MAHARSHI DAYANAND SARASWATI UNIVERSITY
AJMER

Syllabus

Scheme of Examination and Courses of Study

Faculty of Science

M.Sc. Microbiology

(Modular Choice Based Credit System)

(Semester I & II w.e.f. 2023-24 & III & IV w.e.f. 2024-25)

Program of Learning: M.Sc. Microbiology

Small components are the most vital and potent parts of any system and so are microorganisms for the planet earth. The University started the first ever M.Sc. Microbiology program of Rajasthan in 1993.

Aim and motto

The Department of Microbiology (DoM) aims to quench the curiosity about life of organisms invisible to the naked eye. Knowledge about this microcosmos shall impart deeper understanding of life. It answers how life is sustained (evolution), whether there is life on other planets (exobiology), how do the microorganisms live (cell biology, physiology and genetics), how many different types of microorganisms are there (biodiversity), what is their role, how do they interact with other beings and what are the extremes of their life (biogeochemical cycles-ecology) and whether man can utilize them for his benefit and for the continued existence of life on earth comprising fields of biotechnology, industrial, agricultural, environmental, medical, food, water and air microbiology. With a motto "**unveil the hidden strength**", the faculty tries unveiling the hidden strength of the students and that of the invisible friends.

1. **Program Duration**
   a. Minimum 1 semester for PG Certificate in Basic Microbiology
   b. Minimum 2 semesters for PG Diploma in Microbiology
   c. Minimum 3 semesters for Advanced PG Diploma in Microbiology
   d. Minimum 4 Semesters for M.Sc. in Microbiology

2. **Minimum Eligibility**
   2.1 B.Sc./B.Sc. (Hons)/B.Sc. B.Ed. in any discipline of biology or B.Sc. (Ag)/Graduate degree from medical or paramedical sciences/Graduate degree in Liberal Arts with any discipline of biology/B. Tech. (Biotechnology/Biochemical Engineering/Agricultural Engineering) with min. 50% marks
   2.2 Relaxation in Minimum Qualifying Marks for the SC, ST and Persons with Disabilities Categories: 5%

3. **Criteria for Selection of Students for Admission:** Merit list as per the rules in the prospectus

4. **Program Objectives**

The Master's Program in Microbiology is the flagship program of the DoM that fulfills the aims cited above with the following objectives:

- Prepare the students to occupy any work situation related to microbiology and allied subjects.
- Enable the student to put up his/her best foot forward in all walks of life.

5. **Pedagogy**

The DoM provides one of the best setups in the state of Rajasthan for learning in Microbiology. The M.Sc. Microbiology program at MDS University, Ajmer follows choice-based credit system, semester system and modular system in its true spirit and thus stands amongst the most progressive curricular schemes available in the country.

Other than traditional chalk and board lectures, pedagogy includes ICT-based teaching and Socratic seminars to discuss topics in groups. Later allows them to assimilate knowledge through discussions and working together.

Flip learning is conducted on resources that are made available through online tools like microsphere.wooqer.com. **Online classes** are conducted for specific needs. **Innovation and incidental learning** is provided through short-term and long-term scientific and society-centered projects. Such project-based learning enables **computational thinking**: decomposing (breaking down into smaller bits) the problem, recognizing patterns (looking for similarities between and within problems), abstracting (taking the details and leaving the outliers), generalizing (adapting the solution

to other problems) and forming algorithm (framing the rules to solve similar problems) through reflective thinking.

MSc Microbiology also has elements of **crossover learning** i.e. learning by seeing, feeling and interacting through field trips; enhancing skills and innovating through training and workshops (learning by doing). **Inspirational lectures** of eminent microbiologists are organized in the *Atreya* series of lectures. *Madhavkar* Awareness campaign opens up an **interface with the society**. **Communication skills** are enhanced through seminars and popular writings in the form of a Wall magazine: Zoom-In.

The DoM also promotes **participation and responsibility by** entrusting duties for the laboratories, and maintenance of the germplasm and cultivation systems. The department is **open 24x7** for laboratory/project works.

6. **Program Outcome**

The students will learn Microbiology and allied subjects to the extent that the knowledge and skills learnt may be used in industries, institutes and offices. S/he may specialize in one or more streams of microbiology viz. Biodiversity, Ecology, Biochemistry and Physiology of microorganisms, Microbiology of Extremes, Molecular Biology, Environmental Microbiology and Biotechnology, Industrial Microbiology and Biotechnology, Biofuel & Bioenergy and Medical Microbiology. Student will learn practical skills in using tools, technologies and methods common to microbiology and allied sciences.S/he will learn ethics of research and safety in laboratories.

The student will learn skills for specific technologies through projects, experiments and training/workshops. This boosts their self-confidence and enhances their abilities to

- discuss a problem or subject, assimilate and conclude the discussion.
- carry out a complete scientific work process independently using appropriate statistical design and tools
- critically evaluate methods and interpret results.
- Communicate scientific information to the public and fraternity of microbiologists by writing well-structured reports and scientific publications and making posters and oral presentations
- use ICT for learning, organizing and analyzing data and presenting the information
- solve problems through computational thinking
- learn through seeing, experiencing, interacting and doing
- interact and give back to the society
- work in groups

7.1. **Employment**

The alumni of the Department are Entrepreneurs, Regulatory and Quality Specialists, Operation specialists, managers, research and development officers, quality controllers and microbiologists in reputed biotechnology, microbiology, food and dairy, biopolymer, beverage and hospitality industries viz. Ortho Clinical Diagnostics, Melbourne Australia, Biobig Healthcare Solutions Pvt Ltd, Chandigarh, Shankarpack Poland, Ranbaxy, Reliance Life Science, J Mitra Diagnostics, Thermo Fisher Scientific, Glaxo, Dominos, Redico, Cadila Pharma, CottonConnect, Sun Pharma, Dabur Pharma, IPCA, Usha Remedies, SABMiller, Zydus Cadila, Vikas WSP, Coke, Bisleri and Pepsi.

Many are scientists and professors in renowned institutes such as National Institute of Virology Pune, AIIMS, New Delhi, Central University of Rajasthan Bandarsindari, **Duke University Medical Centre Durham USA , Texas State University, University of Texas, RMIT University Melbourne Australia**, Central University of Haryana Mahendragarh, MGS University Bikaner, College of Horticulture & Forestry Jhalawar, CDFST, MP University of Ag & Tech, Udaipur, Agriculture University Jodhpur, Defence Research lab Tezpur, National Center for Polar and Ocean Research, Vasco da Gama, Ministry of Food Processing Industries, GOI, New Delhi and Forensic Science Department, Kota.

Two of the alumni joined the Indian Air Force, some opted for Rajasthan Public Services while many others are managers in banks viz. Canara Bank, Central Bank of India, Bank of Baroda, Union Bank of

India, Rajasthan Gramin Bank, Rajasthan Cooperative Bank, Indian Bank, Sarv Haryana Gramin Bank and SBI.

7.2. **Progression to higher education**

Several students joined M Phil or PhD or post-doctoral research at International and national institutes viz. IISc Bangalore, IISER Pune, RMIT University Melbourne, National Centre for Cell Science, Pune, National Chemical Laboratory Pune, Defence lab Jodhpur, IIT Jodhpur, CAZRI Jodhpur, CDRI Lucknow, IITR Lucknow, NIO Goa, IARI Delhi, IIT Delhi, NII Delhi, CSIR-IGIB Delhi, Defence lab Gwalior, IISER Mohali, BITS Pilani, BISR Jaipur, FRI Dehradun, NDRI Karnal, NDDB Anand and Universities: DU & JNU, New Delhi; BHU, Varanasi; GBPU A&T, Pantnagar*; MSU, Vadodara, PU Chandigarh CUoR, MDSU, Ajmer JLN TU, Hyderabad, KGMU, Lucknow. There is a record of87 students that qualified for National level tests such as NET, GATE and SLET**.**

8. **Definitions and Credit Requirements**

8.1 An educational programme leading to the award of a Degree, Diploma or Certificate is a **Program of Learning**.

8.2 **A course** is a component of a program of learning which was earlier called 'paper'. It may comprise lectures/tutorials/laboratory work/field work/outreach activities/project work/vocational training/ viva/seminars/term papers/assignments/presentations/e-content/self-study etc. or a combination of some of these.

8.3 Courses are categorized as 1. **Core Course**-Series of essential and fundamental courses without which the certificate/diploma/degree cannot be awarded, 2. **Elective course**-Generic (Elective courses that may be opted in any other department/discipline and Discipline specific (Elective courses offered by the department i.e., within discipline), 3. **Foundation Course**- 1 or 2 credit compulsory or elective courses that are for personality development, soft skill development, improvement of physical and mental health, social and environmental consciousness, appreciation of art/literature, or subjects that may interest students of other disciplines etc.) and 4. **Skill enhancement courses** including training and workshops that may be assigned credits, assessed and graded.

8.4 **Credit** is a unit by which the course work is measured. It determines the number of hours of instructions required per week.

8.5 Credit is assigned to a particular course with due regard to specific Learning Outcomes, Educational Components and Workload requirements including 1 hour/week of tutorials. It also includes 10 minutes of discussion for each credit.

8.6 Each course may be of different size and credit, making it easier for specialists to set the question paper and also allow students to pick specific courses and add on to their desired scheme of specialization. Experiments taking longer, do not get extra weightage based on duration.

	Credits	**Time (h/week)**	**Total hours/Semester**
Lecture	1 L	1	15-17
Tutorial	1 T	1	15-17
Practical/Field work/Short project /Laboratory work	2 P	6*	45-51
*1P credit includes 1h tutorial and 2h of laboratory/practical exercise and/or demonstrations			
Project work/Dissertation	8 P	16	240-272

8.7 A minimum of 80 credits are to be completed by the student, 30% (24 credits) of which will be elective including a minimum of 12 credits (15%) from other programs of studies (Minimum 9 from a single program of study other than M.Sc. Biotechnology) and 70% (56 credits) being core courses that would include minimum 4 credits of Foundation courses (Compulsory and elective).

8.8 The maximum number of credits that a student may opt in a Semester shall not exceed 36 hours per week of teaching, and he/she shall be required to register for such a number of courses accordingly.

8.9 Some courses have prerequisites, i.e. they may be opted only when the course listed as pre-requisite has been completed. Similarly, there may be courses with co-requisites, i.e. they are complete when the co-requisites are also completed and thus cannot be opted in isolation.

9 **Exit and Re-entry**

9.1 Semester I/PG Certificate in Basic Microbiology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after successful completion of minimum 20 credits in 1st semester s/he will be awarded PG Certificate in Basic Microbiology.

9.2 Semester I and II/PG Diploma in Microbiology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after successful completion of minimum 40 credits by the end of Semester II, s/he will be awarded PG Diploma in Microbiology.

9.3 Semester I + II + III/PG Diploma in Advanced Microbiology:A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. If s/he drops after successful completion of minimum 60 credits by the end of Semester III, s/he will be awarded PG Diploma in Advanced Microbiology.

9.4 Semester I+II+III+IV/M.Sc. Microbiology: A student has to opt courses of minimum 20 credits (Core + Electives (Generic and/or Disciplinary) + Foundation Elective) in this semester. However, maximum credits will be limited to 36 hours of teaching only. Successful completion of minimum 80 credits on completion of Semester IV will earn a student the degree of Master of Science in Microbiology.

9.5 The student dropping the course with certificate/diploma/advanced diploma may rejoin the program for further study for completion of the degree.

10. **Credit Registration**

10.1 Students must register for the courses for the semester within the first week of admission.
10.2 The maximum number of students to be registered in each course shall depend upon the physical facilities available while a minimum must be decided by the Board of studies/Committee of course in Microbiology.
10.3 Preference for registration of Courses in Microbiology shall be given to those students for whom the course is a Core course.
10.4 The registration for the elective course shall be on a first come first served basis, provided the student fulfills the prerequisites for that course, if any.
10.5 Normally, every Lecture-based course shall be offered by one teacher. In case of the requirement of more than one teacher, a course leader will be announced by the Head of the Department who will be responsible for the management of the course (viz. class and assessment schedule, student attendance, marks, grades etc.).

11. Time for Credit Registration: Credit registration shall be over within seven days of the commencement of a Semester and no change except withdrawal from a course shall be permissible after that date.

12. Limits for the Registration of Credits per Semester

12.1 A student may register for a minimum of 20 credits and a maximum of 36 credits in a semester provided it does not exceed the contact teaching time of 36 hours. However, s/he will be eligible for the qualification certificate only after completion of minimum requisite credits in each category of courses of a program.
12.2 The maximum number of students to be registered in each course shall depend upon the physical facilities available.

12.3 Preference for registration shall be given to the students of that department for whom the course is a Core course.
12.4 The registration for the elective course shall be on a first come first served basis, provided the student fulfills prerequisites for that course, if any.
12.5 No course shall be offered unless a minimum of 3 students are registered.
12.6 Students admitted late will have to contact the concerned Head of the department, who in turn must introduce and guide him/her through the process of registration.
12.7 Elective courses of a department may be offered or not in a particular semester at a college/department, depending on the availability of faculty and infrastructure. Thus the list of electives being offered must be displayed on the Notice Board of the Department.

13. Beginning of Semester
13.2 The 1st working day of each semester: Orientation and allotment of students to departmental advisors/mentors.
13.3 The 2nd working day of each semester: Mentor-Mentee meet in the concerned department and register students with the concerned course leaders.
13.4 The 3rd day of the semester: Beginning of teaching

14. Class schedule
14.1 Tentative timetable of each department shall be displayed on its Notice Board on the 1st day of the semester and the Head(s) of the concerned Department, a day before the beginning of the semester.
14.2 Being Choice based, it would not be possible to hold practical classes in both morning and afternoon as it would be difficult to adjust time clashes with courses offered in other departments, thus Practical classes will be arranged in the afternoon sessions only.
14.3 Course leaders would adjust the conflicting time slots on the basis of mutual understanding and must give slots in the timetable on the basis of priority to a course leader having more variety of students (i.e., having registrations of students from a maximum number of departments).

15. Courses offered in M.Sc. Microbiology

15.1 Core Courses

15.1.1 Semester I

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial + Lab/Fieldwork)	Hours/week
MIC 101	Essentials of Microbiology	3	0	3
MIC 102	Diversity of Prokaryotes	3	0	3
MIC 103	Biochemistry	4	0	4
MIC 104	Molecular Biology I	2	0	2
MIC 105 Sk	Microbiological & Biochemical Techniques	0	4	12
	IDE/DE	3 or more		
	FC	Min 1		

Minimum 20 credits to be opted

15.1.2 Semester II

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Fieldwork)	Hours/week
MIC 201	Microbial Physiology & Development	4	0	4
MIC 202	Molecular Biology II	2	0	2
MIC 203	Microbial Ecology & Biology of Extremes	4	0	4
MIC 204 Sk	Experiments in Physiology and Ecology	0	4	12
	SE	2-4 or more		
	IDE	2-4 or more		
	FC	Min 1		

Minimum 20 credits to be opted

15.1.3 Semester III

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Fieldwork)	Hours/week
MIC 301Sk	Genetic Engineering	4	0	4
MIC 302	Microbial Genetics	4	0	4
MIC 303 Sk	Experiments in Applied Microbiology & Molecular Biology	0	4	12
MIC304 Sk	Short Term Project		1	3
	SE	3 /4 or more		
	IDE	3 /4 or more		
	FC	Min 1		1

Minimum 20 credits to be opted

15.1.4 Semester IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Fieldwork)	Hours/week
MIC 401	Research Design	3	0	3
MIC 402 Sk	Project Work/Dissertation	0	8	16
	DSE	4	0	4
	DSE/IDE	4 or more		
	FC	1		

Minimum 20 credits to be opted

15.2 Disciplinary Elective courses

15.2.1 Disciplinary Elective Courses for Semester I and III

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Fieldwork)	Hours/week
MIEO11	Pharmaceutical Microbiology	4	0	4
MIEO12	Diversity of Eukaryotic Microorganisms	4	0	4
MIEO13	Medical Microbiology	4	0	4
MIEO14	Virology	2	0	2
MIEO15 Sk	Microbiology of wastes and Waste Remediation	3	0	3
MIEO16 Sk	Industrial Microbiology	4	0	4
MIEO17	Geomicrobiology & Agricultural Microbiology	4	0	4
MIEO18 Sk	Techniques in Geomicrobiology & Agricultural Microbiology (Co-requisite: MIEO17 Sk)	0	2	6
MIEO19	Energy and Alternative Energy	1	0	1
MIEO20 Sk	Seminar/Workshop/Training	0	1	1
MIEO21 Sk	Short Term Project	0	1	3

15.2.2 Disciplinary Elective Course for Semester II & IV

Course code	Core courses	Credits		Contact time
		Lecture/ Tutorial	Practical (Tutorial +Lab/Fieldwork)	Hours/week
MIEE11	Immunology	4	0	4
MIEE12 Sk	Bioprocess Engineering	4	0	4
MIEE13 Sk	Experimental Bioprocess Engineering (Co-requisite: MIEE12 Sk)	0	2	6
MIEE14	Basics of Biofuel & Bioenergy	3	0	3
MIEE15 Sk	Techniques in Biofuel & Bioenergy (Co-requisite: MIEE14 Sk)	0	2	6
MIEE16	Food Microbiology	3	0	3
MIEE17 Sk	Experimental Food Microbiology (Co-requisite: MIEE17 Sk)	0	2	6
MIEE18	Enzymology (Pre-requisite: MIC 103)	3	0	3
MIEE19 Sk	Bioinformatics (Pre-requisite MIC 104, 408)	4	0	4
MIEE20 Sk	Biostatistics & Computational Biology	4	0	4
MIEE21 Sk	Seminar/Workshop/Training	0	1	1
MIEE22 Sk	Short term project	0	1	3
MIEE23	Diagnostic Microbiology	4	0	4

16 Foundation Courses (A student may elect any of these courses listed below (if being offered in a particular semester) or from the pool of such courses categorized as ability enhancement/skill enhancement/value added course being offered in the institute, provided the same has not been picked up by the student at any earlier time).

Course code	Core courses	Credits	Contact time

		Lecture/ Tutorial	**Practical (Tutorial +Lab/Fieldwork)**	**Hours/week**
Skill Enhancement Course (Compulsory)				
MIC FC 01	Scientific Writing (Skill Enhancement Course)	2	0	2
Skill Enhancement Course (Elective)				
MIC FE 01	Internship on Laboratory and Material Management in Microbiology/Biotechnology* (will be evaluated after the final examination of the fourth semester) in the Department of Microbiology or Summer Internship anywhere else	0	4 or 2 credits	2h/week during Ist and IInd semester (including vacations) and 4 h/week in semesters III and IV (including vacations) Total 288h or ~2 months internship in two years. They may also join a job/ internship during summer vacations for a minimum of 1 month (2 credit).
Value Added Course (Elective)				
MIC FE 01	Microorganisms and Health (Value Added Course)	1	0	1
MIC FE 02	Hygiene (Value Added Course)	1	0	1
Ability Enhancement Course (Elective)				
MIC FE 03	Self Actualization (Ability Enhancement Course)	1	1	1

*These 4 credits will be supernumerous to the minimum 80 credits for M.Sc. degree

16.3.1 Foundation courses will be available in all semesters, however they will be offered on the basis of availability of time with the faculty. A student can also pick foundation course being offered by any other department.

17. Specializations

Any student successfully completing a set of specified courses will be able to specialize in any of the following fields: Biochemistry and Physiology of Microorganisms, Microbiology of Extremes
Microbial Diversity and Ecology, Molecular Biology, Environmental Microbiology & Biotechnology, Industrial Microbiology & Biotechnology, Biofuel & Bioenergy, Medical Microbiology and Pharmaceutical Microbiology

18. Detailed outline of Courses offered

18.1 Foundation Courses

MIC FC 01 Scientific Writing (2L) (2h/week) (Skill Enhancement Course)

The methods of scientific writing will be taught, and tasks will be given to the students for writing specific matters, records of which will be evaluated by the course leader(s)

Section A (5L)

What is research? What is Science? Research Design. Ethics in science and scientific writing. Plagiarism. Bioethics.
Choosing a problem, preparing a plan to find answers.
Activity: Identify a problem and prepare a proposal to work on it. Evaluation of ethics in laboratory and club (Microconcern) practices.

Section B (5L)

Journals and their types. Scientific paper, Writing title, Abstract, Introduction, Material and Methods, Results and Discussion and Acknowledgements. Presenting results: Tabulation, graphs and illustrations.
Activity: Write/prepare specific portions of the scientific paper.

Section C (7L)

Citing and listing references, Submission of a paper. Writing a review paper: PRISMA. Preparing a poster paper.
Formats of Conference report, Book review and Thesis. How to present a paper orally? Research at Microbiology Department of MDS University Ajmer.
Activity: Prepare a list of citations for a given format. Write a review article/Prepare a poster paper.

MIC FE 01 Microorganisms and Health (1L) (1h/week) (Value Added Course)

Section A (4L)

What is life? Where can life exist? Limits of Life on earth. Invisible life. Microorganisms, what are they? Types of Microorganisms, Where do they live? What do they do? Microorganisms and man, The friends and foes.

Section B (6L)

Human microbiome, Preventing infectious diseases. New crop of diseases, Legionnaires disease, AIDS, Swine Flu, Bird Flu, SARS, MERS, Ebola, Zika, West Nile Virus, Tomato Pox, Covid19, Alaska Pox

Section C (5L)

Germs and terror. Prevention of infections. Vaccines and vaccine schedules. Return of the old foes: Antibiotic resistance

MIC FE 02 Hygiene (1L) (1h/week) (Value Added Course)

Section A (3L)

Hygiene and its requirements. Personal hygiene, Hand, Head, Oral hygiene and Sleep hygiene.

Section B (4L)

Hygiene at home, Kitchen and Food industry hygiene, restaurant, food parlours, and street food, and Workplace hygiene. Hygiene during travel, at hotels, offices and hospitals.

Section C (8L)

Food contamination and spoilage, food poisoning, food preservation, Sanitation and hygiene in GMP. Alcohol. Effects of alcohol consumption on the human body and society.

MIC FE 03 Self Actualization (Soft skills) (1L+1P) (2h/week) (Ability Enhancement Course)

The program is aimed to inculcate potential skills in the learners to prepare them to deal with the external world in a collaborative manner, communicate effectively, take initiative, solve problems, and demonstrate a positive work ethic so as to hold a good impression and positive impact

Objectives

To develop

- public speaking skills that make a positive impression and enhance their professional image.
- Impactful communication through effectiveness in presentations.
- Listening abilities effectively and empathetically
- ability to influence and persuade through writing
- poise and confidence
- abilities to prevent self victimization

Course content

Section A

Introduction to Soft Skills, self awareness and self management, Communication Skills, Presentation Skills, critical thinking skills

Section B

Effective Leadership and Motivational Skills, team building skills, Time Management Skills. Preparation of CV, Email Writing, Business letter writing, Report writing

Section C

Soft skills, Body Language and Etiquettes, Group Discussion and Interview Skills, Emotional Intelligence Skills, Stress Management

Methodology:

Lectures, Presentation by Participants, Video Playback and Feedback.

MIC FE 04 Sk Internship in Laboratory and Material Management in Microbiology/Biotechnology (LMMM/B) (4P) (Minimum 288 h in the entire duration of the degree) Or Summer Internship anywhere else (2P)

LMMM/B: The student(s) will be required to make inputs on ease of work by working on the design of the laboratory, maintain a placement Register of equipment and material of the laboratory, develop at least one SOP for equipment handling, maintain MSDs and stock register for chemicals, maintain Glassware and learn their identification, prepare an SOP to ensure laboratory, laboratory bench, reagent shelves and other shelves, racks and almirahs, equipment and glassware cleaning and keep its record, maintain log books of equipment, maintain a repair and requirements register, delegate responsibilities of maintaining lab, materials and equipment to students, solve student problems, get repairs and procurements done for the laboratory, prepare work orders through the catalogs, place them before the laboratory assistant and pursue the process for its completion, manage proper and safe disposal of Wastes and maintain all records and work orders on Excel sheet/MS word.

Students will have to devote 2h/week during Ist and IInd semester (including vacations) and 4 h/week (including vacations) in semesters III and IV. Total 288h or ~2 months internship. The record of the attendance will be maintained by the mentor. The students will submit records of all work done and attach a report of what they learned during the internship.

Summer Internship anywhere else and not in the Department of Microbiology: Alternatively, students may join a job/internship during summer vacations after 2nd semester for a minimum of 1 month (2 credit). The students will submit records of all work done and attach a report of what they learned during the internship.

Assessment: The attendance, report (signed by both student and mentor) and records will be evaluated by the mentor(s)/supervisor(s) and/or a Permanent Faculty member of the Department nominated by the Head of the Department as part of continuous assessment (weightage 40%) and by a panel of examiners constituted by the Head of the Department on completion of internship (weightage 60%). Assessed marks/grades of students who did internship elsewhere and not in the Department of Microbiology will be entered in the Grade sheet of semester III while grades of those who opted it in the Department of Microbiology will be entered in the grade sheet of semester IV.

The scale for grading that may be given to the mentor/supervisor is as below:

Performance Ranking	**Letter Grades**	**Points for Calculation of GPA/ CGPA**
Outstanding	O	10
Excellent	A+	9
Very Good	A	8
Good	B+	7
Above Average	B	6
Average	C	5
Below Average	P	4
Unsatisfactory	F	0
Unsatisfactory due to lack of attendance	FA	0

17.2 CORE COURSES
Semester I
MIC 101 Sk. Essentials of Microbiology (3L) (3h/week)

Course objectives: To expose the student to an overview of the diversity of the prokaryotes, difficulties and requirements in studying microorganisms and basic microbiological techniques that will allow him/her to solve ANY problem related to microorganisms in the industries and institutes.

Learning Outcome: The student will learn about

- Methods in the taxonomy of the microorganisms
- Microscopes, their types and microscopy.
- Asepsis and Basic microbiological methods.
- Concepts of biosafety and biohazards.

Section A (16L)

History and scope of Microbiology. Prokaryotes, Eukaryotes. Archaebacteria and eubacteria. Morphology and ultrastructure of bacteria. Specialized components of microorganisms and their structure and function. Shapes and arrangement of bacteria. Observing microorganisms: Principles and use of the microscope. Bright field, Dark field, Phase contrast, fluorescence, interference, Confocal, Atomic Force and Electron microscopes. Stains and staining techniques.

Section B (15L)

Aseptic techniques: Principles and methods of Sterilization and Disinfection. Disinfectants and their mode of action. Antibiotics, their classification and mode of action. Isolation and purification of microorganisms. Environmental and nutritional requirements. Culture Medium and its types. Cultivation of bacteria, Nutritional types.

Growth and its kinetics. growth yields, Cell Division Asynchronous, synchronous, batch and continuous cultures. Steady-state growth and continuous growth. Maintenance and preservation of pure cultures. Measurement of growth and factors affecting growth. Enumeration of microorganisms, *in situ* studies, sampling, isolation techniques and determination of biomass and growth.

Biohazards: Concept of biohazards with cases highlighting the importance. Biosafety: Principles and measures.

Section C (14L)

Basis of classification of bacteria. Phylogenetic and phenetic approaches. Chemotaxonomy, Genetic and molecular methods: G+C ratio, Nucleic acid hybridization. DNA-DNA and DNA-RNA hybridization. PCR-method and application. 16S, 23S rRNA and IGS sequencing, RFLP, RAPD, STRR & LTRR, REP –PCR based DNA fingerprinting methods. Numerical taxonomy and Polyphasic approach in taxonomy. Major groups of bacteria according to Bergey's Manual of Systematic Bacteriology.

Text Books:

1. Salle A.J. Principles of Bacteriology.
2. Brock T.D., Madigan M.T. Biology of microorganisms. Prentice Hall.
3. Pelczar M.J., Chan E.C.S., Kreig N.R. Microbiology. McGraw Hill.
4. Stanier RY, Ingraham J.L., Wheelis M.L., Painter P.R. 1999. General Microbiology. MacMillan Education Ltd., London.
5. Schlegel. General Microbiology. Cambridge University Press, Cambridge.
6. Prescott. Microbiology
7. Priest. Bacterial Taxonomy

References:

1. Bergey's Manual of Determinative Bacteriology. 9/e
2. Bergey's Manual of Systematic Bacteriology (2/e) P.H.A. Sneath, N.S. Mair, M. Elizabeth (eds).
3. Balows A., Thuper A.G., Dworkin M., Harder W., Schleifer K. 1991. The Prokaryotes. Springer-Verlag.
4. Birge E.A. 1992. Modern Microbiology. Wm. C. Brown, Oxford.
5. Gunsales I.C., Stanier R.Y. The Bacteria. Vol. I, II, III. Academic Press.
6. Joklik W.K., Zinssers. Microbiology. McGraw Hill.

Websites

1.Life in a drop of water. http://www.youtube.com/watch?v=_cpBK2t0Yeo
2.Microbes in the News. http://commtechlab.msu.edu/SITES/dlc-me/news/news.html
3.Society for Microbiology Education resources. http://www.sgm.ac.uk/en/education/resources/index.cfm
4.Society for Microbiology http://www.sgm.ac.uk/ An extensive list of links to microbiology resources including professional societies, publications, and online materials.
5.American Society for Microbiology LABORATORY PROTOCOLS http://www.microbelibrary.org/about/51
6.American Society for Microbiology http://www.asmcue.org/
7.MicrobeWorld http://www.microbeworld.org/ MicrobeWorld is a division of ASM with a dedicated team that scours the internet finding every new microbiology report daily.
8.Meet the Scientist with Carl Zimmer, Carl Zimmer interviews microbiologists about their research in some of the hottest and most exciting areas of research today. http://www.microbeworld.org/index.php?option=com_content&view=category&layout=blog&id=37&Itemid=155
9.Small Things Considered http://schaechter.asmblog.org/
10.Twisted Bacteria: https://twitter.com/twistedbacteria blog written by César Sánchez, a scientist turned editor. César was the editor for Trends in Microbiology prior to writing full-time on his own site. On his blog you can find new information in the field of microbiology.

MIC 102. Diversity of Prokaryotes (3L) (3h/week)

Section A Archaea and Chemoautotrophs

Archaea-introduction. Characteristics of important genera of Methanogens, Extreme halophiles, and Thermoacidophiles. Gram negative eubacteria. Characteristics of important genera of Chemoautotrophs.

Section B Gram negative Eubacteria

Characteristics of important genera of Photosynthetic eubacteria. Mycobacteria and other gliding bacteria. Enteric group and related eubacteria. Gram negative anaerobic bacteria. Prosthecate and stalked eubacteria. *Bdellovibrio*. Spirochaetes, Rickettsia Chlamydias, Myxobacteria.

Section C Gram positive Bacteria and Mollicute

Characteristics of important genera of Unicellular endospore forming eubacteria, Gram positive fermentative eubacteria, Actinomycetes and related eubacteria, Mollicutes. Methophilic eubacteria.

Text Books

1. Stanier RY, Ingraham J.L., Wheelis M.L., Painter P.R. 1999. General Microbiology. MacMillan Education Ltd., London.
2. Schlegel. General Microbiology. Cambridge University Press, Cambridge.
3. Prescott. Microbiology

4. Joklik W.K., Zinssers. Microbiology. McGraw Hill.
5. Alan T. Bull. Microbial Diversity and Bioprospecting. ASM press. Washington, D.C

Reference Books

1. Bergey's Manual of Determinative Bacteriology. 9/e
2. Bergey's Manual of Systematic Bacteriology (2/e) P.H.A. Sneath, N.S. Mair, M. Elizabeth (eds).
3. Balows A., Thuper A.G., Dworkin M., Harder W., Schleifer K. 1991. The Prokaryotes. Springer-Verlag.
4. Gunsales I.C., Stanier R.Y. The Bacteria. Vol. I, II, III. Academic Press.

MIC 103. Biochemistry (4L) (4h/week)

Section A Carbohydrates

Definition and characteristics of life. Composition of living matter. Cellular environment. Water, its structure and properties. Physiological buffers. pH. pH indicators. Redox potential and redox indicators. Solutions and other concepts.

Biomolecules: Structure, function, diversity and distribution. Carbohydrates: Definition, Mono-Di-Tri-Poly-saccharides. Sugars and their derivatives. Structure, occurrence and biological importance of polysaccharide viz. cellulose, agar agar, alginic acid, agarose, carrageenan, pectins, sialic acid, blood group polysaccharides, chitin, bacterial cell wall polysaccharides.

Section B Lipids

Lipids: Definition and classification. Classification and nomenclature of Fatty acids. Systematic nomenclature and classes of glycerides: MAG, DAG, TG; Phospholipids: PA, PG, PE, PS, LPC, PI and plasmalogens; Sphingolipids, Sphingosine, Ceramide, sphingomyelin, glycolipids, cerebrosides, gangliosides, sialic acids. Properties and functions of phospholipids and prostaglandins. Classes and structure. Chemistry of sterols, bile acids, steroid hormones, plant sterol, ergosterol, stigmasterol, cholesterol, glucocorticoid, mineralocorticoids. Lipoproteins classification, composition and importance. Role of lipid in cellular architecture and function.

Section C Proteins, Nucleic acids and Other Biomolecules

Structural features, nomenclature, classification and chemistry of proteins. Amino acids: Classification, structure and properties. Enzymes as biocatalysts. Enzyme classification. Specificity. Active site, Unit activity. Isozymes, Enzyme kinetics. Michaelis-Menten equation for simple enzymes.

Nucleic acids: Importance and general composition. Purine and pyrimidine bases. Tautomeric forms of bases. Structure of nucleosides and nucleotides. Deoxynucleotides, cyclic nucleotides and polynucleotides. Watson and Crick model of DNA. Types of DNA and RNA. Peptidoglycans. Vitamins and hormones.

Text Books:

1. Stryer L. 2001. Biochemistry 5/e, W.H. Freeman. New York.
2. Zubey G.L., Parson W.W. and Vance D.E. 1994. Principles of Biochemistry. Wm. C. Brown, Oxford.
3. Lehninger 2000. Principles of Biochemistry. 3/e. Nelson and Cox (Worth) Pub.
4. Harper’s Biochemistry 1999. McGraw Hill.

MIC 104. Molecular Biology I (2L) (2h/week)

Section A Nucleic acids

Experimental evidence for nucleic acids as genetic information carriers, DNA and RNA structure and function, forces that stabilize nucleic acids. Structural variants of DNA and RNA, Organization of nucleic acids in prokaryotes and eukaryotes. Physical and chemical properties of DNA: Absorption, Density, Denaturation, Renaturation, solubility, size fractionation. DNA topology. Topoisomerases and their role in maintaining DNA topology

Section B DNA replication

Different modes of DNA replication, Structure of prokaryotic DNA polymerase in comparison with eukaryotic polymerases. DNA replication mechanism, Asymmetric and dimeric nature of DNA polymerase III and simultaneous synthesis of leading and lagging strands. Leading strand synthesis,

Lagging strand synthesis, events taking place at the replication fork. Termination of replication and segregation of daughter molecules, Replication of linear genomes, mitochondrial DNA, Retroviruses and their unique mode of DNA synthesis. Inhibitors of DNA replication (blocking precursor synthesis, nucleotide polymerization, altering DNA structure).

Section C Gene Expression

Structural features of RNA (rRNA, tRNA and mRNA) and relation to function. Initiator and elongator class of tRNA, ribosome binding site on mRNA and corresponding site on rRNA, peptidyl transferase activity of 23 S rRNA. Transcription: general principles, basic apparatus, types of RNA polymerases.
Steps for transcription: Initiation, elongation and termination, inhibitors of RNA synthesis. Polycistronic and monocistronic RNAs. Maturation and processing of RNA: Methylation, cutting and trimming of rRNA, capping, polyadenylation and splicing of mRNA, cutting and modification of tRNA. mRNA turnover mechanism. RNAi. Catalytic RNA, Group I and group II intron splicing. RNase P.

Books:

Genes VII. Lewin (Oxford University Press) 2000
E.coli and Salmonella, Cellular and molecular biology. 2nd edition. Neidhart e al., 1996 ASM Press.
Molecular Cell Biology. Lodish, Berk, Zippursky (WH Freeman)
Matsudaira, Baltimore, Darnell 4th edition 2000

MIC 105 Sk. Microbiological and Biochemical Techniques (4P) (12h/week)

Experiments based on Essentials of Microbiology, Diversity of Prokaryotes and Diversity of Eukaryotic Microorganisms.
Additional skills: Searching Material Safety data Sheets, reading and understanding them. Keeping alphabetic records of such sheets.
Strong understanding of ethics (scientific and biological), hazards including biohazards and laboratory safety issues. Understanding risk and impact of not following defined procedures/work instructions.
Types of documentation in organization, importance of maintaining the same and different methods of recording information.
Knowledge about the appropriate authority for reporting any imbalances.

Semester II

MIC 201 Microbial Physiology & Development (4L) (4h/week)

Section A Microbial Development and Bioenergetics

Cell wall and membrane chemistry in bacteria, algae and fungi. Peptidoglycan. Biopolymers as cell components. Cell division. Synthesis of cell wall and its regulation in bacteria. Transport in cells. Cell-cell signaling mechanisms. Quorum sensing: A and C signaling system. Microbial development. Sporulation and morphogenesis. Hyphae versus yeast forms and their significance. Multicellular organization of selected microbes, dormancy.

Bioenergetics: Basic aspects: entropy, enthalpy, bonding energy. Phosphorylation. Flow of energy through the biosphere. Strategy of energy production in the cell, oxidation–reduction reactions, coupled reactions and group transfer. ATP production. Structural features of biomembranes. Transport, free energy and spontaneity of reaction. G, G^0, G′ and equilibrium. Strategies of metabolism. Microbial metabolism and fueling reactions.

Section B Catabolism

Catabolic principles and breakdown of carbohydrates. Lipids, proteins and nucleic acids. Respiratory metabolism- Embden Mayer Hoff pathway, Entner Doudoroff pathway. Glyoxylate pathway. Kreb's cycle. Oxidative and substrate level phosphorylation. Reverse TCA cycle. Gluconeogenesis. Pasteur effect. Fermentation of carbohydrates. Homo- and heterolactic fermentations. ETC- Electron carriers. Artificial electron donors. Inhibitors, Uncouplers.

Section C Anabolism

Carbohydrates-anabolism, autotrophy, oxygenic and anoxygenic photosynthesis. Autotrophic generation of ATP, Fixation of carbon dioxide. Calvin cycle. C3, C4 pathway. Chemolithotrophy-Sulfur,

iron, hydrogen, nitrogen oxidations. Methanogenesis, Luminescence. Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobiliproteins. Assimilation of nitrogen, dinitrogen, nitrate nitrogen, ammonia, synthesis of major amino acids. Polyamines. Synthesis of polysaccharides. Biosynthesis of amino acids, fatty acids and nucleotide bases.

Text Books:

1. Caldwell, DR 1995. Microbial physiology and metabolism. Brown Pub.
2. Moat AG & Foster JW 1999. Microbial Physiology. Wiley
3. Stanier RY, Ingraham JL and Wheelis, ML and Painter PR 1986. General Microbiology. Mac Millan Education Ltd., London
4. Brun Y V, and Shimkets LJ 2000. Prokaryotic development. ASM Press.

MIC 202. Molecular Biology II (Prerequisite: MIC 104) (2L) (2h/week)

Section A Regulation of gene expression

Control of transcription by interaction between RNA polymerases and promoter regions, use of alternative sigma factors. Operon concept, constitutive/ induced, negatively/ positively controlled, catabolite repression, inducers, repressors and corepressors. Negative regulation- *E. coli lac* operon; Positive regulation: *E. coli ara*operon, Regulation by attenuation- *his* and *trp* operons; Antitermination- N protein and *nut* sites in Regulatory circuits: SOS regulon, stringent response and regulation by small molecules such as ppGpp and cAMP, antisense RNA, heat shock response, regulation of rRNA and tRNA synthesis.

Section B Genetic code and Translation

Origin of the genetic code, Evolution of the genetic code, General features and characters of the genetic code, Why is the code universal?

Review of RNA types and functions, Structure of the ribosome. Pre-initiation, Initiation of translation, mechanism of action of aminoacyl tRNA synthetase, identity elements, Factors involved in initiation. Chain elongation, elongation factors and their regeneration, Termination of translation. Polyribosomes, coupled transcription and translation. Regulation of translation, Rates and energetics of translation. Post transcriptional modification of proteins. Translational inhibition, synthesis of exported protein on membrane bound ribosomes. Signal hypothesis, In vitro transcription and translational systems.

Section C Recombination

Homologous/ general and non homologous/ illegitimate recombination, Holiday model, single strand invasion, and double strand break model of recombination, Site specific, replicative, nonreplicative, reciprocal, nonreciprocal recombination. Enzymes required for recombination in *E.coli*, other recombination systems: FL/FRT and Cre/Lox recombination. Genetic analysis using recombination. Advantages of genetic recombination.

Reference Books:

1. Lewin Genes VII. (Oxford University Press) 2000
2. E.coli and Salmonella, Cellular and molecular biology. 2nd edition.
3. Neidhart e al., 1996 ASM Press.
4. Lodish, Berk, Zipursky Molecular Cell Biology. (WH Freeman)
5. Matsudaira, Baltimore, Darnell 4th edition 2000

MIC 203. Microbial Ecology & Biology of Extremes (4L) (4h/week)

Section A Microbial Diversity

Diversity of microorganisms. Conventional and molecular methods of studying microbial diversity. TGGE, DGGE. Measures of diversity. Species richness versus Diversity Index. Unculturable and culturable bacteria.

Ecological principles: Distribution, Abundance, Frequency, Ecological Niche and guild. Substrate groups and nutritional strategies. Resource partitioning and successions. Biomonitoring. Ecological indicators and Biomarkers. Biomagnification. Pollution and its indicators.

Section B Interactions and Extremophiles

Abiotic-abiotic and abiotic-biotic interactions. Symbiosis of bacteria- protozoa, algae-invertebrates, Bacteria -plants, insect endosymbionts. Rumen microbiology. Theory of Endosymbiogenesis. Parasitism, mutualism, competition.

Stress and strain. Constant and fluctuating stress. Strategies to survive stress. Density-dependent and density-independent stresses. Life strategies: r- and K- selection. Stresses in arid soils and rocks.

Microbiology of extreme environments. Extremophiles and their types. Mechanisms and adaptations in acidophilic, alkalophilic, barophilic, osmophilic and oligotrophic organisms.

Section C Desert Microbiota and its Survival

Microbial diversity of hot and cold deserts. Desert varnish, rhizosheath, cryptobiotic crust. Rock crusts. Epilithic, endolithic and hypolithic microbiota. Biotechnological potential of desert microorganisms. Hypersaline environments and their microbial diversity. Saline playas of Rajasthan and their microbial diversity.

Physiological and molecular mechanisms to tolerate desiccation, salt stress, cold, heat and radiation. Applications of extremophiles.

Text Books:

1. Johri BN. 2000. Extremophiles. Springer Verlag, New York.
2. Yanagita. Natural Microbial Communities.
3. Odum E.P. Basic Ecology
4. Cowld D. 1999. Microbial diversity.

MIC 205Sk Experiments in Physiology and Ecology (4P) (12h/week)

Experiments based on Microbial Physiology & Development & Microbial Ecology and Biology of Extremes.

Additional Skills: Knowledge of different standard reference material and use of Computer/application software.

Semester III

MIC 301 Sk. Genetic Engineering (4L) (4h/week)

Section A

DNA sequencing: Maxam Gilbert method, Sanger's sequencing, automated sequencing, High throughput sequencing technologies. Essential enzymes used in Genetic engineering. Restriction nucleases: endo and exonucleases, DNA ligase: Properties and specificity, S1 nuclease, BAL 31 nuclease, DNA polymerase, polynucleotide kinase, DNase, RNase, methylase, phosphatase. Reverse transcriptase, its activity and mode of action.

Methods of nucleic acid detection, Polymerase chain reaction (PCR) and its applications, Variations in PCR and their applications, Methods of nucleic acid hybridization, Probe and target sequences, Nucleic acid mutagenesis *in vivo* and *in vitro*.

Section B

Isolation and purification of nucleic acid (genomic/plasmid DNA and RNA), Quantification and storage of nucleic acids, Genomic DNA libraries: Procedures for Partial, Representative,Enriched, Large-insert DNA libraries, Half-arm cloning. cDNA libraries: Prominent Adapters/Linkers based directional cloning.

Cloning strategies: Vector preparation and diverse cloning strategies viz. blunt end cloning, directional cloning, TA-cloning of PCR products, linkers and adaptors based cloning Methodologies. Cloning vectors: Plasmids, Lambda phages, single stranded DNAvectors (M13, fd, f1);Cosmids, Phasmids and Phagemids,Fosmids,YACs,BACs, PACs. Plant Transformation vectors: Introduction to T_i, R_i plasmids and BIBACs. Expression Vectors for high level protein expression

Section C

Gene transfer techniques: biological methods, Gene transfer techniques: chemical methods, Gene transfer techniques: physical or mechanical methods, *Agrobacterium*- mediated gene transfer in plants, Chloroplast transformation.

Selection and screening of recombinant transformants: Introduction to marker and reporter genes and selection strategies, Labeling and detection of nucleic acid sequences: End-Labeling (3'- and 5'), Random priming and Nick translation using radioactive non-radioactive labeling techniques. Site Directed Mutagenesis: Cassette mutagenesis, Primer extension (single primer method), PCR methods for site-directed mutagenesis, selection of mutant peptides by phage/plasmid display).

Text Books:

1. Maloy*et al*. 1994. Microbial Genetics, Jones & Bartlett Pub.
2. Dale J.W. 1994. Molecular Genetics of Bacteria. John Wiley & sons
3. Streips & Yasbin. 1991. Modern Microbial Genetics. Niley Ltd.
4. Old & Primrose. 1994. Principles of Gene Manipulation. Blackwell Scientific Pub.
5. Sambrose& Russell. 2000. Molecular cloning. 3 volumes. CSH Press
6. 2000. Genome Analysis. 4 volumes. CSH Press
7. Peruski Jr. and Peruski 1997. The internet and the new biology: Tools for Genomic and Molecular Research. (ASM Press).
8. Hunt SP and Liveey R (ED).2000. Functional genomics: practical approach (OUP).
9. Schena M. DNA microarrays: A practical approach (OUP).
10. Roderic D. M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell publishing, USA.
11. Principles of Genome Analysis: A Guide to Mapping and Sequencing DNA from Different Organisms by S. B. Primrose (Paperback - Jan 1998)
12. Microbial Genome Methods by Kenneth W. Adolph (Hardcover - Oct 28, 1996)
13. Genome Mapping and Sequencing by Ian Dunham (Hardcover - Sep 1, 2003).
14. Brendan Wren (Editor), Nick Dorrell (2002) Functional Microbial Genomics (Volume 33) (Methods in Microbiology), Academic Press, UK.

MIC 302. Microbial Genetics (4L) (4h/week)

Section A Mutation, Plasmids & Transposons

Molecular basis of spontaneous and induced mutations, Types of mutations:point, frameshift, lethal, conditional lethal, inversion and deletion, null mutation, reversion of mutations, intra and intergenic suppression mutation. Mutational rates. Mutagens:physical and chemical mutagenic agents. Mutational selection and screening. Site directed mutagenesis, PCR based mutagenesis.

Types of plasmids and their properties. Plasmid copy number and Incompatibility. Transposable elements: Types and properties. Mechanism of transposition: replicative, non replicative and conservative transposition. Phages as transposons.

Section B Systems safeguarding DNA and Conjugation

DNA methylation and DNA repair mechanisms - excision, mismatch, SOS, photoreactivation, recombination repair and glycocyclase system.

Basis of fertility in bacteria. Self-transmissible and mobilizable plasmids. Molecular mechanism of gene transfer by conjugation – genes and proteins involved. Regulation of gene transfer by conjugation.Hfr strains. Mapping bacterial genomes using Hfr strains. Chromosomal DNA transfer by plasmids – by integrated plasmids, by chromosome mobilization and by creation of prime factors. Transfer systems in gram positive bacteria. Ti plasmid transfer system and its application in creating transgenics.

Section C Transformation, Phage Genetics & Transduction

Gene transfer by transformation: Natural transformation and competence. Molecular basis of natural transformation–DNA uptake competence systems in Gram positive and Gram negative bacteria. Regulation of competence in *B. subtilis.* Importance of natural transformation. Artificially induced competence. Genetic analysis based on transformation.

T4 virulent phage: structure, life cycle, genetic map and DNA replication. Lambda temperate phage: Structure, genetic map, lytic and lysogenic cycle, Lysogenic repression and phage immunity. Lambda regulon applications of phages in microbial genetics.

Generalized versus specialized transduction-T4 and lambda phage. Mapping bacterial genes by transduction.

Text Books:

1. Lewin 2000. Genes VII. Oxford University Press.
2. *E. coli* and *Salmonella*: Cellular and molecular biology. 2/ed.
3. Lodish, Berk, Zippursky. Molecular Cell Biology.W.H. Freeman.
5. Matsudaira, Baltimore, Darnell 2000. 4/e.

MIC 303 Sk. Experiments in Applied Microbiology & Molecular Biology (4P) (12h/week)

Experiments based on Synthetic Biology, Microbial Genetics, Medical Microbiology, Immunology, Waste remediation andIndustrial Microbiology.

Additional skills: Knowledge on different standard reference material and use of Computer/application software.

Semester IV

MIC 401 Research Design (3L) (3h/week)

Course Objective:

1. introduce students to the fundamental principles of scientific research methodology.
2. To develop skills in formulating research questions, hypotheses, and experimental designs.
3. To equip students with the knowledge of appropriate statistical analyses for scientific research.

Learning outcomes:

- Understanding Knowledge, Research, Science and Scientific method
- Ability to design research proposal
- Select and use appropriate measurement tools.
- Implement data collection methods.
- Evaluate the reliability and validity of measurements.
- Choose and apply appropriate statistical tests.
- Interpret statistical results and draw conclusions.
- Understand the limitations of statistical analyses.

Course outline:

Section A Introduction to Research and Research Design

Introduction to Research: Information and knowledge. How is knowledge created? What is Research? What is science? Why do we do research? Scientific method: Overview and key components.Types of research. Fact, concept, Hypothesis, theory, law and principle.

Research Design: Basic principles and purpose of research design. Finding research problem, formulating research questions and hypotheses, Use of internet and Search engines for research articles and information. Identifying, deconstructing and reconstructing a problem, Formulating clear and concise research questions. Understanding the importance of a well-defined research problem.

Section B Research Plan and Experimental Design

Preparing a research plan, Types of reasoning and research, Maintaining and assessing quality of research. Data gathering tools: Observation, questionnaire, interview, scaling methods, case study. Experimental research: Experimental design and sampling. Ethical considerations in experimental designs. Designing experiments with controls. Sampling and its types. Common experimental designs. Analysis of variance in Completely randomized design.

Section C Statistical Tools

Data Gathering and Statistical tools: Selection and use of measurement tools. Assumptions, limitations, bias, repeatability. Evaluation of reliability, validity, precision and accuracy in measurements.

Presenting results Classification, tabulation, Graphic representation and frequency distribution. Descriptive statistics- Types of data. Normal distribution. Measurements to summarize information. Principles to choose (assumptions, applicable data type, interpretation and limitations) specific tools for central tendency and dispersion and drawing inference. Probability and probability of error.

Hypothesis testing: Statement of hypothesis, Null and alternate hypothesis. Confidence limits, Types of errors, Standard Error.

Tests of significance: Principles to choose (assumptions, applicable data type, interpretation and limitations) specific tools for various tests of significance.

Determining interactions: Correlation and regression for parametric and non-parametric data. Use of spreadsheets.

Continuous Assessment Indicators: Research proposal, Experimental design project, Data analysis assignments, Research report and presentation

Recommended Texts:

1. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches by John W. Creswell and J. David Creswell.
2. Practical Research: Planning and Design by Paul D. Leedy and Jeanne Ellis Ormrod.
3. The Craft of Research by Wayne C. Booth, Gregory G. Colomb, and Joseph M. Williams.

MIC 402 Sk Project Work/Dissertation (8P) (7hT+9h lab work/week)

Eight credits (16 hours of work/week/student) including 8hT/week/group of students allotted) will include guidance, explanations, discussions for field work, project work/dissertation work to meet specific goals in an independent individual/group effort. Details are as below:

S. No.	Course	Credits (batch limit 10 students)	Student workload (h/week)
1	Plan of work	1	1
2	Conduction of Experiments	1	9
3	Presentation of data	1	1
4	Analysis of data	1	1
5	Presenting weekly reports (20 min seminars+5min discussion)	3	3
6	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper	1	1
	Total (1-6)	08	16

Skills to be learnt
Writing skills
Record and communicate details of work done to appropriate people
Use written/typed report or computer based record/electronic mail
Write detailed reports for investigation.
Maintain proper and concise records as per given format.

Reading Skills
Searching Material Safety data Sheets, reading and understanding them. Keeping alphabetic records of such sheets.
Read and understand manuals, SOPs, health and safety instructions, memos, reports, job cards etc.
Read images, graphs, diagrams.

Oral Communication (Listening and Speaking skills)
To know and understand how to be clear and precise in communication; communicate confidential and sensitive information discretely to authorized person as per SOP. Listen effectively.

Decision making
How to evaluate multiple options on defined, objective parameters and appropriately use the escalation matrix for complex decisions

Critical Thinking
Know and understand how to apply balanced judgment to different situations; apply, analyze and evaluate information to define action steps and provide sound, constructive, objective opinion.

Planning and Organizing
Know and understand how to plan and organize investigation as per deadlines.

Analytical Skills
Know and understand how to identify, define and resolve problems using a structured methodology and suggest improvements (if any) in process based on experience.
Work with biostatisticians, scientists in the other field and from different regions collaboratively to develop study design and pursue research further.
Know different standard reference material and use Computer/application software .

17.3 Elective Courses

Semester I & III

MIEO11 Pharmaceutical Microbiology (4L)(4h/week)

Section A

Microbial Targets in Drug Discovery- Identification and validation , Exploration of bacterial, viral, and fungal targets, Importance of understanding microbial pathogenesis
Introduction to chemotherapeutic agents: History and development of chemotherapeutic agent, Properties of antimicrobial agents, Types of chemotherapeutic agents – Synthetic, Semisynthetic, Natural. Antibiotics: Types of antibiotics with their mode of action; antibacterial, antifungal, antiviral, antiprotozoal

Section B

Principles of drug discovery-finding a lead compound, combinatorial chemistry, rational drug design, target selection, computer aided drug design, new drug development and approval process, preclinical and clinical trials
Microbiome and Drug Metabolism Overview:
how the microbiome can influence drug metabolism. Discussion on the role of gut microbiota in drug absorption, distribution, metabolism, and excretion (ADME). Examples of drugs affected by microbiome interactions.

Section C

Drug Optimization:
Pharmacokinetics and Pharmacodynamics: Optimizing drug properties for effective absorption, distribution, metabolism, and excretion. Ensuring that drug concentrations at the site of infection are sufficient to exert therapeutic effects.
Formulation and Delivery: Developing formulations that enhance drug stability, bioavailability, and patient compliance, Overcoming Resistance: Combination Therapies, Continuous Surveillance

MIEO12. Diversity of eukaryotic microorganisms (4L) (4h/week)

Section A Algae

Algae: General characteristics. Classification up to class level with their distinctive features. Thallus organization. Nutrition, cultivation and reproduction. Types of life histories. Blooms and toxic algae. Control of algal growth. Importance of algae.

Section B Fungi

General features of fungi. Classification up to class level with their distinctive features. Life cycle of selected fungi (*Aspergillus, Penicillium*, Yeasts). Nutrition and cultivation of fungi. Structure of fungal cells and growth. Effect of environment on growth. Prevention of fungal growth. Heterothallism, Dormancy and reproduction in fungi. Spore diversity. Importance of fungi.

Dermatophytes. Dimorphic fungi. Opportunistic fungal pathogens. Description and classification of pathogenic fungi and their laboratory diagnosis.

Section C Lichens & Protozoa

Lichens. Biotechnological potential of microalgae – food – feed –Colourant -fuel and bioactive compounds. Protozoa: Classification up to class level with their distinctive features. Body coverings and skeletons. Locomotive organelles and locomotion. Nutrition, Reproduction, cultivation. Importance of protozoa.

Text Books

1. Burnett J.H. Fundamentals of Mycology. Edwar Arnold, Crane Russak.
2. Charlie M. and Watkinson S.C. The Fungi. Academic Press.
3. Moore E. Landeekeer. The Fundamentals of Fungi. Prentice Hall.
4. Venkataraman G.S., Goyal S.K., Kaushik, B.D. and Rouchoudhary, P. Algae-Form and Function.
5. Alexopolous C.J. and Mims C.W. 1979. Introduction to Mycology (3/e). Wiley Eastern, New Delhi.
6. Kotpal R.L. Protozoa.
7. Mehrotra RS and Aneja KR 1990. An introduction to Mycology. New Age Int Pub.
8. E. Moore & Lendecker Fundamentals of the fungi
9. I.K. Ross Biology of the fungi
10. Alan T. Bull. Microbial Diversity and Bioprospecting. ASM press. Washington, D.C.
11. Stanier RY, Ingraham J.L., Wheelis M.L., Painter P.R. 1999. General Microbiology. MacMillan Education Ltd., London.
12. Schlegel. General Microbiology. Cambridge University Press, Cambridge.
13. Prescott. Microbiology
14. Joklik W.K., Zinssers. Microbiology. McGraw Hill.

MIEO13 Medical Microbiology (4L) (4h/week)

Section A Cellular Microbiology

Prokaryotic and Eukaryotic signaling mechanisms: Eukaryotic cell-to-cell signaling. Endocrine signaling. Prokaryotic signaling: Quorum sensing. Bacterial pheromones. Intracellular signaling. Signaling pathways.

Normal microbial flora of the human body and its role. Sources, vehicles and reservoirs of infection. Pathogenesis: Microbial pathogenicity, transmissibility, infectivity, virulence and virulence factors. Opportunistic pathogens, true pathogens.

Virulence and process of infection – Crossing physical, chemical and biological barriers, Colonization, Association, Adhesion. Invasion of host tissue and toxigenesis with detailed account of virulence factors – Adhesins (pili, capsule, hemagglutinins). Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Invasins (Fibrinolysins, hyaluronidase, hemolysins, hyphal extensions), Evasins (catalase, coagulase, Siderophores, Leucocidins, Kinins), Toxins (diphtheria, cholera, tetanus toxins and endotoxins of Gram negative bacteria – mode of action and *in vivo* and *in vitro* assay systems). Mechanisms of bacterial resistance to host cellular (phagocytosis) and humoral defenses. Molecular basis of bacterial pathogenicity – cytoskeletal modulation of host cell, virulence genes and pathogenicity islands.

Section B Human Diseases (Viral)

Exogenous and endogenous infection. Respiratory, skin, wound and burn infection, venereal infections, alimentary tract infection, arthropod-borne blood infections and laboratory infections. Diagnosis, symptoms, etiology, treatment, prevention and disease development in man with reference to Hepatitis, Cancer, HIV, Dengue, Polio, Mumps, Smallpox, Chicken pox, Measles, SARS, MERS, Ebola, Swine flu, Chicken Guinea, Infectious hepatitis and AIDS. Viral vaccines (Conventional, genetic recombinant vaccines used in National Immunization programs with examples. Newer generation vaccines including DNA vaccines with examples). Interferons and antiviral drugs.

Section C Human Diseases (Bacterial and Protozoan)

Causal organisms, diagnosis, symptoms, toxic components, etiology and disease development in man with reference to TB, leprosy, typhoid, cholera, diphtheria, gonorrhea, tetanus, syphilis,

trachoma, amoebic & bacterial dysentery, malaria and kala azar. Antibiotics, their classification and mode of action.

Text Books:

1. Morag C. and Timbury M.C. 1994. Medical virology. X/e. Churchill Livingstone, London.
2.Topley and Wilson 1995. Text book on Principles of Bacteriology, Virology and Immunology. Edward Arnold, London.
3. Ananth Narayanan R and Jayaram C.K. 1997.Textbook of Microbiology. Orient Longman.
4. Mackie and McCartney. 1996. Medical Microbiology. Vol.1. Microbial Infection, Vol. 2. Practical Medical Microbiology. Churchill Livingstone.
5. Shanson DC. Wright PSG1982. Microbiology in Clinical Practice.
6. Baron EJ, Peterson LR and Finegold SM. 1990. Bailey and Scott's Diagnostic Microbiology. Mosby

MIEO14. Virology (2L) (2h/week)

Section A Basic Virology

Acellular living entities (Virus, Viroid, Virusoid, Prion). Brief outline of the discovery of viruses. Virus, their nature, structure, diversity and mode of replication. Nomenclature and classification of viruses. Viral genome, their types and structures. General Methods of Diagnosis and Serology: Cell cultures. Cultivation of viruses in embryonated eggs. Serological methods- Haemagglutination and Haemagglutination inhibition. Complement fixation, Immunofluorescence methods, ELISA and radioimmunoassays. Physical and chemical assays, Infectivity assays.

Section B Bacterial and Plant Viruses

Bacterial viruses: Bacteriophage structure, organization and life cycles (Lysogenic and Lytic). One step growth curve. Transcription. DNA replication. Eclipse phase. Phage production. Burst size. Bacteriophage typing. Applications in bacterial genetics. Viruses of cyanobacteria, algae and fungi. Plant Viruses: Classification and nomenclature. Effects of viruses on plants: Paddy, Cotton, Tomato, Sugarcane. Transmission of plant viruses with (insect, nematodes, fungi) and without vectors (Contact, seed, pollen).

Section C Animal Viruses

Animal Viruses: Classification, nomenclature and structure of animal and human viruses. Life cycle of RNA viruses: Picorna, Orthomyxo, Paramyxo, Toga and arbo- virus, Rhabdo, Rota, HIV and oncogenic viruses. DNA viruses: Pox, Herpes, Adeno, SV 40, Hepatitis viruses. Viral vaccines, interferons and antiviral drugs.

Text Books:

1. Morag C. and Timbury M.C. 1994. Medical virology. X/e. Churchill Livingstone, London.
2. Dimmock N.J., Primrose S.B. 1994. Introduction to Modern Virology.IV/e. Blackwell Scientific, Oxford.
3. Conrat H.F., Kimball P.C. and Levy J.A. 1994. Virology-III/e. Prentice Hall, New Jersey.
4. Mathews R.E. 1992. Fundamentals of Plant Virology. Academic Press, San Diego.
5. Topley and Wilson 1995. Text book on Principles of Bacteriology, Virology and Immunology. Edward Arnold, London.
6. Lennetter E.H. 1984. Diagnostic procedures for viral and Rickettsial diseases. American Public Health Asso., New York.
7. Hayes W. 1985. The genetics of Bacteria and their viruses. Blackwell Scientific Publishers, London.

MIEO15Sk Microbiology of Wastes and Waste Remediation (3L) (3h/week)

Section A Wastewater Bioremediation

Bioremediation and Bioaugmentation: Pollution, wastes, their types and characterization. Methods of treatment-Physical, chemical, biological-aerobic and anaerobic (Oxidation ponds, HRABP, ASP, Trickling Filter, Fluidized Bed Reactor, Biogas, Rotating contactor). Bioaccumulation of metals and detoxification, biosorption, scavenging. Biodegradation of Xenobiotics (Pesticides and dyes).

Section B Biofilms and Solid Waste Remediation

Biofilms in natural and manmade environments. Solid waste treatment (Agricultural/urban): Degradable wastes: Saccharification, gasification, composting, vermicompost, mushroom compost, ensilage. Utilization of solid wastes- food (SCP, mushroom, yeast), fuel (ethanol, methane-biogas plant), manure (composting). Non biodegradable solid waste and its management: Landfill development, incineration and recycling.

Section C Flue Gas Management & Nanotechnology

Flue Gas Management: Treatment strategies and microbiological options. Fuel desulfurization. Biological alternatives for xenobiotic and Chemical synthesis (biopesticides, biosurfactants, biocolours and Biofuel). Genetically Engineered Microorganisms for bioremediation. Genetic modification of crops. Environmental concerns regarding release of GMOs.

Nanotechnology : Concept, scope and techniques. Microorganisms and nanotechnology.

Text Books:

1. Alexander M 1971. Microbial Ecology. John Wiley & Sons Inc., New York.
2. EldowneyEc S., Hardman DJ. and Waite S 1993. Pollution: Ecology and biotreatment. Longman Scientific Technical.
3. Baker KH and Herson DS 1994. Bioremediation. McGraw Hill Inc., New York.
4. Norris JR and Pettipher GL 1987. Essays in agricultural and food microbiology. John Wiley & Sons, Singapore.
5. Michel R. 1999. Introduction to environmental microbiology.
6. Atlas & Bartha. Microbial Ecology
7. Mayer & Mayer. EnvironmentalMicrobiology
8. Indu Shekhar. EnvironmentalBiotechnology
9. Environmental engineering and management S. K. Dhameja, Publ: Kataria& Sons
10. A text book of environmental chemistry and pollution control S. S. Dara
11. Biotechnology U. Satyanarayana
12. Experimental ecology R.M. Atlas
13. Assessing Ecological Risks of Biotechnology Lev R. Ginzburg
14. Environmental biotechnology G. M. Evans and J. C. Furlong
15. Environmental biotechnology A. Scragg, Oxford
16. Environmental Microbiology – A Laboratory Manual Pepper et. al
17. Genetic control of environmental pollutants Gilbert & Alexander
18. Handbook of water and waste water treatment Technology Paul
19. WasteWater Treatment Arceivala
20. Environmental Microbiology by A.H. Varnam& M.G. Evans, Manson Publishing Ltd., 2000.
21. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
22. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Pu
23. Ewesis ET. Al. 1998. Bioremediation Principles. Mcgraw Hill.
24. Dart. R.K. and Shettron R.J. 1980. Microbiological aspects of pollution control. 2 ed.

Websites

EPA MicrobiologyResources. http://www.epa.gov/nerlcwww/microbes/epamicrobiology.html
EPA Microbiology Home Page http://www.epa.gov/nerlcwww/index.html

MIEO16Sk Industrial Microbiology (4L) (4h/week)

Section A

Microbial Fermentations: Metabolic pathways and metabolic control mechanisms. Industrial production of citric acid, lactic acid, enzymes (alpha-amylase, lipase, xylase, pectinases, proteases), acetone- butanol, lysine and glutamic acid. Vitamin B_{12} and riboflavin fermentation.

Section B

Microbial production of therapeutic compounds (beta-lactam, aminoglycosides, ansamycins (Rifamycin), peptide antibiotics, quinolones). Biotransformation of steroids.

Modern trends in microbial production of bioplastics (PHB, PHA), bioinsecticides (thuricide), biopolymer (dextran, alginate, xanthan, pullulan), Biofertilizers (*Azotobacter*, *Rhizobium*, Cyanobacteria, Mycorrhiza, *Azolla* and Phosphate solubilizing microorganisms).

Section C

Alcoholic brews: Types and their production.

Biofuels. Useful features of biofuels. Gasohol. Production of ethanol from sugar, molasses, starch and cellulosic materials. Ethanol recovery. Biogas production (biomethanation). Algae as biodiesel feedstock and its production. Microbial production of hydrogen gas. Microbial Fuel Cell.

Immobilization. Techniques for whole cell and enzyme immobilization. Application and advantages of cell and enzyme immobilization in pharmaceutical, food and fine chemical industries.

Books

1. Biotechnological Innovations in Chemical Synthesis. BIOTOL. Publishers / Butterworth- Heinemann.
2. Industrial Microbiology by G. Reed (Ed), CBS Publishers (AVI Publishing Co.)
3. Biology of Industrial Microorganisms by A.L. Demain.
4. Genetics and Biotechnology of Industrial Microorganisms by C.l.Hershnergey, S.W. Queener and Q. Hegeman. Publisher ASM.
5. Annual Reports in Fermentation Processes by D. Pearlman, Academic Press.
6. Fundamentals of Biochemical Engineering by Bailey and Ollis.
7. Annual Review of Microbiology by Charles E. Cliffton (Volumes)
8. Biotechnology, A Textbook of Industrial Microbiology by Creuger and Creuger, Sinaeur associates.
9. Manual of Industrial Microbiology and Biotechnology 2nd edition by Davis J.E. and Demain A.L. ASM publications.
10. Biotechnology: A Text Book of Industrial Microbiology by W. Crueger& A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore, 2000.
11. Principles of Fermentation Technology by P.F. Stanbury, W. Whitaker &S.J. Hall, Aditya Books (P) Ltd., New Delhi, 1997.
12. Modern Industrial Microbiology & Biotechnology by N. Okafer, Scientific Publishers, Enfield, USA., 2007.
13. Fermentation Microbiology and Biotechnology by El Mansi & Bryce, Taylor & Francis, London, Philadelphia, 1999.
14. Fermentation Biotechnology by O.P. Ward, Open University Press, Milton Keynes, U.K., 1989
15. Industrial Microbiology: An Introduction by Waites, Morgan, Rockey & Highton, Blackwell Science, 2001.
16. Biology of Industrial Microorganisms A.L. Duncan
17. Microbial Biotechnology A. N. Glazer and H. Nikaido
18. Molecular Industrial Mycology Leong & Berka
19. Manual of Industrial Microbiology and Biotechnology, Demain& Davies, 2nd ed.
20. Microbial Biotechnology A. N. Glazer and H. Nikaido
21. Biotechnology An Introduction Susan R. Barnum
22. Topics in Enzyme & Fermentation Biotechnology Volumes by Wisemen

MIEO17Sk Geomicrobiology & Agricultural Microbiology (4L) (4h/week)

Section A Geomicrobiology

Atmosphere and its microbiology. Geomicrobiology: Basic concepts in Biogeochemical cycles. Biogeochemical cycles of Carbon, Nitrogen, Phosphorus and Sulfur. Geomicrobiology of Iron, Magnesium, Manganese and Calcium.

Bioleaching and biomining. Mechanisms of biogeohydrotechnology of sulphidic minerals, Methods of biogeohydrotechnology, Biobeneficiation, Acid mine drainage formation and control.

Fossil fuel microbiology-Petroleum prospecting, migration, MEOR. Petroleum degradation.

Section B Soil Microbiology

Soil Microbiology: Soil, its formation, physical and chemical characteristics. Microflora of various soils. Rhizosphere and phyllosphere. Biological nitrogen fixation. Nitrogenase and its regulation. Symbiotic and non symbiotic nitrogen fixation.

Biofertilizers versus fertilizers. Mycorrhiza. PGPR. Process, structure, biochemistry and genetics of *Rhizobium*-legume, *Frankia*-nonlegume, and *Anabaena-Azolla* symbiosis.

Section C Aquatic Microbiology

Aquatic microbiology: Freshwater (Ponds, lakes, streams) and marine habitats (estuaries, mangroves, deep sea, brackish water, hydrothermal vents, salt pans, coral reefs). Zonations of aquatic ecosystems. Upwelling. Potability of water. Microbial assessment of water quality. Water purification. Water borne diseases. Eutrophication. Algal/cyanobacterial blooms and toxic algae. Subterranean microbes. Groundwater contamination.

Text Books:

1. Alexander M 1971. Microbial Ecology. John Wiley & Sons Inc., New York.
2. Alexander M. 1977. Introduction to Soil Microbiology. John Wiley & Sons New York.
3. Erneasst WC 1982. The environment of the deep sea. Vol.II J.G. Morin Rubey.
4. Marshall KC 1985. Advances in Microbial Ecology. Vol.8 Plenum Press.
5. Burns RG and Slater JH 1982. Experimental Microbial Ecology. Blackwell Scientific Pub, Oxford.
6. Norris JR and Pettipher GL 1987. Essays in agricultural and food microbiology. John Wiley & Sons, Singapore.
7. Burges A and Raw F 1967. Soil Biology. Academic Press, London.
8. Vaughan D and Malcolm RE. 1985. Soil Organic Matter and Biological Activity. Martinus Nighoff W. Junk Pub.
9. Buckman H. and Brady N.C. The nature and properties of soil. Eurasis Pub. House (P.) Ltd. New Delhi.
10. Michel R. 1999. Introduction to environmental microbiology.
11. Atlas & Bartha. Microbial Ecology
12. Mayer & Mayer. EnvironmentalMicrobiology
13. Indu Shekhar. EnvironmentalBiotechnology
14. Geomicrobiology Ehrlich & Newman, CRC Press
15. Microbial ecology Bartha and Atlas, Pearson Edu
16. Experimental ecology R.M. Atlas
17. Environmental Microbiology – A Laboratory Manual Pepper et. al
18. Microbial Mineral Recovery Ehrlich & Bierley
19. Environmental Microbiology by A.H. Varnam& M.G. Evans, Manson Publishing Ltd., 2000.
20. Manual of Environmental Microbiology by Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, ASM Press, 2007.
21. Environmental Microbiology by W.D. Grant & P.E. Long, Kluwer Academic Pu
22. Reiheimer. G. 1991. Aquatic microbiology, 4 ed.

Websites

EPA MicrobiologyResources. http://www.epa.gov/nerlcwww/microbes/epamicrobiology.html
EPA Microbiology Home Page http://www.epa.gov/nerlcwww/index.html

MIEO18 Sk Geomicrobiology & Agricultural Microbiology (2P) (6h/week)
(Co-requisite: MIEO17 Sk)

Experiments based on Geomicrobiology, Soil microbiology and Plant Microbe Interactions.

MIEO19. Energy and Alternative Energy (1L) (1h/week)

Section A Introduction to Energy and Fuels

Energy and Fuel. Sources of energy. Current Energy scenario: Demand, supply and prospects. Transport energy and fuels. Pros and cons of each fuel/energy source. Problems arising with current sources of energy and fuels. Alternative sources of energy (Nuclear, solar, wind, tidal and others).

Section B Solid fuel and Fossil fuels

Solid fuel.Clean Energy. Clean coal. Improving energy efficiency. Co-generation and other strategies. Fossil fuels: Coal, Natural Gas and Petroleum. Petroleum refineries and petro bye products. Pollution and Global warming.

Section C Bioenergy and Biofuels

Bioenergy and Biofuels: Biomass for steam and power. Biofuel crops in the world. Oil crops, Starch crops, Sugar crops. Extraction of oil, starch and sugar. Food vs fuel controversy. Lignocellulosic candidates and their production. Wastelands available in India and candidate biofuel crops for these regions. Life cycle analysis of biofuels.

MIEO20 Sk. Seminar/Workshop/Training (1T/1P) (1h/week)

The course will prepare the student for public speech and defense of the ideas presented. It would train student for the need and preparations for various forms of public speaking (Keynote address, workshops, seminars, team engagement (brainstorming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing powerpoint presentations, presenting less and providing more, giving credits to sources, overcoming nervousness, developing instant rapport with audience-using humor, quotes, statistics, poetry, cartoons, eye contact with individuals without making them uncomfortable, preparing them to cast stage presence by way of Voice control, Body language, Delivery, Audience relations, Inoculation messages and overcoming fear.

Alternatively or additionally, a workshop or training conducted by the Department for a minimum of 6 days will be considered as a skill course of 1P credit which would include time for lecture(s) and activities (demonstration(s), experimental work, hands on activity) and assessment covering a **minimum** of 9h of lectures/tutorials including assessment and 12h of activities (experimentation/hands on work/demonstration etc.).

Semesters II and IV

MIEE11 Immunology (4L) (4h/week)

Section A

Immune response: Humoral, cellular, actively acquired, passively acquired. Natural or innate immunity. Determinants of innate immunity. Species and strains. Individual differences. Influence of age, hormonal influence, nutritional factors, mechanical barriers and surface secretions, Tissue metabolites with bactericidal properties (lysozymes, nucleins, histones, protamines). Basic peptides of tissues-Leukins, Phagocytins, Lecterin, Heme compounds), Other Non specific immune mechanisms: Opsonization, Inflammatory reactions, Interferon, Complement system: Structure, properties and functions. Complement pathways and biological consequence of complement activation.

Immune system: Organs and cells involved in immune system and immune response. Lymphocytes, their subpopulation, their properties and functions, Membrane bound receptors of lymph cells. Helper T cells in immune response. T cell suppression in immune response.

Antigens, structure, properties and types of antigens, antigen specificity, haptens. Adjuvants-antigen specificity, form, dose and route of entry of antigen. Vaccines and toxoids.

Section B

Immunity to infection- Theories of antigen recognition. Immunoglobulins, Structure, heterogeneity, types and subtypes, properties. Diversity of antibodies and its generation. Lymphoid cell interactions. *In vivo*-immune memory.

Major Histocompatibility Complex and Tumor Immunology: Structure and functions of MHC and HL-A system. HL-A and tissue transplantation. Tissue typing methods for organ and tissue transplantations in humans. Graft versus host reaction and rejection. Tumor specific antigens. Immune response to tumors. Immunodiagnosis of tumors. Detection of tumor markers. Alpha Fetal proteins, Carcinoembryonic antigen.

Section C

Immune tolerance and autoimmunity. Immunosuppression-Specific, nonspecific. Autoimmunity-theories, mechanisms and diseases with their diagnosis. Hypersensitivity reactions-Antibody mediated hypersensitivity. Type I- Anaphylaxis. Type II- Antibody dependent cell cytotoxicity. Type III- Immune complex mediated reactions. Type IV-Cell mediated hypersensitivity reactions. Antigen-antibody reactions- *In vitro* methods-agglutination, precipitation, complement fixation,

immunofluorescence, ELISA, Radioimmunoassays. *In vivo* methods- Skin tests and immune complex tissue demonstrations. Applications of these methods in diagnosis of microbial diseases.

Text Books:

1. Henderson *et al*. 1999. Cellular Microbiology. Wiley.
2. de Bruijn et al. 1998. Bacterial genomics. Chapman & Hall.
3. Dorman C.J. 1994. Genetics of bacterial virulence. Blackwell.
4. Barrett J.T. 1983. Textbook of immunology: An introduction to immunochemistry and immunology. Mosby, Missouri.
5. Boyd R.F. 1984. General Microbiology. Times Mirror/Mosby (College Pub, St. Louis).
6. Davis, Dulbecco. Microbiology.
7. Broude A.I. 1981. Medical Microbiology and infectious diseases. W.B. Saunders & Co., Philadelphia.
8. Chapel and Haeney 1984. Essentials of Clinical Immunology. Blackwell Sci.

References:

1. Clark W.R. 1991. The experimental foundations of modern immunology. John Wiley
2. Mackie & McCartney. Medical Microbiology. 14/e.
3. Bailey & Scott's Diagnostic Microbiology.
4. Franklin TJ, Snow GA. 1981.Biochemistry of antimicrobial action. Chapman & Hall, New York.
5. Roitt IM. 1995. Essential Immunology. Blackwell Sci. Oxford.
6. Roth J.A. 1985. Virulence mechanisms of bacterial pathogens. American Society for Microbiology. Washington D.C.
7. Smith CGC. 1976. Epidemiology and infections. Medowfief Press Ltd. Shildon, England.
8. Stiem F. 1980. Immunological disorders in infants and children. W.B. Saunders & Co. Philadelphia.
9. Todd IR. 1990. Lecture notes in immunology. Blackwell Sci. Pub. Oxford.
10. Roitt IM, Brostoff and Male 1995. Immunology 4/e Gower Medical Pub Co..
11. Kuby J 1994. Immunology. 2/e. W.H. Freeman and Co., New York.

Websites

CELLS Alive! About unique images of microorganisms that make you sick, and the blood cells that do battle to keep you well. Includes links to sites offering further information on microbiology, infectious diseases and cell biology. http://www.cellsalive.com/

MIEE12 Sk Bioprocess Engineering (4L) (4h/week)

Section A Bioreactors

Bioreactors: Design of a basic fermenter, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring, measurement and control of process. Reactors for specialized applications: Tube reactors, packed bed reactors, fluidized bed reactors, cyclone reactors, trickle flow reactors, their basic construction and types for distribution of gasses.

Transport phenomena in fermentation: Gas- liquid exchange and mass transfer, oxygen transfer, critical oxygen concentration, determination of Kla, heat transfer, aeration/agitation and their importance. Sterilization of Bioreactors, nutrients, air supply, products and effluents.

Section B Fermentation and Downstream Processing

Fermentation process: Media formulation, selection of components, buffers, precursors, pH adjustment. Growth of cultures in the fermenter. Kinetics of growth with respect to substrate utilization. Specific growth rate. Batch culture, Fed-batch and continuous culture. Steady state in a chemostat. Yield of biomass and product. Inoculum development. Storage of cultures for repeated fermentations, scaling up of processes from shake flask to industrial fermentation.

Downstream processing: Biomass separation by centrifugation, filtration, flocculation and other recent developments. Cell disintegration: Physical, chemical and enzymatic methods. Methods of extraction of the product. Purification of the product: Concentration by precipitation, ultra-filtration, reverse osmosis. Drying and crystallization.

Section C Strategies to reduce cost of production

Expenses for industrial organisms, strain improvement, media sterilization, heating, cooling, aeration, agitation, Cost of plant and equipments, batch process cyclic time, continuous culture, recovery and effluent treatments**,** Cost recovery due to waste usages and recycling

Prospecting: Isolation and screening microbial cultures, Screening for primary and secondary metabolites, enrichment and specific screening for the desired product. Modification of medium and techniques of fermentation.

Strain improvement: Mutation and screening of improved cultures, random and strategic screening methods, strategies of strain improvement for primary and secondary metabolites with relevant examples. Use of recombinant DNA technology and protoplast fusion techniques.

Production of recombinant molecules in heterologous systems, problems associated with strain improvement programs, improvement of characters other than products and its application in the industry.

Preservation of cultures.

MIEE13 Sk Experimental Bioprocess Engineering (2P) (6h/week)
(Co-requisite MIEE12 Sk)

Experiments on Industrial Microbiology and fermentation technology.

Books:

1. Principles of Fermentation Technology by Stanbury, P.F., Whitekar A. and Hall. 1995., Pergaman. McNeil and Harvey.
2. Fermentations - A practical approach. IRL.
3. Bioprocess Technology: Fundamentals and Applications. Stockholm KTH.
4. Biochemical Reactors by Atkinson B., Pion, Ltd. London.
5. Biotechnology - A Text Book of Industrial Microbiology by Cruger.
6. Fermentation Biotechnology: Industrial Perspectives by Chand.
7. Biochemical Engineering Fundamentals by Bailey and Ollis, Tata McGraw Hill, N.Y.
8. Biotechnology. Volume 3. Edited by H. J. Rehm and G. Reed. Verlag Chemie. 1983.
9. Advances in Biochemical Engineering by T.K. Bhosh, A.Fiechter and N. Blakebrough. Springer Verlag Publications, New York.
10. Biotechnology- A textbook of Industrial Microbiology by Creuger and Creuger, Sinauer Associates.
11. Bioprocess Engineering Kinetics, Mass Transport, Reactors, and Gene expressions by Veith, W.F., John Wiley and Sons.
12. Applied Microbiology Series.
13. Industrial Microbiology by L.E. Casida, Wiley Eastern
14. Bioseparation: Downstream processing for Biotechnology by Belter, P.A. Cussler, E.L. and Hu, W.S., John Wiley and Sons, N.Y.
15. Separation process in Biotechnology by Asenjo, J.A. Eds. Marcel Dekkar, N.Y.
16. Bioprocess Engineering Principles by Doran, Acad. Press, London.
17. Bioreaction Engineering Principles by Nielsen, J. and Villadsen, plenum Press, N.Y.
18. Fermentation, Biocatalysis and bioseparation, Encyclopedia of Bioprocess Technology by Chisti, Y., Vol. 5, John Wiley and Sons, N, Y.
19. Cussler E L 1984. Diffusion. Cambridge University Press.
20. Fermentation Microbiology and Biotechnology EL-Mansi &C.F.A.Bryce eds
21. Bioprocess Engineering P.K. Ghosh
22. Bioseparations: principles and techniques B. Sivasankar, PHI, New Delhi
23. Process Biotechnology Fundamentals S. N. Mukhopadhyay
24. Demain, A.L. and Davies, J.E. (1999). Manual of Industrial Microbiology and Biotechnology. ASM Press.
25. Glick, B.R. and Pasternak, J.J. (1994). Molecular Biotechnology, ASM Press.

MIEE14. Basics of Biofuel & Bioenergy (3L) (3h/week)

Section A

Biomass for energy. Calorific value and its estimation. Co-generation of energy. Alternatives as biofuels: Alkanes, Biobutanol, bioethanol, biomethanol, biodiesel, biogas, hydrogen, syngas/synfuels and other energy dense molecules and their comparisons.

Starch to sucrose conversion and Sucrose to ethanol fermentation. Distillation and Quantification of ethanol. Biobutanol production, Estimation of biobutanol. Biogas production. Biogas and methane estimation. Lignocellulosics hydrolysis, Fermentation of pentoses and other issues in bioethanol production from lignocellulosics.

Section B

Global biodiesel scenario. Oil crops. Wastewater remediation and biomass generation for biofuel purposes. Commercialized microalgae (*Spirulina, Dunaliella, Hematococcus, Chlorella,* and others) and their production. Systems of Cultivation, harvesting and protection from grazers. Economics of microalgae production. Cultivation of seaweeds. Techniques of lipid extraction and conversion to biodiesel (lipid transesterification), Biodiesel quality and its assessment.

Section C

Food vs Fuel debate. Carbon sequestration and its necessity. Carbon credits. Biorefinery, Thermochemical Conversion Processes (Gasification: Biofuels from Synthesis Gas and Pyrolysis) Biochemical Conversion Processes, Photobiological conversion: Biohydrogen production Lignocellulosic and cellulosic wastes as prospective energy sources: biogas or bioalcohol or bioenergy? Strategies of genetic engineering of organisms for biofuel production. Microbial Fuel Cells.

MIEE15 Sk Techniques in Biofuel & Bioenergy (2P) (6h/week)
(Co-requisite: MIEE14 Sk)

Experiments on biofuels and bioenergy.

MIEE16 Food Microbiology (3L) (3h/week)

Section A Basic Principles of Food Microbiology

Food as substrate for microorganisms: Microorganisms important in food microbiology-Molds, Yeasts and bacteria. General characteristics, classification and importance. Principles of food preservation. Asepsis-Removal of microorganisms (anaerobic conditions, high temperatures, low temperature, drying). Factors influencing microbial growth in food. Extrinsic and intrinsic factors. Chemical preservatives and food additives. Canning, processing for heat treatment-D, Z and F values and working out treatment parameters.

Section B Food Spoilage and Food Borne Infections

Contamination and spoilage: Cereals, Sugar products, vegetables, fruits, meat and meat products. Milk and milk products, Fish and sea foods, poultry, spoilage of canned foods. Detection of spoilage and characterization.

Food-borne infections and intoxications: Bacterial and non bacterial with examples of infective and toxic types- *Brucella, Bacillus, Clostridium, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia*. Nematodes, protozoa, algae, fungi and viruses. Food borne outbreaks. Laboratory testing procedures. Prevention measures. Food sanitation in manufacturing and retail trade.

Section C Fermented Food Products

Food fermentation: Bread, Cheese, Vinegar, Indian fermented foods. Idli, Non-bevearagic, Plant based fermented foods – Miso, Ogi, Olives, Pickles, Sauerkraut, Soy sauce, Tempeh. Meat and fishery products. Country cured hams, Dry sausages, Katsuobushi.

Fermented dairy products. Butter, Buttermilk, Sour cream, Yogurt, Cheese, Kefir, Koumiss, Taette and Tarhama. Experimental and industrial production methods. Spoilage and defects of fermented dairy products.

Food produced by microbes: Microbial cell as food (SCP), SCO. Mushroom cultivation. Production of yeast (Baker's yeast as food and fodder. Food control agencies and regulations. Plant sanitation. Employees' health standards. Waste treatment. Disposal. Quality control. Genetically modified foods.

MIEE17 Sk Experimental Food Microbiology (2P) (6h/week)
(Co-requisite MIEE16 Sk)

Experiments on Food and water quality, Spoilage and contaminations and their prevention.

Text Books:

1. Adams MR and Moss MO 1995. Food Microbiology. Royal Society of Chemistry Pub., Cambridge.
2. Frazier WC and Westhoff DC 1988. Food Microbiology. Tata Mc Graw Hill Pub Comp. New Delhi.
3. Robinson RK. 1990. Dairy Microbiology. Elsevier Applied Sciences, London.
4. Banwart GJ 1989. Basic Food Microbiology. CBS Pub and distributors, Delhi.
5. Hobbs BC and Roberts D 1993. Food Poisoning and Food Hygiene. Edward Arnold (A division of Hodder and Stoughton) London.

Websites

The "Bad Bug" Book. This handbook, developed by the Food and Drug Administration, provides basic facts regarding foodborne pathogenic microorganisms and natural toxins.
http://www.fda.gov/Food/FoodborneIllnessContaminants/CausesOfIllnessBadBugBook/default.htm

MIEE18Sk ENZYMOLOGY (3L) (3h/week)

Section A

Enzymology- Introduction, Nomenclature and classification, General characteristics of enzymes, Activation energy, Coupled reactions, active site and its importance, Factors influencing catalytic efficiency.
Enzyme kinetics, Rapid Equilibrium, Henry-Nucgaekkus-Menten's equations, Steady State approach, significance of Km, Haldane equation, Velocity vital Substrate concentration curves.
Methods of plotting enzyme kinetics data-Lineweaver-Burk, Hanes-Woolf,
Woolf-Augustinsson-Hofstee, Eadsie-Scatchard; Advantages and disadvantages of the methods, Comparisons and applications; Integrated form of the Henry-Michaelis-Menten equation.

Section B

Equilibrium dialysis, Scatchard plot for equilibrium binding, Effect of pH on enzyme stability and activity, Effect of temperature on enzyme stability, Arrhenius equation.
Formation of E.S covalent intermediates, transient kinetics, flow techniques (continuous, stopped, quenched), Temp-Jump. General mechanistic principles: Role of proximity effect, bound distortion, multistep catalysis, bifunctional catalysis and solvent effects.

Section C

Regulation of enzyme activity: Feedback inhibition, reversible covalent modification, irreversible covalent modification, allosteric concept, Aspartate transcarbamylalse, ligand-protein interaction, scatchard plot, Hill plot, cooperativity index, Models for allostery (MWC, KNF), Half site reactivity. Enzyme Inhibition, Models and types of inhibition.
Applied enzymology: Application of enzymes in analytical labs. (clinical and industrial), enzymes as industrial catalysts, Immobilized enzymes, enzyme electrodes, assay of enzyme activities for diagnostic purposes, abzymes, recent developments.

Books

1. Cook P. F., Cleland W.W. Enzyme Kinetics and Mechanism. Garland Science Publishing, London, England and New York, USA, 2007.
2. Buchholz K., Kasche V., Bornscheuer U.T. Biocatalysts and Enzyme Technology.

MIEE19 Sk. Bioinformatics (Prerequisite MIC 104, 408) (4L) (4h/week)

Section A

Introduction to bioinformatics. Microbial and eukaryotic genomes. Genome analysis, Introduction to genomic libraries and gene cloning. DNA sequencing technologies: Conventional sequencing and automated sequencing, Next generation sequencing technologies. Database: Types of databases, Database structure, accession codes and identifiers, Database searching tools

Section B

Homology, Introduction to sequence alignment. Global, local and semiglobal alignments, optimal and suboptimal alignments. Pairwise alignments: Dot blots, Dynamic programming algorithms, Gap penalties, scoring matrices for DNA and Protein, Heuristic methods: BLAST, FASTA. Suffix Trees and

suffix arrays. Patterns, Profiles and Multiple sequence alignments. Software for multiple alignment. Annotations of genes.

Section C

Phylogenetic analysis :Introduction to Molecular phylogeny: Cladistics, Phylogenetic tree construction: additive trees and ultrametric trees, rooted, unrooted trees and tree shapes, data likelihood, distance, parsimony and probabilistic methods, softwares for making phylogenetic trees – MEGA, Phylip. Annotation of genome, Gene prediction.

DNA microarray. Analysis of single nucleotide polymorphisms using DNA chips. Proteome analysis: Two dimensional separation of total cellular proteins, isolation and sequence analysis of individual protein spots by mass spectroscopy. Protein microarray.

Text Books:

1. 2000. Genome Analysis. 4 volumes. CSH Press
2. Peruski Jr. and Peruski 1997. The internet and the new biology: Tools for Genomic and Molecular Research. (ASM Press).
3. Hunt SP and Livery R (ED).2000. Functional genomics: practical approach (OUP).
4. Schena M. DNA microarrays: A practical approach (OUP).
5. Baxevanis A.D. and Ouellette, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins 3rd Ed. John Wiley and Son Inc., 2005.
6. Higgins & Taylor Bioinformatics 2000
7. Roderic D. M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach. Blackwell publishing, USA.
8. Principles of Genome Analysis: A Guide to Mapping and Sequencing DNA from Different Organisms by S. B. Primrose (Paperback - Jan 1998)
9. Microbial Genome Methods by Kenneth W. Adolph (Hardcover - Oct 28, 1996)
10. Genome Mapping and Sequencing by Ian Dunham (Hardcover - Sep 1, 2003).
11. Brendan Wren (Editor), Nick Dorrell (2002) Functional Microbial Genomics (Volume 33) (Methods in Microbiology), Academic Press, UK.
12. W.J. Ewens, Gregory Grant,(2005). Statistical Methods in Bioinformatics: An Introduction (Statistics for Biology & Health), Springer
13. Bryan Bergeron,(2003).Bioinformatics Computing. First Indian Edition, Prentice Hall
14. Cynthia Gibas& Per Jambeck (2001). Developing Bioinformatics Computer Skills: Shroff Publishers & Distributors Pvt. Ltd (O'Reilly), Mumbai
15. HH Rashidi & LK Buehler (2002). Bioinformatics Basics: Applications in Biological Science and Medicine, CRC Press, London
16. Des Higgins & Willie Taylor (2002). Bioinformatics: Sequence, structure and databanks, Oxford University Press

MIEE20 Sk. Biostatistics & Computational Biology (4L) (4h/week)

Section A

Science, scientific methods, scientific approach. Types of research. Exploratory and descriptive. Hypothesis, theory, and principle. Meaning, scope and need of statistics. Data, population, sample, statistics. Variables and their types. Basic assumptions in qualitative and quantitative, parametric and non-parametric studies.

Basic principles of research design. Purpose of designing. Theory and design in quantitative research. Definition and types of qualitative research. Methods and techniques of data collection: Group discussions, interviews, key informants, in depth interviews, observations, social mapping.

Data gathering tools: Observation, questionnaire, interview, scaling methods, case study. Experimental research: Reliability and validity of measuring instruments. Precision and Accuracy. Probability. Sampling and its types.

Section B

Interpreting Results: Assumptions, bias, repeatability. Descriptive statistics- Classification and tabulation of data. Proportion and count data. Graphic representation and frequency distribution. Statistical inference. Measures of Central Tendency- Mean, mode median. Measures of dispersion- Mean, deviation, standard deviation, variance and coefficient of variance.

Hypothesis testing: Statement of hypothesis, Null and alternate hypothesis. Confidence limits, Types of error, Standard Error. Parametric and Non parametric tests of significance: goodness of fit, Student's t-, F -, chi square, Kruskaal Wallis' H-, Wilcoxon's T- and Mann Whitney's U- test.

Section C

Correlation (Pearson's and Spearman's), testing significance of correlation coefficient. Linear regression. Coefficient of determination.

Experimental designs, their types, advantages, disadvantages. Analysis of variance: One way and two way ANOVA. Critical difference or least significant difference.

Data processing and presentation of results. Use of spreadsheets and statistical tools in computers. Computers in laboratory (LIMS) and learning (CAL), taxonomy, clinical microbiology, fermentation technology, simulation and modeling. Computers as audio visual aid and as word processor. Use of the internet. Search engines, finding scientific articles - Pubmed – public biological databases.

Books

1. Bliss C.I.K. 1967. Statistics in Biology. Vol. I. Mc Graw Hill, New York.
2. Campbell R.C. 1974. Statistics for Biologists. Cambridge University Press, Cambridge.
3. Hewitt W. 1977. Microbiological assay. Academic press, New York.
4. Hard Law A.C.T. 1982. (i) Four point parallel line assay of penicillin pp. 370-379. (ii) Microbiological assay of a vitamin-nicotinic acid. Pp. 214-233. In: S.B. Primrose and A.C. Wardlaw (eds) Sourcebook of experiments for the teaching of microbiology. Academic Press, London.
5. Wardlaw A.C. 1985. Practical statistics for experimental biologists. John Wiley and sons, New York.
6. Ron White. 2000. How computers work. Techmedia.
7. Preston Gralla 2000. How the internet works. Techmedia
8. Holmes D., Moody, P. Dine D. 2006. Research Methods for the Biosciences. Oxford University Press.
9. Kothari CR 1990. Research methodology- Methods and Techniques (2/e). VishvaPrakashan, C.A. Division of Wiley Eastern, New Delhi.
10. Gupta S 1999. Research methodology and statistical techniques. Deep and Deep Publications, New Delhi.
11. Scrimshaw NS and Gleason GR 1992. Rapid assessment procedures. Quantitative methodologies for planning and evaluation of health related programs. International Nutrition Foundation for Developing Countries, Boston.
12. Van Maanen 1983. Quantitative methodology. Sage publications.
13. Cook TD and Reichardt CS 1979. Qualitative and quantitative methods in evaluation research. Sage Pub., London.
14. Creswell J 1994. Research design: Qualitative and quantitative approaches. Thousand Oaks. CA, Sage Pub.
15. Denzin NK and Lincoln YS 1994. Handbook of qualitative research. Sage pub.
16. Mienert CL 1986. Clinical trials: Design, conduct and analysis. Oxford Univ Press, New York.
17. Arora PN & Malhon PK (1996). Biostatistics. Himalaya Publishing House, Mumbai.
18. Sokal & Rohif (1973). Introduction to Biostatistics, Toppan Co. Japan.
19. Stanton A & Clantz, Primer of Biostatistics (2005). The McGraw Hill Inc., New York

MIEO21 Sk. Seminar/Workshop/Training (1T/1P) (1h/week)

The seminar course will prepare the student for public speech and defense of the ideas presented. It would train student for the need and preparations for various forms of public speaking (Keynote address, workshops, seminars, team engagement (brainstorming, activities, etc.) and picking up topic, organizing thoughts, preparing an abstract and the write-ups, preparing powerpoint presentations, presenting less and providing more, giving credits to sources, overcoming nervousness, developing instant rapport with audience-using humor, quotes, statistics, poetry, cartoons, eye contact with individuals without making them uncomfortable, preparing them to cast stage presence by way of Voice control, Body language, Delivery, Audience relations, Inoculation messages and overcoming fear.

Alternatively or additionally, a workshop or training conducted by the Department for a minimum of 6 days will be considered as a skill course of 1P credit which would include time for lecture(s) and

activities (demonstration(s), experimental work, hands on activity) and assessment covering a **minimum** of 9 h of lectures/tutorials including assessment and 12h of activities (experimentation/hands on work/demonstration etc.).

MIEE22, MIEO22, MIC 304 Sk. Short term Project (1P) (3h/week)

Students will be given experimental work, and optimize techniques to achieve specific goals.
Skill: How to plan, conduct, record, analyze and report an activity. Learn data presentation through software.

MIEE23 Diagnostic Microbiology (4L) (4h/week)

Section A

Universal Safety Precautions in Laboratory: Sterilization and Disinfection, Standard precautions including hand hygiene, Hospital acquired infections, Biomedical waste management.
Sample Collection, Transport and Preparation: Smear preparation and fixation, Thin and thick smear for Malaria parasite.
Basics of Microscopic and Staining Techniques: Types of microscopy for identification of microorganisms - Light, Dark field, Fluorescent, Phase contrast and Electron microscopy. Simple staining, Differential staining (Grams stain, Acid-Fast stain) and Special staining (Albert's stain, Negative staining - India ink and Nigrosin), Silver impregnation techniques. Hanging drop preparation. Fungal identification and staining - histopathologic stains (PAS, GMS, H and E), Lactophenol cotton blue mount. Germ tube test. Wet mount preparation (KOH, Saline and Iodine mount). Stool/faeces examination to detect Ova and Cysts of parasites.
Bacteriology of Water, Air and Surface - Presumptive and Differential coliform count (Settle plate method, Slit sampler method and Surface sampling).

Section B

Culture Methods for Identification of Clinically Relevant Microorganisms: Solid culture media - Nutrient agar, Blood agar, Chocolate agar, MacConkey's agar, SDA, PDA and Selective media - Mannitol salt agar, Chromogenic media, SS agar, DCA, XLD, GTTA, LJ media and Loeffler's serum slope. Liquid culture media - Peptone water, Glucose broth, Thioglycollate broth, RCM broth, BHI and Blood culture. Biphasic media - Castaneda. Others - RPMI and NNN media.
Biochemical Tests for Identification: Catalase, Coagulase, Oxidase, Bile-Esculin test, IMViC, Urease, TSI, PPA test, Sugar and Amino acid fermentation, Optochin and Bacitracin Disc, ONPG.
Antimicrobial Susceptibility Testing (AST): Disk Diffusion (Stokes and Kirby Bauer), Dilution (Broth and Agar Dilution), MIC testing (E-test).
Isolation of Viruses: Egg and Animal inoculation, Tissue culture.

Section C

Immunological Techniques: Immunoassays - Conventional techniques - Precipitation (VDRL, RPR) and Agglutination (Widal test, ASLO, CRP, RA test). Use of Antisera for microbial detection. Newer techniques - ELISA, IFA, CLIA, Western Blot. Rapid tests - Lateral flow and Flow through Assays).
Molecular Techniques: Nucleic acid amplification tests - PCR, RT-PCR, Real-Time PCR, Ligase chain reaction, Transcription mediated amplification, CB-NAAT/GeneXpert. Nucleic acid Probes for direct detection of pathogens and antimicrobial resistance in clinical specimens.
Automated Systems for Microbial Identification: MALDI-TOF MS, VITEK 2, BACTEC and BacT/Alert, MGIT, MicroScan WalkAway system.

18. Assessment and Evaluation

18.1.1 All courses except for the Seminars/Workshop/Training in a PG program shall have continuous assessment which would include In term assessment (40% marks) by the course leader (including attendance above 75%, two quizzes and one assignment) and an end term examination (60%) at the level of the University.

18.1.2 A student shall not be permitted to repeat any course only for the purpose of improving the grade.
18.1.3 It comprises in-term continuous assessment and end term assessment.

18.2 **In term Continuous Assessment**
18.2.1 It is mandatory for all students to participate in all the in-term continuous assessment and course-related activities for award of the marks. Therefore a schedule of in-term continuous assessment tests shall be prepared by the Course Leader and informed to the students at the very beginning of the semester.
18.2.2 Each course leader shall organize a continuous assessment of each of the courses assigned to him/her. The internal assessment shall be as per the following breakup:

S. No.	Item	Max Marks
1	Tests/Term Papers/Quizzes (1 x 20 or 2 x10)	20
2	Assignments (May include Case Demos/Presentations/Write ups/ Viva etc.)	10
3	Attendance	10
	Total	40

18.2.3 In-term Continuous Assessment marks shall be displayed within a week from the date of conduct of examination and all corrected answer books with comments, if any, shall be shown to students.
18.2.4 Marks for attendance must be given as below:

Attendance (%)	Marks	Attendance (%)	Marks
75	1	86-88	6
76	2	89-91	7
77-79	3	92-94	8
80-82	4	95-97	9
83-85	5	98-100	10

Percentage of attendance in decimal values must be rounded off to the nearest number; i.e. <0.5 as the nearest lower number and 0.5 or more as the nearest higher number.

18.2.5 **Seminars**
18.2.5.1 A seminar leader nominated by the Head of the Department to act as a guide to the students will assign topics for the seminars to the students. They will present an Abstract not exceeding 500 words along with a few important references. The seminar leader will give a schedule for providing abstracts, showing presentations to him/her, date and time of the final presentation and submission of the write-up of the seminar. Students will present their seminar presentations in front of the faculty, research scholars and students of the Department as per the schedule provided by the seminar leader, informed to the Head of the Department and faculty, and displayed on the Notice Board.
18.2.5.2 The attendance (10 marks), abstract (10 marks) and write up (20 marks) will be assessed by the seminar leader.
18.2.5.3 Final presentation (60) of the seminar will be assessed by the seminar leader and another faculty member appointed by the Head of the Department.

18.3 End-Semester examination
18.3.1 An End Semester examination shall be conducted by the University for all courses offered to the student by the department except for the Seminar/Workshop/Training. The duration of the end semester examination shall be 3 hours.
18.3.1 A schedule of End term examinations be prepared by the Examination Section and displayed at the departments at least one-month ahead of the conduct of the examination.
18.3.2 No student who has less than 75% attendance in any course shall be permitted to attend the end-semester examination and s/he shall be given grade of FA-failure due to lack of attendance. S/He shall be asked to repeat that course the next time it is offered.

18.4 Conduct of End-Semester Exams and Evaluation

18.4.1 End-Semester Examination shall be conducted by the University by inviting Question Papers from the External Examiners except for the Foundation courses/Seminars/Skill based training/ workshop courses.
18.4.2 An alternative Question paper should also be made available for any contingency.

18.5 Scheme of the End Semester question paper
18.5.1 All Question Papers for the End Semester will be set out of a maximum of 60 marks.
18.5.2 Question paper for each Core and Elective theory course with more than 2 credits will have three sections: Part A, B and C.
18.5.2.1 Part A (Maximum 9 marks) will have 9 questions of 1 mark each, all of which must be attempted by the candidate. This part will have at least three questions set from each unit of the course contents of the paper. Word limit for the answers is 20 only.
18.5.2.2 Part B (Maximum 15 marks) of the question paper will have 5 compulsory questions. A minimum of 1 question will be asked from each unit of the course content. Each question will carry 3 marks. Word limit for the answer is 50 only.
18.5.2.3 Part C (Maximum 36 marks) will have a total of 3 questions, one from each unit of the course content. Each question will carry 12 marks and will have one choice from the same unit. Word limit for the answer to each question is 400 only.
18.5.3 The answer books of end-term examination (theory) should be evaluated by the External Examiner except for the Foundation courses/seminars/skill based training/workshop based courses.

18.6 **The Foundation Course** must be assessed by the examiner nominated by the Head of the Department concerned.

18.7 **Practical examinations**: There will be a panel of examiners consisting of one external and one internal examiner.
18.7.1 Following shall be the distribution of marks in practical courses:

S. No.	Item	Maximum marks
1	Experimental work assigned during examination	50
2	Attendance	10
3	Record	20
4	Viva voce	20

18.8 **Short term projects**: A panel of examiners consisting of one external (a faculty from the departments of MDS University, other than that of the DoM/faculty from local institutions/institutions from other cities) and one internal examiner (faculty from the DoM) must evaluate short term projects. Following shall be the distribution of marks for the short-term projects:

S. No.	Item	Maximum marks
1	Project report	60
2	Attendance	10
3	Viva voce	30

18.9 **Project work/dissertation**: Evaluation of project work/dissertation shall be done by a panel of examiners consisting of one external and one internal expert. Project will be evaluated based on regularity (attendance and reporting work, Groundwork/Review of Literature, plan of work, conduction of experiments, presentation of data, analysis of data, presentation of weekly reports, report writing, presentation skills etc.).

18.10 Skills taught through workshops/trainings
18.10.1 Only those showing 100% attendance will be assessed.
18.10.2 A student will be assessed by the coordinator of the training/workshop on one or combined basis of presentations (oral/poster/write-ups/report) or oral/written quiz out of a maximum of 100 marks and graded as per the CBCS norms.
18.10.3 The system of assessment must be informed to the participants prior to the start of the course.

18.10.4 The grades will be informed by the Head of the Department along with the title of workshop/training to the Controller of Examinations for inclusion in the grade-sheet of the student concerned.

19. Promotion

A student who registers for the end semester examination shall be promoted to the next semester on the basis of an undertaking that if s/he fails in the previous semester, his/her admission shall be treated as canceled.

20. Consolidation of Marks

20.1 The Head of the Department must send the list of the consolidated awards for In-term continuous assessment of each course and awards for seminars and creditable skill based workshops/training to the examination section. The examination section shall consolidate the marks of the In-term and End-Term Assessment and prepare a consolidated Statement of Marks.
20.2 In order to declare the pass, a Student should get a minimum of 40% marks in the aggregate of In-term and End-term assessment.
20.3 A candidate who has successfully completed all the Core courses in a semester and accumulated not less than minimum number of credits prescribed shall be eligible to receive the Certificate/Diploma/Advanced Diploma/Degree.

21 Due Courses

21.1 Any student who has failed in a maximum of three courses may be allowed to keep the term provided s/he meets the attendance requirement and has a minimum of 40% marks in in-term continuous assessment.
21.2 S/he may be permitted to register for the end-semester examination in the semester in which the course is offered next.
21.3 Only one attempt will be allowed for the end term examination of due courses in which a student has failed.
21.4 Students who have failed due to insufficient attendance and/or less than 40% marks in in-term continuous assessment should repeat the course as and when it is offered. However s/he will be considered fail if the number of courses where s/he has failed due to attendance or the number of courses in which s/he has failed is more than two.

25 Grading and Grade Card

The Examination Section shall prepare two copies of the results, one with marks to be sent to the Department and another for the University Office, not later than 15 days after the last day of semester examinations.
25.1 In this system, **grade Point** is a numerical weight allotted to each letter grade on a 10-point scale. **Credit Point** is the product of grade point and number of credits for a course and **Letter Grade** is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P, F and FA.
25.1.1 Performances of students in each course are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to the nearest integer. The class interval for the purpose of awarding the grades can be arrived at by dividing the difference between the highest mark secured and the minimum pass mark by 7 as there are seven passing grades. The formula is given below:

$K = (X-40)/7$

Where, K = class interval, X= the highest mark in the subject.

25.1.2 The grades will be awarded as shown in the following table:

Range of Marks in %	Letter Grade	Points for Calculation of GPA/ CGPA
X to (X-K)+1	O	10
(X-K) to (X-2K)+1	A+	9
(X-2K) to (X-3K)+1	A	8
(X-3K) to (X-4K)+1	B+	7
(X-4K) to (X-5K)+1	B	6
(X-5K) to (X-6K)+1	C	5

(X-6K) to 40	P	4
Below 40	F	0
Failure due to lack of attendance	FA	0

25.1.3 K should not be rounded off to less than two decimal places. The numbers given in Range of Marks column, (X-K), (X-2K), (X-3K), etc., can be rounded off to the nearest whole number.
25.1.4 Absolute grading may be done as below in courses where the number of students registered is less than 10.

Range of Marks in %	**Letter Grades**	**Points for Calculation of GPA/ CGPA**
81-100	O	10
71-80	A+	9
66-70	A	8
61-65	B+	7
56-60	B	6
50-55	C	5
40-50	P	4
<40	F	0
Failure due to lack of attendance	FA	0

25.1.5 The GPA and CGPA will be calculated as weighted average of points secured by the student in all the courses registered by him/her. The weights are the number of credits for each course. For example, a student getting an A+ grade in 4 credit course, A grade in 2 credit course, O grade in a 3 credit course and F grade in a 3 credit course will have a GPA as (9x4 + 8 x 2 +10 x 3 + 0x3)/(4+2+3+3)=(36+16+30+0)/12=82/12 = 6.83 out of 10.0; GPA = 6.83. The CGPA shall also be calculated on similar lines taking all subjects taken by the students in all semesters.
25.1.6 Students with a CGPA of 9.0 and above and who did not fail in any of the courses taken by him/her shall be awarded Distinction.
25.1.7 A CGPA of 6.0 and above shall be placed in First class.
25.1.8 Students who have secured less than 40% marks in any course get F Grade and will be treated as a failure in that course.
25.1.9 A candidate who has successfully completed all the Core courses in a semester and accumulated not less than the minimum number of Credits prescribed shall be eligible to receive the Certificate/Diploma/Advanced Diploma/Degree.

26. Conditions for the Award of the Degree/Diploma/Certificate
26.1 In case a student admitted to the Program opts out of the program after successful completion of -

- 22 credits of Semester I, he/she will be awarded PG Certificate in Molecular Biology
- 44 credits of Semester I and II he/she will be awarded PG Diploma in Molecular Biology & Biotechnology
- 66 credits of Semester I, II and III, he/she will be awarded Advanced PG Diploma in Biotechnology
- 88 credits till Semester I, II, III and IV, M.Sc. in Biotechnology

26.2 Students opting out with the PG Certificate/PG Diploma/Advanced PG Diploma may be permitted to get entry into the Program within a maximum period of two years to complete their master's degree.

29. Grade Card
29.1 The University Office shall issue a Grade card for the students containing the marks and grades obtained by the student in the previous semester and Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA).
29.2 For the conversion of grade points to percentage of marks, the following formula shall apply: Percentage of Marks= GPAx9.5.