuttle systems to convey cytosolic NADH into mitochondria for oxidation – malate aspartate shuttle, glycerol – 3 – phosphate shuttle. **Regulation of oxidative phosphorylation** **Mitochondrial genes:** Their origin and the effects of mutations. Role of mitochondria in Apoptosis and oxidative stress.	15	25%
4	**Photophosphorylation:** General features of photophosphorylation's, light absorption, primary Light absorbing pigment – Chlorophylls, Secondary Light absorbing pigments or accessory pigment, organization of photo system (PS). **Photophosphorylation in bacteria:** Type II reaction center in purple bacteria Type I reaction center in Gre1en sulfur bacteria Photosynthesis in cyanobacteria, algae and vascular plants. Photosystem II (PS II) and photosystem I (PS I) integration in chloroplast Dual roles of cytochrome b6f and cytochrome C6 in cyanobacteria. Photophosphorylation in halophilic bacterium Halobacterium Salina rum. **ATP synthesis: Mechanisms:** Chemiosmotic coupling electron flow and phosphorylation ATP synthase complex of chloroplast.	15	25%

Course Outcome: After completion of this course, student will be able to

1) Have knowledge about phototactic, chemotactic and magnetostatic bacteria.
2) Illustrate various anabolic and catabolic pathways of carbohydrates, lipids, proteins and amino acids.
3) Describe various mechanisms of ATP synthesis by metabolism and chemiosmotic hypothesis of ATP synthesis.

4) Comprehend Photophosphorylation.

List of Text Books:

- "Lehninger Principles of Biochemistry", by David L Nelson and Michael M Cox, 4th edition, W.H. Freeman and Co.
- "Principles of Microbiology", by R.M. Atlas, 1995, mosby year bwk, Inc. St. Louis, Missouri 631146 (USA).

List of Reference Books:

- "Bacterial Metabolism", by Doelle H.W. Academic Press 2005.
- "General Microbiology", by Schlegel H.G. Cambridge University Press 2004.
- "General Microbiology", by Stanier R. *et al*, Macmillan Co. 2005.
- "Microbial Physiology", by moat AG and JW Foster, 1988, John Wiley and sons, New York.
- "Physiology of the Bacterial cell a molecular approach" by Neidhardt FC, JL Ingraham, in scratchier: 1990, sinauer, Sunderland, MA.

Open e-Resource:

- Swayam Portal: General Microbiology - Course (swayam2.ac.in)
- OpenStax: Microbiology - OpenStax.
- Learn Microbiology With Online Courses, Classes, and Lessons | edX
- Free Online Certificate Courses to Become a Microbiologist - Alison

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1

Subject Code: 10230102	**Subject Title: Microbial Diversity**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective: (1) To develop a detailed understanding of the taxonomy, relationships and evolution of microorganisms.
(2) To understand the intricacies of a microbial community, the concept of a species, and the classification and naming of microorganisms.
(3) To study various classes of fungi & Algae in terms of their characteristic features.
(4) To assimilate the concepts of culturable and unculturable bacterial diversity.
(5) To learn about Extremophiles.
(6) To expand knowledge on applications of Microbial Diversity.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Evolution and Taxonomy:** Evolutionary History of present-day microorganisms, Endosymbiosis, Evolutionary significance of microbial life, Evolutionary Chronometers, Signature sequences, Microbial phylogeny as revealed by RNA sequencing, Phenotypic characteristics of the Primary domains (Cell wall; lipids; RNA polymerase; features of protein synthesis), Taxonomy, nomenclature and Bergey's manual.	15	25%

2	**Basics of Diversity:** Extent of microbial diversity on earth, Sources of diversity, Biodiversity study of Culturable bacteria, Biodiversity study of Unculturable bacteria, Algae (Classification of algae), Fungi (Classification of fungi; introductory description of mold, yeast and mushroom).	15	25%
3	**Extremophiles: (i)** Extreme environments (Low temperature; high temperature; water stress; salinity; pH; oxygen; low nutrient environment; resting stages and survival; light) **(ii)** Habitats, microorganisms, and biochemistry and physiology of adaptation of Hyperthermophiles, Extreme Acidophiles, Psychrophiles, Barophiles, Halophiles, Alkaliphiles.	15	25%
4	**Technical Applications of Biodiversity:** **Economic value of microbial diversity:** Role of microbial diversity in biodiversity maintenance, biosphere functions and in sustainable development, need for diversity, Categories of microorganisms (Substrate based groups, Size based groups), Species specific interactions, Qualitative and stabilizing effects of diversity, Changes in biodiversity and microbial activity (Biotic interactions; trace gas production and; Carbon and nutrient cycling). **Conservation strategies**: Causes of biodiversity loss, Biodiversity indicators relevant for decision makers for formulation of conservation strategies. **Biotechnological applications of Microbial diversity:** Accessing and using molecular DNA data on biodiversity. **Key technologies used in biotechnology studies:** Chemical screening, DNA technologies: Genome mapping, Biotechnology applications in biodiversity assessment and management. **Increasing option values:** **Providing the knowledge base for biodiversity culture and preservation:** Ex-situ conservation, Biotechnology-enhances option values, Role of DNA libraries and sequence data in biodiversity conservation and in biodiversity assessment and utilization, Application of biotechnology for the utilization of biodiversity, Impact of biotechnology on biodiversity (Direct impacts and indirect impacts).	15	25%

Course Outcome: After completion of this course, student will be able to

1) Know basic and applied aspects of microbial diversity, in sense physiological diversity, biochemistry, molecular diversity and applications of basic aspects of microbial diversity.
2) Explore taxonomic strategies and approaches used to name microorganisms, and the criteria used to define bacterial species and intrasubspecific divisions within species.
3) Understand the principles and methods behind studying and identifying cultured and uncultured microorganisms.
4) Understand and evaluate methods and approaches used to study relationships and evolution (phylogeny) of microbes, particularly Bacteria and Archaea, and develop an understanding of the current classification of microbe groups.
5) Know basic and applied aspects of extremophiles.
6) Know biotechnological aspects and exploitation of theoretical knowledge of Biodiversity.

List of Text Books:

- Brock Biology of Microorganisms" Eighth Edition By- Madigan, T.M.; Martinko, J.M. and Parker, J. Prentice Hall Publication, U.K.
- Microbial Evolution, Systematic and Taxonomy" *In:* Brock Biology of Microorganisms Eighth Edition By- Madigan, T.M.; Martinko, J.M. and Parker, J. Prentice Hall Publication, U.K.

List of Reference Books:

- Biodiversity of Microbial Life" Editor-Staley, J.T. and Reysenbach, A.L. Wiley-Liss Publication, New York.
- Encyclopedia of Microbiology" Second Edition, Volume-2 Editor-in-chief- Lederberg, J. Academic Press, New York.
- Global Biodiversity Assessment" Editor-Heywood, V.H. and Watson, R.T. Cambridge University, Press.
- Global Biodiversity Status of The Earth's Living Resources" Editor-Groombridge, B. Chapmman and Hall Publication, London.
- Manual of Industrial Microbiology and Biotechnology" Second Edition Editor-in ChiefArnold, L.; Demain and Julian, E. Davies Editors- Ronald, M. Atlas; Gerald Cohen; Charles, L. Hershberger; Wei-Shou Hu; David, H. Sherman; Richard, C. Willson and David Wu, J.H. ASM Press, Washington.
- The Prokaryotes-A Handbook on The Biology of Bacteria: Ecophysiology, Isolation, Identification, Application" Second Edition, Volume-I Editors-Balows, A.; Truper, H.G.; Dworkin, M.; Harder, W. and Schleiffer, K.H. Springer-Verlag Publication, New York.

Open e-Resource:

- Swayam Portal: General Microbiology - Course (swayam2.ac.in)
- OpenStax: Microbiology - OpenStax.
- https://www.mbl.edu/education/advanced-research-training courses/courseofferings/microbial-diversity

Gandhinagar Institute of Science
Master of Science – Microbiology/ Biotechnology/ Environmental Science/ Pharmaceutical Science
Semester-II

Subject Code: 10230204	**Subject Title: Bioinformatics**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective:

- To give the students the basic knowledge about computers, operating system, internet resources.
- To acquaint the students with the various important tools and techniques of information technology, Metabolimics and Phylogenetic analysis.
- To make the students understand the basics of biological databases, Methods of sequence alignment, Genomics & Proteomics, Protein structure prediction & drug designing.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Introduction to databases:** **Databases:** Primary, Secondary; Relational and Non-relational; Redundant and Non-Redundant. **E-R Model:** a. Entity and Entity sets b. E-R Diagrams c. Reducing E-R diagram to tables. **Introduction to SQL**: a. Select statement b. Data definition Statements c. Data manipulation statements.	15	25%
2	**Biological Databases:** **Bioinformatics Resources:** NCBI, EBI, ExPASY**.** **Biological search Engines:** SRS and ENTREZ**.**	15	25%

	Biological Databanks: PDB, MMDB. **Derived, Databases:** PROSITE, Pfam, PRINTS, CATH, SCOP, DSSP, FSSP, DALI. **Nucleic Acid databases and Protein databases:**		
3	**Biological Data Analysis:** 1) Overview, Concepts and tools. 2) Sequence comparison by Dot Matrix and Dynamic Programming. 3) Pair wise Sequence Analysis by Needle man and Wunch algorithm 4) Scoring Matrices: PAM, BLOSSUM 5) Database Search: BLAST and FASTA 6) Multiple Sequence Alignment: Basic concepts, Progressive and Hierarchical approaches CLUSTAL-W, Applications. 7) Immunoinformatic databases.	15	25%
4	**Protein structure prediction:** 1) Necessity of Protein structure Prediction 2) Secondary structure prediction 3) Fold Recognition 4) Homology Modeling 5) Ab-initio Methods. **Microbial Genomics and Proteomics:** **Genomics:** 1) Functional genomics and comparative genomics. 2) Insight from microbial Genomes- Identification of genes with unknown function, Genomic analysis of pathogenic microbes and extremophiles, Environmental genomics (metagenomics) **Proteomics:** Functional proteomics, structural proteomics, protein modeling **Metabolimics':** 1) Metabolic Pathway databases a. KEGG b. EcoCyc and MetaCyc 2) Enzyme compounds and Reaction Databases a. LIGAND-Biochemical and Reaction Databases b. ENZYME- Enzymes c. BRENDA d. Metabolic Pathway Prediction. **Structure based Drug Design:** Introduction	15	25%

Course Outcome: After completion of this course, student will be able to

CO1: Students will acquire the knowledge of computers, operating system, internet resources.

CO2: Students will get introduced with tools and techniques of information technology, Metabolimics and Phylogenetic analysis.

CO3: Students will acquire the knowledge of biological databases, Methods of sequence alignment, Genomics and Proteomics.

CO4: Students will get introduced with protein structure prediction and drug designing.

List of Text Books:

- "Bioinformatics", by C.S.V. Murthy, 2003, Himalaya Publishing House, Mumbai.
- "Fundamentals of computers", by Rajaraman, V. Printice Hall of India, New Delhi.

List of Reference Books:

- "Discovering genomics, proteomics and Bioinformatics", by Campbell, A.M, and Heyer, L.J., 2003, Benjamin cunnings, San Francisco, CA.
- "Fundamental concepts of Bioinformatics", by Krane, D.E. and Raymer, M. L. 2003, Benjamin cunning, San Francisco, Calif.
- "Introduction to computers", by Leon A. and Leon M. Vikas Publishing House Pvt., New Delhi.
- "Introduction to SQL and PLSQL", by Ivan Dayross".
- "Prescott, Harley and Klein's microbiology", by Willey, Sherwood and Woolverton, 2008, Mc Graw- Hil companies, Inc, New york.

Open e-Resource:

- Swayam Portal
- OpenStax: Bioinformatics - OpenStax.
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf
- https://www.pdfdrive.com/
- http://www.ebi.ac.uk/embl/
- http://www.ncbi.nlm.nih.gov/Genbank/
- http://www.ddbj.nig.ac.jp/
- http://www.uniprot.org/
- http://www.rcsb.org/pdb/
- lab-manual-cs-2019.pdf (psgrkcw.ac.in)
- https://webstor.srmist.edu.in/web_assets/srm_mainsite/files/files/BI0505%20LAB%20MANUAL.pdf

Gandhinagar Institute of Science
Master of Science – Microbiology/ Biotechnology/ Environmental Science/ Pharmaceutical Science
Semester-II

Subject Code: 10230201	**Subject Title: Bioinstrumentation**
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective:

- To gain a deeper insight into the techniques they use for analysis and research including Nanotechnology.
- To make student understand about basic techniques for isolation, separation, purification, detection, and analysis of biological molecules.
- To get trained in Molecular Biology Techniques.
- Basic understanding of instrumentation routinely used in biotechnology.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Microscopy Techniques:** Principle and applications of light, phase contrast, fluorescent microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), scanning tunneling microscopy (STM), atomic force microscopy (AFM), confocal microscopy. **Measurement of colligative properties:** Viscosity, osmosis, surface tension, diffusion, dialysis. **Bio-nanotechnology:** Introduction to concept and principles of nanotechnology, Properties of nanomaterials, carbon nanotubes, Techniques and methodology used to study	15	25%

	nanoparticles, Application of nanoparticles in molecular biology, industry agriculture and environment.		
2	**Separation techniques:** **Centrifugation:** Types and Applications **Electrophoresis:** Types of electrophoresis, instrumentation and applications: Capillary, Agarose gel, SDS-PAGE, 2D-Elecrophotresis **Chromatography:** Types of chromatography, instrumentation and applications: paper, TLC, HPTLC, Column, HPLC, GC.	15	25%
3	**Molecular Biology Techniques:** Isolation, purification and analysis of DNA (Genomic and plasmid), RNA, Proteins and Lipids, Instrumentation and applications of PCR and Its modifications (reverse transcriptase PCR, real time PCR, anchored PCR, emulsion PCR, SAGE etc.), Blotting techniques, DNA Sequencing techniques, Sanger 's Method and Next generation sequencing methods, Protein sequencing, Microarray, SAGE, RFLP, RAPD, AFLP.	15	25%
4	**Spectroscopy Techniques:** UV/Vis, fluorescence, circular dichroism (CD), NMR, ESR, X-ray diffraction, light scattering, mass spectrometry, atomic absorption spectroscopy, surface plasma emission spectroscopy, IR and Raman spectroscopy. **Electrochemical and radio isotope techniques Radioisotope techniques:** types and applications Guideline to use radio isotopes Electrochemical Techniques: types and application	15	25%

Course Outcome: After completion of this course, student will be able to

CO1: Will have detailed understanding of the concepts and principles of sample preparation.

CO2: Will have thorough knowledge of different microscopic techniques, spectroscopic techniques, Chromatography techniques, and the techniques for the measurements of colligative properties.

CO3: Will have fundamental and critical understanding of the current approaches to the analysis of biomolecules.

CO4: Will have insights of routine instruments used in biotechnology.

CO5: Will be able to troubleshoot the errors in the analytical experiments.

CO6: Will be able to analyze and interpret the data obtained using instrumentation.

CO7: Will learn various applications of instruments in biotechnology.

List of Text Books:

- Analytical biochemistry by Wilson and walker.
- Gene cloning: An introduction by TA Brown.
- Prescott 's Microbiology by Willey, Sherwood, Woolverton Tata McGraw Hill.
- Principles and techniques of Biochemistry and Molecular Biology by Wilson and Walker.

List of Reference Books:

- Biochemical Calculations by Segel. I. R. - 1995 - John Wiley and Sons.
- Biochemical Methods by Pingoud A. et al.
- Biotechnology Exploartions: Applying the fundamentals By Judith A Scheppler, Pattricia E Cassin and Rosa M Gambler.
- Instrumental methods of chemical analysis by Anand and Chatwal, Himalaya Publishing Co.
- Physical Biochemistry, applications to biochemistry and molecular biology, second edition (Freifelder, David).
- Principles of Gene manipulations and genomics by Primrose.
- Spectrometric Identification of Organic compounds by R M Silverstein and F X Webster, Sixth edition (2002).
- Spectroscopy: D.R. Browning.
- Standard Methods of Biochemical analysis by S.R. Thimmaiah.
- Validation Standard Operating Procedures, 2nd edn., by Haider, SI (2006) CRC Press Taylor and Francis Group, NY (ISBN: 0-8493-9529).

Open e-Resource:

- https://onlinecourses.nptel.ac.in/noc22_bt33/preview
- OpenStax: Microbiology - OpenStax.
- https://www.edx.org/learn/cellular-biology
- https://www.coursera.org/courses?query=cell%20biology
- https://www.ibiology.org/online-biology-courses/cell-biology-flipped-course/

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-II

Subject Code: 10230203	**Subject Title:** Microbial Technology
Pre-requisite: Student must have achieved Graduate degree in Microbiology/Biotechnology/Biochemistry with minimum 45%. Student should have basic knowledge of technical terminology.	

Course Objective:

- To make the students well versed with the instrumentation used in fermentation industry. Students should also know applications of computers in fermentation industry.
- To give the students deep theoretical knowledge about the industrial production of yeast, yeast products, mushrooms, polysaccharides, pigments, bioinsecticides etc.
- To introduce the students with economics of fermentation processes, IPR, Patent office, Patent filling process, Immobilization etc.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Methods for laboratory fermentations – an overview**: Introduction, Experimental Design, Screening Techniques, Media Selection, Equipment, Intermediate scale-up. **Instrumentation of fermentation system:** Concepts of biological process Analysis and Control, Types of Instrumentation used in biological process analysis, Measurement and control environmental variables, Electronic Analysis of process data, Evaluation of control concepts in biological process, Auxiliary instrumentation.	15	25%
2	**Production of Carotenoids:** Introduction, Production of β – carotene, Production of Lycopene, Production of Xanthophylls and Other pigments, Marketing Prospects for Carotenoids. **Microbial production of Nucleosides and Nucleotides:** Introduction, Classification of methods for Production of 5′ IMP and 5′ GMP, Production 5 ′ - IMP and 5′ -GMP by hydrolysis of RNA, Production of 5′ IMP and 5′GMP	15	25%

	by fermentation, Production of Nucleic acid- related substances by fermentation. **Microbial production of Polysaccharides:** Introduction, Nature of Microbial Polysaccharides, Mechanism of synthesis, Bacterial Polysaccharides, Fungal Polysaccharides, Yeast Polysaccharides, commercially produced Polysaccharides.		
3	**Mushroom Fermentation:** Introduction, Mushroom fermentation, Spawn production, Mushroom formation, Processing problems. **Production of yeasts and yeast Products:** Introduction, Yeast Production, Yeast- Derived product. **Production of Bioinsecticides:** Introduction, Historical background, Candidate microbial insecticides, Developmental phases of microbial insecticide, Technical Parameters: Microbial Insecticides.	15	25%
4	**Production of alcohol as a fuel source.** **Vinegar Production:** History and development, Mechanism of Acetic Acid Fermentation, Organisms involved, Commercial Vinegar Production, Finished Vinegars, Processing of Vinegar, Annual Production and Uses. **Production of acetone butanol by fermentation.** **Microbial synthesis of rubber, adhesive proteins & melanin.** **Fermentation Processes and products:** Intellectual Property Rights, Patenting/Trading, Patent Practice, Problems and Trouble shooting. **Economics of fermentation processes:** Introduction, Plant Design, Process Design, Case study – project evaluation. **Use of Immobilized cell systems to prepare Fine chemicals:** Introduction, Immobilization of microbial cells, Characteristic of Immobilized cells, Production of chemical by Immobilized microbial cells.	15	25%

Course Outcome: After completion of this course,

- Students will gain deep theoretical knowledge about the industrial production of yeast, yeast products, mushrooms, polysaccharides, pigments, bioinsecticides etc.
- Students will be well versed with the instrumentation used in fermentation industry.
- Students will learn about the applications of computer in fermentation industry which will be increasing his skills for working in industry.

List of References:

1. "Microbial Technology", 2nd edition, volume I, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York. Page 67.
2. "Microbial Technology", 2nd edition, volume II, edited by Peppler, H. J. and Perlman, D. 1979 Academic Press, New York.

3. “Basic Biotechnology”, 2nd edition, by Colin Ratledge and Bjorn Kristiansen, 2001, Cambridge University Press, New York.
4. “Prescott and Dunn’s Industrial Microbiology”, edited by Reed, G., 4th edition, 1982.

Open e-Resource:

- Swayam Portal
- OpenStax: Microbiology - OpenStax.
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf
- https://microbenotes.com/
- https://unacademy.com/
- https://www.pdfdrive.com/
- https://kamarajcollege.ac.in/

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-1I

Subject Code: 20230205	**Subject Title: Laboratory - II**
Pre-requisite: Candidate must have achieved regular degree in the 10+2 system from any recognized Board. Candidate must have studied core subjects like Chemistry and Biology at their Higher Secondary level and he/she may have complete Certificate Course (First Year, B.Sc.) with Basic Microbiology and Chemistry subjects.	

Course Objective:

- To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.
- To provide the students with the current updates in the areas of Analytical Techniques, Instrumentation, Enzyme production, purification, analysis of enzymes.
- To generate competent skilled for various microbial technological productions.
- To impart the practical skills for Bioinformatics.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	12	06	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
	BIOINSTRUMENTATION	Approx. 16 hours per week	100 %
1	Verification of Beer-Lambert Law.		
2	Determination of absorption maxima of given sample using spectrophotometer.		
3	Colorimetry and spectrophotometry: Estimation of sugar and total carbohydrates, estimation of protein by lowry. Bradford and UV spectrophotometry.		
4	Demonstration of PCR, DNA sequencer and Fermenter.		

5	Isolation, purification and analysis of DNA (Genomic and plasmid)., RNA and Proteins from *E.coli*.		
6	Demonstration of RFLP/AFLP.		
7	Electrophoresis: Agarose gel electrophoresis.		
8	Electrophoresis: SDS PAGE of proteins.		
	ENZYMOLOGY		
9	To study oxidase activity of given microbial culture.		
10	Production of fungal alpha amylase using solid-state fermentation/ production of protease by bacterial species and confirmation by determining the achromic point.		
11	Purification of fungal alpha-amylase or bacterial protease by fractionation, chromatographic techniques and electrophoretic separation.		
12	Studies on enzyme kinetics of alpha amylase/Protease [Optimization of parameters viz. Substrate, enzyme concentration, reaction temperature, reaction pH, Km, Vmax and metal ions as activators and inhibitors).		
13	Determination of Acid-Phosphatase activity in soil.		
14	Determination of Alkaline-Phosphatase activity in soil.		
	MICROBIAL TECHNOLOGY		
15	Isolation, screening, and optimization of conditions for production: • Solid state fermentation: enzymes, alcohol • Submerged fermentation: enzymes, exopolysaccharide, alcohol, organic acids, and antibiotics		
16	Mushroom Fermentation.		
17	Pigment Production with the use of Microorganisms.		
18	Microbial production of Wine.		
19	Influence of different parameters on immobilization of cells and enzymes.		
20	Rheological study of culture broth by Brookfield viscometer.		
21	Estimation, recovery and purification of fermentation products-enzymes, antibiotics, organic acids, alcohol, exopolysaccharide.		
22	Scale up study		
	BIOINFORMATICS		
23	Data base exploration		
24	BLAST		
25	Sequence alignment: Multiple and Pair-wise		
26	Phylogenetic tree construction		
27	Sequence submission		

Course Outcome: After completion of this course, student will be able to

- Will be able to troubleshoot the errors in the analytical experiments.
- Will be able to analyze and interpret the data obtained using instrumentation.

- Operate and access different microscopic techniques, spectroscopic techniques, Chromatography techniques, and the techniques for the measurements of colligative properties.
- Learn commercial production of Alcoholic products, organic acids, antibiotics, exopolysaccharides, wine etc.
- Acquire the knowledge of computers, operating system, internet resources.
- Access biological databases, Methods of sequence alignment, Genomics and Proteomics applicability.

List of Text Books:

- "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.1.
- "Laboratory exercises in Microbiology", by Harlcy Prescott, 2002, 6th edition, The MaCraw-Hill.
- "Laboratory manual in Biochemistry", by Jayraman, J., 1998, New age International Publishers, New Delhi.

List of Reference Books:

- "Bioinformatics", by C.S.V. Murthy 1st edition publishers Himalaya Publishing House, Mumbai.
- "Laboratory Manual in Industrial Biotechnology", by P. Chellapandi 2007, Pointer Publishers, Jaipur.
- "Manual of laboratory techniques", by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.
- "Methods in Microbiology", Vol.3A and Vol.3B edited by Norris and Ribbons, Academic Press,
- "Practical Biotechnology", by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical Cox M. M., Nelson D. L., (2008)
- Lehninger Principles of Biochemistry, Fifth edition, W. H. Frreman and CompanyNew York. London.
- Methods in Microbiology", Vol.4 edited by Booth, C., Academic Press, London.
- Methods in Microbiology", Vol.5 edited by Norris and Ribbons, Academic Press, London.
- Microbiological applications", by Benson, H. J., 6th edition, 1994, Wm. C. Brown Publishers, Dubuque, Iowa. Publishers(p) Ltd. New Delhi.

Open e-Resource:

- http://www.vlab.co.in
- https://vlab.amrita.edu/?sub=3&brch=73
- https://www.futurelearn.com/courses
- https://www.labster.com/explore/microbiology-virtual-labs

Gandhinagar University
UG/PG
Semester-II

Subject Code: IKS0201	Subject Title: Indian Ancient History and Cultural Heritage

Course Objective:

- Foster an appreciation for the composite nature of Indian history, culture and heritage.
- Instill a sense of love and belonging among learners, contributing to nation-building efforts.
- Provide an overview of various components of cultural heritage, including fairs, festivals, dances, art, architecture, and historical landmarks, which are crucial for a deeper understanding of history.

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
				Theory		Practical		
Lecture	Tutorial	Practical	Credit	University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	Total
01	0	2	02	0	25/ Project	25/ Project		50

Subject Contents			
Sr. No	**Topics**	**Total Hours**	**Credit**
1	**Indian Ancient History:** Introduction of Ancient India. Harappan Civilization. Rigvedic & Later Vedic Period. India in the 6th Century B.C. Persian and Greek invasions and its impact. Mauryan and Gupta Periods. Post – Mauryan. Brief History of the Sanskrit literature: The Vedas, The Brahmanas and Upanishads & Sutras, Epics: Ramayana and Mahabharata & Puranas.	15	1
2	**Indian Cultural Heritage:** Ethnic Indian Cultural Construct – Fairs & Festivals and their historical background. Indian dances as Cultural Heritage. Indian Architecture: Temples, Stupas, Caves, Chaityas. Medieval Architecture and Colonial Architecture. Social culture in India- Vedic culture. Ancient period- varna and jati, family and marriage in India, position of women in ancient India, Contemporary period; caste system and communalism.	15	1

Course Outcome: After completion of this course, students will be able to

- Demonstrate knowledge of the key events, periods, and figures that have shaped Indian history from ancient to modern times, including their impact on the socio-political and economic landscape.
- Analyze the rich cultural heritage of India, including art, architecture, literature, and philosophy, while recognizing the contributions of various communities to India's pluralistic society.

List of Text Books:

1. An advanced history of India – causes and decline of Guptas by B.C. Majumdar and others, 1967, Macmillan.
2. Ancient India by R.C. Majumdar, 1977, Motilal Banarasi Das.
3. History of Ancient India by Rama sankar Tripati, 1942, Motilal Banarasi Das.
4. History and culture of India to 1000 A.D. by H.V. Srinivasa Murthy, 1980, S. Chand and Co.
5. History of South India by K.A. Nilakanta Sastry 1976, Oxford University Press.
6. History of Ancient India by Krishnaswamy Aiyangar, 1980, Seema Publishers.
7. Ancient India by V.D. Mahajan, 1985, S.Chand and Company.
8. Advance History of India by K.A. Nilakantasastry and C.S.Srinivasachari, 1980, Allied Publishers.
9. Ancient Indian History and Civilization by Silendranath Sen, 1988, Wiley Eastern.
10. Lothal and Indus Civilizations by S.R.Rao, 1972, Asia Publishers, Madras

Gandhinagar Institute of Science
M.Sc. Microbiology
Sem-3

Subject Code: 10230303	**Subject Title: Medical Microbiology (Theory)**

Pre-requisite:

- Candidate should have opted graduation degree in any biological field as per UGC norms in any recognized Board/University.
- Candidate must have achieved regular degree in the 10+2 system from any recognized Board.
- Candidate must have studied core subjects like Physics, Chemistry and Biology at their Higher Secondary level.

Course Objective: (1) To introduce the concepts of Human anatomy and Microbial infections.
(2) To enable the students to understand the interactions of human body and microorganisms.
(3) To enable the students to understand classical and advanced diagnostic techniques and preventive measures

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Bacterial and Fungal infections: Bacterial infections:** Molecular basis of infection: Antimicrobial mechanisms of phagocytes and bacterial evasion strategies (*Mycobacterium tuberculosis* and *Leisteria monocytogenes*). Pathogenicity islands (PAI): Definition, characteristics of PAI. PAI in enteric bacteria with special reference to EPEC, EHEC and UPEC, cag A pathogenicity island of *H.pylori* Molecular basis of Toxins- Cholera, diphtheria Botulinum, Actinomycetes (Athlete‘s foot). **Fungal infections:** Cutaneous & Sub cutaneous and Systemic Mycosis; Lab diagnosis of fungal Infections; Opportunistic mycosis.	**15**	25%

2	**Viral, Protozoal and vector-borne infections:** Viral diseases transmitted via air: Influenza, SARS; Viral diseases of childhood: Measles, Mumps. **Viruses transmitted via food or water:** Rotavirus, Polio, Hepatitis A; Other viruses - Herpes virus, Rabies virus, Oncogenic viruses; Human immunodeficiency virus: AIDS Protozoal diseases - Malaria, Leishmaniasis, Dysentery.	**15**	25%
3	**Clinical Microbiology:** 1. Specimen: types of specimens, methods of collection, storage and transportation. 2. Methods used for diagnosis and identification of pathogens: A. Microscopy B. Growth and biochemical characteristics C. Clinical immunology D. Pathological changes in blood and body fluids and tissues E. Significance of computer and possible uses of biosensors.	**15**	25%
4	**Disorders of red blood cells:** Introduction to anemia, classification – morphological and etiological classification of red blood cells, clinical features, pathophysiology, laboratory investigations of, iron deficiency anemia, megaloblastic anemia, hemolytic anemia. Brief introduction to thalassemia's. Disorders of white blood cells: Introduction, classification - French American and British- FAB classification, pathophysiology, clinical features, Lab investigations, leukemoid reaction Hemorrhagic disorders: Hemostasis mechanism, pathogenesis, clinical feature, classification of, vascular disorders, platelet disorders, coagulation disorders	**15**	25%

Course Outcome: After completion of this course, student will be able to

- Understand the human physiology
- Understand various microbial infections
- Understand classical and advanced diagnostic techniques
- Comprehend various disorders related to red blood cells.

List of Text Books:

- Ananthanarayan R and Paniker C.K.J. (2005). Textbook of Microbiology. 7th edition (edited by Paniker CKJ). University Press Publication.
- Kuby Immunology by Kindt, Goldsby and Osborne, 7th Edition, Mac Millan Education.

List of Reference Books:

- Brooks G.F., Carroll K.C., Butel J.S. and Morse S.A. (2007). Jawetz, Melnick and Adelberg's Medical Microbiology. 24th edition. McGraw Hill Publication.
- Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims' Medical Microbiology. 4th edition. Elsevier.
- Immunology by Raj Khanna. Oxford University Press.
- Joklik W.K., Willett HP and Amos DB (1995). Zinsser Microbiology. 19th edition Appleton Centuary-Crofts publication.
- Willey J.M., Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

Open e-Resource:

- https://digimat.in/nptel/courses/medical/microbiology/MB11.html
- Clinical Microbiology and Infectious Diseases (Online Learning) MSc, PgDip (ICL), PgCert (ICL), PgCert, PgDip, PgProfDev | The University of Edinburgh
- https://healthsciencesprograms.gwu.edu/programs/mshs-in-clinical-microbiology-online/courses/

Gandhinagar Institute of Science
M.Sc. Microbiology
Sem-3

Subject Code: 10230305	**Subject Title:** Laboratory-3
Pre-requisite: Candidate should have opted graduation degree in any biological field as per UGC norms in any recognized Board/University. Candidate must have achieved regular degree in the 10+2 system from any recognized Board. Candidate must have studied core subjects like Mathematics, Physics, Chemistry and Biology at their Higher Secondary level.	

Course Objective:

- To provide the students with laboratory (experimental) training so that they are competent enough to work in industries.
- To train the students in the field of Medical Microbiology, various diagnostic techniques.
- Hands on training in the field of Genetic Engineering.
- To impart practical skills for waste characterization, treatment and other bioremediation techniques for creating better environment.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
-	-	12	06	-	-	140	60	200

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	To induce mutation by UV radiations and to exhibit DNA repair by photoreactivation.	12	100%
2	To isolate and produce UV induced auxotrophic mutants by replica plating method.		
3	Isolation of antibiotic resistant mutants by chemical mutagenesis.		
4	To prepare competent cells and transform plasmid.		
5	Isolation of genetic material of Yeast.		
6	To perform ELISA for assay of antibodies in serum sample against given antigen.		
7	Determination of MBC of Antibiotics.		
8	Determination of MIC of Antibiotics.		
9	Ouchterlony double diffusion (Ab titration)		
10	To perform Widal agglutination test (slide and tube) for diagnosis of typhoid.		
11	Quantitative precipitin assay		
12	Bio-oxidation and determination of oxidation rate: Fe, Cu, S.		

13	Bioleaching of Cu from sulphidic ore.		
14	Desulphurization of coal.		
15	Physical Characterization of water odour, colour, turbidity, temperature, salinity, Volatile Solids (VS), Dissolved Solids (DS), Suspended Solids (SS) and Total Solids (TS)		
16	Chemical characterization of water: acidity, alkalinity, chloride, phosphate, sulphate, copper, magnesium and total hardness.		
17	Decolorization of dye.		
18	Biodeterioration of lignocellulosic waste and pharmaceutical products: • Determination of microbial load • Characterization of bio deteriorating microorganisms		
19	Statistical analysis of data: Calculation of Standard Mean and deviation.		
20	Antioxidant activity of pigment		

Course Outcome: After completion of this course, student will be able to

- Perform molecular biology experiments.
- Learn biodeterioration process *in vitro* with use of microorganisms.
- Perform diagnostic procedures for many diseases.
- Analyze statistical data of all experiments.

List of References:

1. "Experiments in Microbiology, Plant Pathology and Tissue Culture", by Aneja, K. R., 1993, Wishwa Prakashan.
2. "Hand book of microbiological media", by Atlas, R. M., 1993, CRC Press, Inc. Florida.1.
3. "Laboratory exercises in Microbiology", by Harlcy Prescott, 2002, 6th edition, The MaCraw-Hill.
4. "Laboratory manual in Biochemistry", by Jayraman, J., 1998, New age International Publishers, New Delhi.
5. "Manual of laboratory techniques", by Rghumulla, N., Nair, K. M., and Kalyansundaram, S., 2nd edition, 2003, National Institute of Nutrition Press, Hyderabad.
6. "Medical Microbiology", Vol. 2, 12th edition, 1975 by Cruickshank, R. Duguid, J. P. Marriman, B. P. and R. A. Swan, Churchill Livingstone, London.
7. "Methods in Microbiology", Vol.3A and Vol.3B edited by Norris and Ribbons, Academic Press, London.
8. Methods in Microbiology", Vol.4 edited by Booth, C., Academic Press, London.
9. Methods in Microbiology", Vol.5 edited by Norris and Ribbons, Academic Press, London.
10. "Practical Biotechnology", by P. Ramadass and A. Wilson Aruni, 2007, Jaypee Brothers Medical Publishers(p) Ltd. New Delhi.
11. "Standard methods for the examination of water and waste water", 20th edition, edited by Greenberg, *et al.*, 1998, APHA, AWWA, Washington, DC.

Open e-Resource:

- Swayam Portal: General Microbiology - Course (swayam2.ac.in)
- OpenStax: Microbiology - OpenStax.

Gandhinagar Institute of Science
Master of Science - Microbiology
Semester-3

Subject Code: 20230306	**Subject Title: Traditional Fermented Foods and Beverages**
Pre-requisite: Candidate should have ● Basic understanding of Food Microbiology and Biochemistry ● Knowledge of microbial growth, metabolism, and enzyme activity ● Familiarity with food preservation and processing principles	

Course Objective:

(1) Introduce the microbial and biochemical basis of traditional food fermentations.
(2) Explore the cultural, nutritional, and economic importance of traditional fermented foods and beverages.
(3) Understand microorganisms involved, fermentation conditions, and product characteristics of selected traditional foods.
(4) Develop knowledge on quality, safety, and standardization aspects of fermented products.
(5) Provide hands-on experience in the preparation and analysis of fermented foods and beverages.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
01	-	02	02	-	25	-	25	50

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Fundamentals of Food Fermentation** ● Definition, history, and importance of food fermentation ● Classification of fermented foods (based on substrate, microorganisms, and region) ● Role of lactic acid bacteria, yeasts, and molds in fermentation ● Nutritional and functional benefits of fermented foods ● Microbiological and biochemical changes during fermentation ● Factors affecting fermentation (temperature, pH, salt concentration, etc.)	15	33%
2	**Traditional Fermented Foods of India and the World** ● Cereal-based fermentations: Idli, Dosa, Dhokla, Bhatura, and Appam ● Vegetable and fruit fermentations: Sauerkraut, Kimchi, Pickles ● Dairy fermentations: Yogurt, Dahi, Lassi, Kefir, and Cheese	15	33%

	• Meat and fish fermentations: Fermented sausages, Fish sauce, and Ngari • Microbial diversity and starter cultures used in traditional fermentations		
3	**Fermented Beverages and Quality Aspects** • Overview of alcoholic and non-alcoholic traditional beverages • Fermented beverages: Toddy, Sonti, Palm wine, Kombucha, Kvass, and Sake • Fermentation processes and microorganisms involved • Quality control, safety, and standardization in fermented foods and beverages • Probiotic and health-promoting fermented foods • Industrialization and commercialization of traditional fermented products • Preservation and packaging of fermented foods and beverages	15	34%

Course Outcome: After completion of this course, student will be able to

CO1: Explain the principles and microbiology of traditional food fermentations.

CO2: Identify microorganisms involved in various traditional fermented foods and beverages.

CO3: Analyze the biochemical and nutritional changes occurring during fermentation.

CO4: Demonstrate the preparation of selected traditional fermented foods and beverages in the laboratory.

CO5: Evaluate the safety, quality, and probiotic aspects of fermented products.

List of Text Books:

- Joshi, V.K. & Pandey, A. (1999). *Biotechnology: Food Fermentation – Microbiology, Biochemistry, and Technology.* Vol. I & II. Educational Publishers & Distributors, New Delhi.
- Ray, R.C. & Joshi, V.K. (2014). *Fermented Foods: Part I – Biochemistry and Biotechnology.* CRC Press.
- Steinkraus, K.H. (1996). *Handbook of Indigenous Fermented Foods.* CRC Press, Boca Raton.

List of Reference Books:

- Campbell-Platt, G. (1994). *Fermented Foods of the World – A Dictionary and Guide.* Butterworths.
- Holzapfel, W. (Ed.). (2014). *Advances in Fermented Foods and Beverages: Improving Quality, Technologies and Health Benefits.* Woodhead Publishing.
- Hutkins, R.W. (2019). *Microbiology and Technology of Fermented Foods.* Wiley-Blackwell.
- Tamang, J.P. (Ed.). (2015). *Ethnic Fermented Foods and Beverages of India: Science History and Culture.* Springer.

Suggested Practicals:

1. Preparation and study of lactic acid fermented foods (e.g., curd, idli batter).
2. Isolation and identification of microorganisms from fermented foods (microscopic and cultural characteristics).
3. Preparation of vegetable or fruit fermented products (e.g., sauerkraut, pickles).
4. Production of fermented beverages such as ginger beer or kombucha.
5. Measurement of pH, acidity, and microbial count during fermentation.
6. Sensory and biochemical evaluation of fermented foods.
7. Study of starter cultures used in traditional fermentations.
8. Safety assessment – detection of spoilage or contamination in fermented foods.

Open e-Resource:

- Fermentation Technician Training | Free Online Course | Alison
- Food Microbiology - Course
- Food Microbiology and Food Safety - Course
- Free Course: Food Microbiology from CEC | Class Central
- HarvardX: Food Fermentation: The Science of Cooking with Microbes | edX

Gandhinagar Institute of Science
M.Sc. Microbiology
Sem-3

Subject Code: 10230301	**Subject Title: Genetic Engineering (Theory)**

Pre-requisite:

- Candidate should have opted graduation degree in any biological field as per UGC norms in any recognized Board/University.
- Candidate must have achieved regular degree in the 10+2 system from any recognized Board.
- Candidate must have studied core subjects like Mathematics, Physics, Chemistry and Biology at their Higher Secondary level.

Course Objective: (1) To gain a thorough understanding of the basic principles of molecular biology.
(2) To understand the tools of DNA technology.
(3) To design approaches to addressing questions in molecular biology and to interpret experimental data in molecular biology.
(4) To become proficient with a number of advanced and basic tools in molecular biology.

Teaching Scheme (Hours per week)				**Evaluation Scheme (Marks)**				
				Theory		**Practical**		
Lecture	**Tutorial**	**Practical**	**Credit**	**University Assessment**	**Continuous Assessment**	**University Assessment**	**Continuous Assessment**	**Total**
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Principle, Tools and Concept of Gene Cloning:** Molecular tools and applications- restriction enzymes, ligases, polymerases, alkaline phosphatase. Gene Recombination and Gene transfer: Transformation, Episomes, Plasmids and other cloning vectors (Bacteriophage-derived vectors, artificial chromosomes), Microinjection, Electroporation, Ultrasonication, Principle and applications of Polymerase chain reaction (PCR), primer-design, and RT-(Reverse transcription) PCR.	**15**	25%

2	**Cloning Vectors and Host Strains:** Plasmid based vectors, Phage based vectors, Cosmids, Phagemids, BACs and yeast-based vectors. Salient features of Host strains.	**15**	25%
3	**Methods of Gene Manipulation and Selection of Clones:** Screening and selection of clones, Random and site-directed mutagenesis: Primer extension and PCR based methods of site directed mutagenesis, Random mutagenesis, Gene shuffling, production of chimeric proteins, Protein engineering concepts and examples (any two).	**15**	25%
4	**Applications of Genetic Engineering:** Genetic engineering in plants: Use of *Agrobacterium tumefaciens* and *A. rhizogenes*, Ti plasmids, Strategies for gene transfer to plant cells, Direct DNA transfer to plants, Gene targeting in plants, Use of plant viruses as episomal expression vectors. Therapeutic products produced by genetic engineering-blood proteins, human hormones, immune modulators and vaccines (one example each).	**15**	25%

Course Outcome: After completion of this course, student will be able to

1) Describe various theoretical models of the creative process.
2) Identify and interact with creative pockets in the community to continue to re-energize their skills.
3) Develop understanding about the molecular mechanisms behind different modes of gene regulation in bacteria and eukaryotes.
4) Gain basic concepts of synthetic biology and its applications.
5) Interpret and critique data from primary research articles.

List of Text Books:

- Brown TA. (2006). Gene Cloning and DNA Analysis. 5th edition. Blackwell Publishing, Oxford, U.K.
- Desmond, S. T. Nicholl, (2008). An Introduction to Genetic Engineering. 3rd Edition. Cambridge University Press.

List of Reference Books:

- Clark DP and Pazdernik NJ. (2010). Biotechnology-Applying the Genetic Revolution. 1st Edition. Elsevier Academic Press, USA.
- Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
- Primrose SB and Twyman RM. (2013). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
- Sambrook J, Fritsch EF and Maniatis T. (2012). Molecular Cloning-A Laboratory Manual. 4th edition. Cold Spring Harbor Laboratory Press.

Open e-Resource:

- Genetic Engineering: Theory and Application - Course (nptel.ac.in)
- Free Online Certificate Courses to Become a Genetic Engineer - Alison
- Free Online Course: Genetic Engineering: Theory And Application from Swayam | Class Central

Gandhinagar Institute of Science
Master of Science – Microbiology/ Biotechnology/ Environmental Science/ Pharmaceutical Science
Semester-III

Subject Code: 10230302	Subject Title: Biostatistics (Theory)

Pre-requisite:

- Candidate should have opted graduation degree in any biological field as per UGC norms in any recognized Board/University.
- Candidate must have achieved regular degree in the 10+2 system from any recognized Board.
- Candidate must have studied core subjects like Mathematics, Physics, Chemistry and Biology at their Higher Secondary level.

Course Objective:

- To impart the knowledge regarding basic statistics.
- To make students enable to perform the basic statistical analysis in the field of Biology.

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
				Theory		Practical		
Lecture	Tutorial	Practical	Credit	University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	Total
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Concepts of population and sample:** need for sampling, census and sample surveys, designing of a questionnaire, sampling and non-sampling errors, sample size determination, finite population sampling techniques-SRSWR, SRSWOR, Measures of Central Tendency-Arithmetic Mean, Median, Mode, Standard Deviation. **Representation of Data.**	15	25%
2	**Correlation And Regression:** Introduction, Correlation analysis, Types of Correlation, Methods of studying correlation, Degree of Correlation, Significance test for Correlation Coefficient, Regression analysis, Significance test for Regression Coefficient, Uses of Regression Analysis.	15	25%

3	**Chi- Square test, One way classification, Analysis of variance (ANOVA):** One-way and Two-way, Single factor ANOVA, Two-factor ANOVA with unequal and equal replication (with/without interactions). **Three basic principles of design of experiments:** Randomization, replication and local control. Designs of Experiments: Completely Randomized Designs (CRD), Randomized Block Designs (RBD), Latin Square Designs (LSD).	15	25%
4	Advanced Designs for Analysis, Repeated measures designs, ANCOVA (for CRD and RBD), Factorial Designs.	15	25%

Course Outcome: After completion of this course, student will be able to

CO1: Interpret commonly used statistics

CO2: Develop judgment about the application of statistical techniques in a given situation.

CO3: Implement basic statistical techniques, including descriptive and inferential (estimation and hypothesis testing) by hand.

List of Text Books:

- Kempthorne O. (2007): Design and Analysis of Experiments, 2nd Edition, Vol I-II, Wiley. 2.
- Montgomery D. C. (2008): Design and Analysis of Experiment, 7th Edition, John Wiley & sons.
- Statistics in biology, Vol. 1 by Bliss, C.I.K. (1967) Mc Graw Hill, NewYork.

List of Reference Books:

- Des Raj and P. Chandhok (1998): Sample Survey Theory. Narosa publishing House.
- Sukhatme P.V., Sukhatme B.V., Sukhatme S. and Ashok C. (1997): Sampling Theory of Surveys and Applications-Piyush Publications.
- William G. Cochran (1977): Sampling Techniques, 3rd edition- John Wiley & Sons.

Open e-Resource:

- Best Biostatistics Courses & Certifications [2023] | Coursera
- Learn Biostatistics With Online Courses and Programs | edX
- Free Online Biostatistics Courses | Alison
- Introduction to Biostatistics - Course (nptel.ac.in)

Gandhinagar Institute of Science
Master of Science -Microbiology/Biotechnology/Environmental Science
Semester-III

Subject Code: 10230304	Subject Title: Environmental Biotechnology (Theory)

Pre-requisite:

- Candidate should have opted graduation degree in any biological field as per UGC norms in any recognized Board/University.
- Candidate must have achieved regular degree in the 10+2 system from any recognized Board.
- Candidate must have studied core subjects like Mathematics, Physics, Chemistry and Biology at their Higher Secondary level.

Course Objective:

- Become aware of the important role microbes play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.
- Gain in depth knowledge of different types of solid waste, liquid waste and their management.
- Get familiar with problems of pollution and applications of clear up technologies for the pollutants.
- Know about the diverse microbial populations in various natural habitats like soil, air, water.

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
				Theory		Practical		
Lecture	Tutorial	Practical	Credit	University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	Total
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Principles of Waste Treatment:** 1. Issues and scopes of environmental biotechnology. 2.Waste water treatment: Waste water characterization and its significance: COD, BOD, Inorganic constituents, solids, biological components. 3.Principles and aims of biological wastewater treatment processes: Primary, secondary and tertiary treatment of waste water. 4. Biochemistry and Microbiology of inorganic phosphorus and nitrogen removal. 5.Suspended growth technologies: Activated sludge,	15	25%

	oxidation ditches, waste stabilization ponds. 6.Fixed film technologies: Trickling filters, rotating biological contactors, fluidized bed and submerged aerated filters.		
2	**Techniques of Waste Treatment:** 1.Toxicity testing in waste water treatment plants using microorganisms. 2. Anaerobic digestion: microbiological and biochemical fundamentals, factors influencing anaerobic digestion. 3.Anaerobic waste water treatment systems: RBC, UASB, anaerobic filters. Merits and demerits of anaerobic treatment of waste.	15	25%
3	**Biodegradation and Deterioration:** 1.Biodegradation of organic pollutants: Mechanisms and factors affecting biodegradation. 2.Pollution problems and biodegradation of simple aliphatic, aromatic, polycyclic aromatic hydrocarbons, halogenated hydrocarbons, azo dyes, lignin and pesticides. 3.Bioremediation: Intrinsic bioremediation, Bio stimulation and Bioaugmentation. In situ and ex situ bioremediation technologies. Bioremediation of oil spills. Bioremediation of heavy metal pollution, Phytoremediation. 4. Use of GMO in bioremediation. Biological treatment of waste gas (polluted air): biofilters, bio scrubbers, membrane bioreactors, bio trickling filters.	15	25%
4	**Biogeotechnology:** 1.Bioleaching of metals: Characteristics of commercially important microbes, mechanisms of bioleaching, factors affecting bioleaching and current biomining processes. 2. Bio beneficiation of gold ores. Microbially enhanced oil recovery. 3. Bio desulfurization of coal: Removal of organic and inorganic Sulphur from coal.	15	25%

Course Outcome: After completion of this course, student will be able to

CO1: Student will understand the characterization of wastes.
CO2: Student will understand the treatment of wastes.
CO3: Will be able to explain Biodegradation principles and related environmental issues.
CO4: Student will know geology and geological techniques for Bioremediation.

List of Text Books:

- Biotechnology-Rehm and Reid.
- Comprehensive Biotechnology Vol-4, Murray Moo Young.

List of Reference Books:

- Waste water microbiology by G. Bitton
- Biodegradation and bioremediation by M. Alexander
- Waste water treatment for pollution control, 2nd edition. Arceivala
- Environmental Biotechnology by H. Jordening and Josef Winter.

Open e-Resource:

- https://www.classcentral.com/tag/microbiology
- https://www.mooc-list.com/tags/biotechnology
- https://asm.org/articles/2020/december/virtual-resources-to-teach-microbiology-techniques
- https://www.futuredirections.org.au/publication/living-soils-role-microorganisms-soil-health

Gandhinagar Institute of Science
Master of Science

Semester-IV

Subject Code: 10230401	Subject Title: Research Methodology
Pre-requisite: Student must have achieved Graduate degree in Chemistry with minimum three years on regular basis, from any UGC recognized university. Student should have basic knowledge and technical skill for the concern subject.	

Course Objective:

- To give an overview of the research methodology and explain the technique of defining a research problem
- To explain the functions of the literature review in research.
- To explain carrying out a literature search, its review, developing theoretical and conceptual frameworks and writing a review.
- To explain various research designs and their characteristics.
- To explain the details of sampling designs, and also different methods of data collections.
- To explain the art of interpretation and the art of writing research reports.

Teaching Scheme (Hours per week)				Evaluation Scheme (Marks)				
				Theory		Practical		
Lecture	Tutorial	Practical	Credit	University Assessment	Continuous Assessment	University Assessment	Continuous Assessment	Total
04	-	-	04	70	30	-	-	100

Subject Contents			
Sr. No	**Topic**	**Total Hours**	**Weight (%)**
1	**Introduction to Research Methodology:** Research Defined: Understanding the Meaning of Research, Research Goals: Exploring Objectives and Motivations, Diverse Research Types and Approaches, Significance of Research and Its Place in Scientific Methods, Navigating the Research Process, Identifying Criteria for High-Quality Research.	15	25%
2	**Defining the Research Problem & Research Design:** Deciphering the Research Problem, Selecting and Framing Research Questions, The Importance of Problem Definition, Techniques for Articulating Research Problems. Unpacking Research Design: Meaning and Necessity, Features of an Effective Research Design, Core Concepts and Types of Research Design, Basics of Experimental Design Principles, Design a Research Plan.	15	25%
3	**Testing of Hypothesis:** Understanding Hypothesis Testing: Concepts and Flow, Evaluating the Power of a Hypothesis Test, Parametric Tests: Hypothesis Testing for Means and Proportions, Comparing Variances and Correlation Coefficients, Recognizing Limitations in Hypothesis Testing.	15	25%
4	**Methods of Data Collection:**	15	25%

	Collecting Primary Data: Observation, Interviews, Questionnaires and More, Gathering Secondary Data and Selecting the Appropriate Method, Insights into Case Study Methodology, Guidelines for Developing Effective Questionnaires, Comparing Surveys and Experiments. **Processing and Analysis of Data:** Data Processing Fundamentals and Challenges, Analyzing Data Elements, Statistical Tools in Research, Measures of Central Tendency and Dispersion, Exploring Relationships and Regression Analysis.		

Course Outcome: After completion of this course, student will be able to

1. Demonstrate the ability to choose methods appropriate to research aims and objectives.
2. Understand the limitations of particular research methods.
3. Develop skills in qualitative and quantitative data analysis and presentation.
4. Develop advanced critical thinking skills.

References:

1. Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi, Wiley Eastern Limited.
2. Das, S. K., 1986, An Introduction to Research, Kolkata, Mukherjee and Company Pvt. Ltd.
3. Misra R.P., 1989, Research Methodology: A Handbook, New Delhi, Concept Publishing Company Kumar, R., 2005, Research Methodology-A Step-by-Step Guide for for Beginners, (2nd.ed.), Singapore, Pearson Education.
4. Bhattachraya, D.K., 2006, Research Methodology, (2nd.ed.), New Delhi, Excel Books.
5. Panneerselvam R., 2012, Research Methodology, New Delhi, PHI Learning Pvt. Ltd.
6. Khan, Irfan Ali, 2008, Fundamentals of Biostatistics, Ukaaz Publications
7. Rosner B.A., 2011, Fundamentals of Biostatistics, Cengage Learning
8. Katz J.M., 2009, Form Research to Manuscript: A guide to scientific writing, USA, Springer Science