MAHARSHI DAYANAND SARASWATI UNIVERSITY,
AJMER

पाठ्यक्रम

SYLLABUS

SCHEME OF EXAMINATION AND
COURSES OF STUDY

FACULTY OF SCIENCE

M.Sc. Microbiology

(Modular Choice Based Credit System)

M.Sc. (Semester I & II)

(w.e.f. 2015-16)

M.Sc. (Semester III & IV)

(w.e.f. 2016-17)

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NOTICE

1. Change in Statutes/Ordinances/Rules/ Regulations Syllabus and Books may, from time to time, be made by amendment or remaking, and a candidate shall, except in so far as the University determines otherwise comply with any change that applies to years he has not completed at the time of change. **The decision taken by the Academic Council shall be final.**

सूचना

1. समय-समय पर संशोधन या पुन: निर्माण कर परिनियमों/ अध्यादेशों/नियमों / विनियमों / पाठ्यक्रमों व पुस्तकों में परिवर्तन किया जा सकता है, तथा किसी भी परिवर्तन को छात्र को मानना होगा बशर्ते कि विश्वविद्यालय ने अन्यथा प्रकार से उनको छूट न दी हो और छात्र ने उस परिवर्तन के पूर्व वर्ष पाठ्यक्रम को पूरा न किया हो। **विद्या परिषद द्वारा लिये गये निर्णय अन्तिम होंगे।**

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Name of the Program of Study: M.Sc. Microbiology

1. **Programme 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 PG Diploma in Applied Microbiology
d. Minimum 4 Semesters for M.Sc. in Microbiology
2. **Minimum Eligibility Conditions:** B.Sc./B.Sc. (Hons)/B.Sc. B.Ed. in any discipline of biology or B.Sc. (Ag) with min. 50% marks
3. **Relaxation in Minimum Qualifying Marks for** the SC, ST and Persons with Disabilities Categories: 5%
4. **Criteria for Selection of Students for Admission:** Merit list as per the rules in Prospectus
5. **Credit Requirements:**
   a. 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 form a single program of study other than M.Sc. Microbiology) and 70% (56 credits) being core courses. Core courses include 4 L credits of Foundation courses (Compulsory and elective). Of the remaining 52 core credits, one short term project (3P) will have to be done in each of the first three semesters, and one long term project work/dissertation (10 credits) in the fourth semester.
   b. The maximum number of credits that a student may earn in a Semester shall not exceed 36 hours of teaching, and he/she shall be required to register for such number of courses accordingly.
6. **Conditions for the Award of Degree/Diploma/Certificate:**

6.1 In case a student admitted to the Programme opts out of the Programme after successful completion of minimum
20 credits of Semester I, he/she will be awarded PG Certificate in Basic Microbiology
40 credits of Semesters I and II he/she will be awarded PG Diploma in Advanced Microbiology
60 credits of Semesters I, II and III, he/she will be awarded Advanced PG Diploma in Applied Microbiology
80 credits of Semesters I, II, III and IV, he/she will be awarded M.Sc. in Microbiology

6.2 Students opting out with the PG Certificate/PG Diploma/Advanced PG Diploma may be permitted to get lateral entry into the Programme within a period of maximum two years to complete their Master's Degree.

6.3 There is a provision of Certificate of specialization or skills learnt which would be given away to a student by the Dean PG Studies for the University teaching departments (UTDs) on the recommendation of the Council of the Department of Microbiology, if a minimum of 9 credits have been completed by the student in a specific skill or field of specialization.

Courses offered in M.Sc. Microbiology
Foundation Courses

Department of Microbiology offers following Foundation Courses, all of which are elective:
FOO 421 Microorganisms and Health (1L) (1h/week)

FOO 422 Hygiene (1L) (1h/week)
FOO 423 Scientific Writing (1L) (1h/week)
These courses will be available in all semesters, however they will be offered on the basis of availability of free time with the faculty.

Semester I
Core Courses: (12L +4P = 24H)
MIC 401Sk. Essentials of Microbiology (3L) (3h/week)
MIC 402. Diversity of Prokaryotes (3L) (3h/week)
MIC 403. Biochemistry (4L) (4h/week)
MIC 404. Molecular Biology I (2L) (2h/week)
MIC 405 S Sk. Short term Project (1P) (3h/week)
MIC 406 Sk. Microbiological Techniques (3P) (9h/week)

Elective Courses for Semester I and III
MIC 421 Sk. Biochemistry & Molecular Biology (2P) (6h/week)
MIC 422. Diversity of Eukaryotic Microorganisms (4L) (4h/week)
MIC 423 Medical Microbiology (4L) (4h/week)
MIC 424 Sk. Virology (2L) (2h/week)
MIC 430 Sk Microbiology of wastes and Waste Remediation (3L) (3h/week)
MIC 431 Sk Industrial Microbiology (4L) (4h/week)
MIC 432 Sk Geomicrobiology & Agricultural Microbiology (4L + 2P) (10h/week)
MIC 433 Energy and Alternative Energy (1L) (1h/week)

A student has to opt courses of minimum 20 credits in this semester, if s/he drops after successful completion of minimum 20 credits in 1st semester s/he will be awarded PG Certificate in Basic Microbiology

Semester II
Core Courses: (10L + 4P = 22h)
MIC 407 Microbial Physiology & Development (4L) (Pre-requisite: MIC 403) (4h/week)
MIC 408 Molecular Biology II (Pre requisite: MIC 404) (2L) (2h/week)
MIC 409 Microbial Ecology & Biology of Extremes (4L) (4h/week)
MIC 410 S Sk. Short term Project (1P) (3h/week)
MIC 411 Sk Physiology and Ecology (3P) (9h/week)

Elective Courses for Semesters II & IV
MIC 425 Immunology (4L) (4h/week)
MIC 426 Sk Bioprocess Engineering (4L + 2P) (10h/week)
MIC 427 Sk Biofuel & Bioenergy (3L+2P) (9h/week)
MIC 428 Sk Food Microbiology (3L + 2P) (9h/week)
MIC 429 Sk Enzymology (Pre-requisite: MIC 403) (3L) (3h/week)
MIC 434 Sk Bionformatics (Pre-requisite MIC 404, 408) (4L= 4h/week)
MIC 435 Biostatistics & Computational Biology (4L) (4h/week)

A student has to opt courses of minimum 20 credits in this semester. 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.

Semester III
Core Courses: (8L+4P = 20h)
MIC 412 Sk Synthetic Biology (4L) (4h/week)
MIC 413 Microbial Genetics (4L) (4h/week)
MIC 414 S Sk Short term Project (1P)

MIC 415 Sk Applied Microbiology & Molecular Biology (3P) (9h/week)

Elective Courses for Semester I and III
MIC 421 Sk. Biochemistry & Molecular Biology (2P) (h/week)
MIC 422. Diversity of Eukaryotic Microorganisms (4L) (4h/week)
MIC 423 Medical Microbiology (4L) (4h/week)
MIC 424 Sk. Virology (2L) (2h/week)
MIC 430 Sk Microbiology of wastes and Waste Remediation (3L) (3h/week)
MIC 431 Sk Industrial Microbiology (4L) (4h/week)
MIC 432 Sk Geomicrobiology & Agricultural Microbiology (4L + 2P) (10h/week)
MIC 433 Energy and Alternative Energy (1L) (1h/week)

A student has to opt courses of minimum 20 credits in this semester. If s/he drops after successful completion of minimum 60 credits by the end of Semester III, s/he will be awarded Advanced PG Diploma in Applied Microbiology.

Semester IV
Core Course: (10P= 25H workload and 10h teaching load)
MIC 500L Sk Project Work /Dissertation (10 P= 25h per week)

Elective Courses for Semesters II & IV
MIC 425 Immunology (4L) (4h/week)
MIC 426 Sk Bioprocess Engineering (4L + 2P) (10h/week)
MIC 427 Sk Biofuel & Bioenergy (3L+2P) (9h/week)
MIC 428 Sk Food Microbiology (3L + 2P) (9h/week)
MIC 429 Sk Enzymology (Pre-requisite: MIC 403) (3L) (3h/week)
MIC 434 Sk Bionformatics (Pre-requisite MIC 404, 408) (4L= 4h/week)
MIC 435 Biostatistics & Computational Biology (4L) (4h/week)

A student has to opt courses of minimum 20 credits in this semester. Successful completion of minimum 80 credits on completion of Semester IV will earn a student the degree of Master of Science in Microbiology.

Certificate of specialization for skills learnt

Any student completing successfully a set of specified courses will be eligible for a Certificate of specialization as depicted below:

Specialization in Biochemistry and Physiology of Microorganisms
All of the following courses:
MIC 403. Biochemistry (4L)
MIC 421 Sk. Biochemistry & Molecular Biology (2P)
MIC 407 Microbial Physiology & Development (4L)
MIC 411 Sk Physiology and Ecology (3P)

Specialization in Microbiology of Extremes
All of the following courses:
MIC 402. Diversity of Prokaryotes (3L)
MIC 403. Biochemistry (4L)
MIC 407 Microbial Physiology & Development (4L)
MIC 422. Diversity of Eukaryotic Microorganisms (4L)
MIC 409 Microbial Ecology & Biology of Extremes (4L)
MIC 411 Sk Physiology and Ecology (3P)
MIC 421 Sk. Biochemistry & Molecular Biology (2P)

Specialization in Microbial Diversity and Ecology
Courses including MIC 402. Diversity of Prokaryotes (3L) and MIC 409 Microbial Ecology & Biology of Extremes (4L) **with minimum 9 credits from the following:**
MIC 422. Diversity of Eukaryotic Microorganisms (4L)

MIC 424 Sk Virology (2L)
MIC 432 Sk Geomicrobiology & Agricultural Microbiology (4L + 2P)
MIC 411 Sk Physiology and Ecology (3P)
Specialization in Molecular Biology
Minimum 9 credits from the following:
MIC 421 Sk. Biochemistry & Molecular Biology (2P)
MIC 425 Immunology (4L)
MIC 434 Sk Bionformatics (4L)
MIC 415 Sk Applied Microbiology & Molecular Biology (3P)
Specialization in Environmental Microbiology & Biotechnology
Courses including MIC 430 Sk Microbiology of Wastes and Waste Remediation (3L) **with minimum 9 credits from the following:**
MIC 433 Energy and Alternative Energy (1L)
MIC 432 Sk Geomicrobiology & Agricultural Microbiology (4L + 2P)
MIC 426 Sk Bioprocess Engineering (4L + 2P)
MIC 427 Sk Biofuel & Bioenergy (3L+2P)
MIC 435 Biostatistics & Computational Biology (4L)
Specialization in Industrial Microbiology & Biotechnology
MIC 426 Sk Bioprocess Engineering (4L + 2P) **and minimum 5 credits of the following:**
MIC 431 Sk Industrial Microbiology (4L)
MIC 429 Sk Enzymology (Pre-requisite: MIC 403) (3L)
MIC 435 Biostatistics & Computational Biology (4L)
MIC 427 Sk Biofuel & Bioenergy (3L+2P)
MIC 428 Sk Food Microbiology (3L + 2P)
MIC 430 Sk Microbiology of wastes and Waste Remediation (3L)
Specialization in Biofuel & Bioenergy
Courses including MIC 433 Energy and Alternative Energy (1L). MIC 427 Sk Biofuel & Bioenergy (3L+2P) **with minimum one of the following:**
MIC 426 Sk Bioprocess Engineering (4L + 2P)
MIC 435 Biostatistics & Computational Biology (4L)
Specialization in Medical Microbiology
MIC 423 Medical Microbiology (4L) **with minimum 6 credits from the following:**
MIC 424 Sk. Virology (2L)
MIC 425 Immunology (4L)
MIC 435 Biostatistics & Computational Biology (4L)

Detailed course outline of Courses offered at the Department of Microbiology for PG Students

Foundation Courses

FOO 421 Microorganisms and Health (1L) (1h/week)

Section A (4 L)

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, Zica, West Nile Virus

Section C (5L)

Germs and terror. Prevention of infections. Vaccines and vaccine schedules. Return

of the old fear: Antibiotic resistance

FOO 422 Hygiene (1L) (1h/week)

Section A (3L)

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

Section B (4L)

Hygiene at home. Kitchen and Food industry hygiene, restaurant, food parlours, and street food, Workplace hygiene, Hygiene during travel, at hotel and office, hospital

Section C (8L)

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

FOO 423 Scientific Writing (1L) (1h/week)

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 look for answers. Writing funding proposals. Presenting results; Tabulation and Graphs

Section B (5L)

Journals and their types. Scientific paper. Writing title, Aostract, Introduction, Material and Methods. Writing Results and Discussion. Acknowledgements. Citing references. Preparing tables and illustrations. Applying patents

Section C (7L)

Submission and review of paper.
Writing a review paper, Conference report, Book review and Thesis.
How to present a paper orally. Preparing a poster. Research at Microbiology Department of MDS University Ajmer

CORE COURSES

Semester I

MIC 401 Sk Essentials of Microbiology (3L) (3h/week)

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 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 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 finger printing 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. Spriger-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. Mc Graw Hill.

Websites

1. Life in a drop of water. http://www.youtube.com/watch?v=_epBK2t0Yeo
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 402. Diversity of Prokaryotes (3L) (3h/week)

Section A Archaea and Chemonutotrophs

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*. Spirocahetes. Rickettsia Chlamydias. Myxobacteria.

Section B Gram positive Bacteria and Mollicutes

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. Mc Graw 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 403 Biochemistry (4L) (4h/week)

Section A Instrumentation and 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.

Instrumentation: Centrifugation, Colorimetry, Photometry, Nephelometry, Vis, UV-Vis and IR spectroscopy, Flame photometry. Electrophoresis, Chromatography: PC, TLC, Column chromatography, GC and HPLC.

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, carragenan, 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, gangliosdies, 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 polynucelotides. 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. Brwon, Oxford.
3. Lehninger 2000. Principles of Biochemistry. 3/e. Nelson and Cox (Worth) Pub.
4. Harper's Biochemistry 1999. Mc Graw Hill.

MIC 404. 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 relationship with function. Initiator and elongator class of tRNA, ribosome binding site on mRNA and corresponding site on rRNA, peptidyltransferase 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 405 S Sk. Short term Project (1P) (3h/week)

Students will be given basic experimental work to achieve specific goal so as to

acquaint him/her with the handling of microorganisms.

MIC 406 Sk. Microbiological Techniques (3P) (9h/week)

Experiments based on MIC 401, 402 and 422

Semester II

MIC 407 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 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 di oxide. Calvin cycle, C3, C4 pathway. Chemolithotrophy-Sulfur, iron, hydrogen, nitrogen oxidations. Methanogenesis. Luminiscence. Brief account of photosynthetic and accessory pigments-chlorophyll, bacteriochlorophyll, rhodopsin, carotenoids, phycobilliproteins. 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 408 Molecular Biology II (Pre requisite: MIC 404) (2L) (2h/week)

Section A Regulation of gene expression

Control of transcription by interaction between RNA polymerases and promoter regions, use of alternate 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, Zippursky Molecular Cell Biology. (WH Freeman)
5. Matsudaira, Baltimore, Darnell 4th edition 2000

MIC 409 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 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, their microbial diversity. Saline playas of Rajasthan and their microbial diversity.

Physiological and molecular mechanisms to tolerate desiccation, salt stress, cold, heat and radiations. 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 410 S Sk. Short term Project (1P) (3h/week)

Students will be given basic experimental work to achieve specific goal so as to acquaint him/her with the handling of microorganisms.

MIC 411 Sk Physiology and Ecology (3P) (9h/week)

Experiments based on MIC 407 & 409

Semester III

MIC 412 Sk Synthetic Biology (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 cloningstrategies viz. blunt end cloning, directional cloning, TA-cloningof 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-Labelling (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 Livesey 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 Differen. 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 413 Microbial Genetics (4L) (4h/week)

Section A Mutation, Plasmids & Transposons

Molecular basis of spontaneous and induced mutations, Types of mutations: point, frame shift, 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, nonreplicative 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-transmissable 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. Lamda 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 414 S Sk Short term Project (1P)

Students will be given basic experimental work to achieve specific goal so as to acquaint him/her with the handling of microorganisms.

MIC 415 Sk Applied Microbiology & Molecular Biology (3P) (9h/week)

Experiments based on MIC 412, 413, 423, 425, 430 & 431

Semester IV

MIC 500L Sk Project Work /Dissertation (10 P)

Ten credits (30 hour/week each) of workload such as independent individual/group work, obligatory / optional work placement: field work: project work/ dissertation, which will be equivalent to 10 credits (10h/week) workload for the advisor teacher. Details are as below:

S. No.	Course	Credits (batch limit 10 students)	Student workload (h/week)
1	Ground work (Review of literature)	1	1.5
2	Plan of work	1	1.5
3	Conduction of Experiments		14
4	Presentation of data	1	1.5
5	Analysis of data	2	2
6	Presenting weekly reports (20 min seminars+5min discussion)	1	1
7	Report Writing	1	1.5
8	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper	1	1
9	Popular writing on social/scientific issues/ awareness/presenting on public platform	2	1
	Total (1-9)	10	25

Content of Elective Courses

Semester I & III

MIC 421 Sk. Biochemistry & Molecular Biology (2P) (h/week)

Safety norms

Handling of instruments: pH meter, Flame Photometer, Colorimeter, Vis and UV-vis Spectrophotometer, FTIR Spectrometer, Electrophoresis units, Centrifuge, GC, HPLC.

Experiments to learn techniques in biochemistry and molecular biology.

MIC 422. 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. Mc Graw Hill.

MIC 423 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 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 details 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, hypal 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 pathogenecity – cytoskeletal modulation of host cell, virulence genes and pathogenecity 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, Small pox, 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, gonorrhoea, 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. Ananthnarayanan 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

MIC 424 Sk. 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 Ricketssial diseases. American Public Health Asso., New York.
7. Hayes W. 1985. The genetics of Bacteria and their viruses. Blackwell Scientific Publishers, London.

MIC 430 Sk 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. Eldowney Ec S., Hardman DJ, and Waite S 1993. Pollution: Ecology and biotretament. Longman Scientific Technical.
3. Baker KH and Herson DS 1994. Bioremediation. Mc Graw 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. Environmental Microbiology
8. Indu Shekhar. Environmental Biotechnology
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. Waste Water 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. Mac Graw Hill.
24. Dart. R.K. and Shettron R.J. 1980. Microbiological aspects of pollution control. 2 ed.

Websites

EPA Microbiology Resources. http://www.epa.gov/nerlcwww/microbes/epamicrobiology.html

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

MIC 431 Sk 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, quinolinones). 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.I. 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. Clifflon (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. Duncun
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 Wiseman

MIC 432 Sk Geomicrobiology & Agricultural Microbiology (4L+ 2P) (10h/week)
The course is divided into two papers, Part I Theory and Part II Practical.

Part I Theory

Section A Geomicrobiology

Atmosphere and its microbiology. Geomicrobiology: Basic concepts in Biogeocemical 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, deeps 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. Ground water contamination.

Part II Practical

Experiments based on part I of this course.

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. Vanghan 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. Eurasia Pub. House (P.) Ltd. New Delhi.
10. Michel R. 1999. Introduction to environmental microbiology.
11. Atlas & Bartha. Microbial Ecology
12. Mayer & Mayer. Environmental Microbiology
13. Indu Shekhar. Environmental Biotechnology
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 Microbiology Resources. http://www.epa.gov/nerlcwww/microbes/epamicrobiology.html
EPA Microbiology Home Page http://www.epa.gov/nerlcwww/index.html

MIC 433 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.

Content of Elective Courses
Semesters II and IV

MIC 425 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. Alphafoetal proteins, Carcinoembryonic antigen.

Section C

Immune tolerance and autoimmunity. Immunosuppression-Specific, nonspecific. Autoimmunity-theories, mechanism 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. Essential 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/

MIC 426 Sk Bioprocess Engineering (4L + 2P) (10h/week)

The course is divided into two parts, Part I Theory and Part II Practical.

Part I Theory

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 gases.

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 process 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 cycle 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 system, problems associated with strain improvement program, improvement of characters other than products and its application in the industry.

Preservation of cultures.

Part II Practical

Experiments based on part I of this course.

Books:

1. Principles of Fermentation Technology by Stanbury. P.F., Whitekar A. and Hall. 1995., Pergaman. McNeul 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, Sinaeur 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: Down stream 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.

MIC 427 Sk Biofuel & Bioenergy (3L+2P) (9h/week)

The course is divided into two parts, Part I Theory and Part II Practical.

Part I Theory

Section A

Biomass for energy. Calorific value and its estimation. Co-generation of energy. Alternatives as biofuels: Alkanes, Biobutanol, bioethanol, biomethanol, biodiesd, 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. Lignocelluosics hydrolysis, Fermentation of pentoses and other issues in bioethanol production form lignocellulosics.

Section B

Global biodiesel scenario. Oil crops. Wastewater remediation and biomass generaton for biofuel purposes. Commercialized microalgae (*Spirulina, Dunaliela,*

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.

Part II Practical

Experiments based on part I of this course.

MIC 428 Sk Food Microbiology (3L + 2P) (9h/week)

The course is divided into two parts, Part I Theory and Part II Practical.

Part I Theory

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 manufacture 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, Butter milk, Sour cream, Youghurt, 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.

Part II Practical

Experiments based on part I of this course.

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. Banwari 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

MIC 429 Sk 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-Nuegaekkus-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 transcarbamylase, 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.

MIC 434 Sk Bionformatics (Pre-requisite MIC 404, 408)

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 Livesy 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

MIC 435 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, statistic. 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 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. Hardlaw A.C. 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. Waardlaw (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). Vishva Prakashan, 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 Imalaya Publishing House, Mumbai.
18. Sokal & Rohlf (1973). Introduction to Biostatistics, Toppan Co. Japan.
19. Stanton A & Clantz, Primer of Biostatistics (2005). The McGraw Hill Inc., New York

9 Assessment and Evaluation

9.1 Breakup of Internal/External End Semester Examinations

9.1.1 All subjects in a PG programme shall carry an Internal Assessment component to the extent of 40% marks and End Semester for 60% marks. For UG programs it should be 30% marks internal and 70% marks for external.

9.1.2 In case of Laboratory/Field/Project work based subjects, appropriate distribution of marks for Practical Record/Project Report, Practical end-Semester exam, Viva, etc., if any shall be made by the respective Committee of Courses/Board of Studies.

9.1.3 A student shall not be permitted to repeat any course only for the purpose of improving the grade.

9.2 Breakup of Internal/Continuous Assessment Marks

9.2.1 Each teacher 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	Internal Assessment Tests/Term Papers/Quizzes (two) 1 x 30 or 2 x15	30
2	Seminars/Assignments/Case Demos/Presentations/Write ups/ Viva, etc.	10
	Total	40

9.2.2 It is mandatory for all students to participate in all the Internal Assessment tests and in various course-work related activities for award of the above marks. Therefore a schedule of Internal Assessment tests shall be prepared by the Course Leader and informed to the students at the very beginning of the semester.

9.2.3 Internal Assessment marks shall be displayed within a week from the date of conduct of examination and all corrected answer papers shall be given back to students with comments, if any.

9.3 End-semester examinations

9.3.1 An End Semester examination shall be conducted for all courses offered in the department. The duration of the end semester examination shall be for 3 hours.

9.3.2 All Papers except for those of the Foundation courses will be set and evaluated externally for a maximum of 60 marks. The papers for Foundation Course will be set and evaluated by the Course leader or an examiner appointed by the Head of the Department concerned. In case of a Foundation course that is not being run by any department, the Dean of the faculty may appoint the examiner. A minimum of 22 marks will be required to pass in the paper.

9.3.2.1 Question paper for each Core and Elective theory paper will have three sections: Part A, B and C.

b. 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.

c. 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 of the paper. Each question will carry 3 marks. Word limit for the answer is 50 only.

d. Part C (Maximum 36 marks) will have total 3 questions, one from each unit of the course content of the paper. 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.

9.3.3 A schedule of End Semester examinations be prepared by the Examination Section and displayed at the departments at least one-month ahead of the conduct of the examination.

9.3.4 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.

9.4 Conduct of End-Semester Exams and Evaluation

9.4.1 End-Semester Examination shall be conducted by the University by inviting Question Papers from the External Examiners.

9.4.2 An alternative Question paper should also be made available for any contingency.

9.4.3 The scheme of the paper must be as has been stated at 9.3.1 and 9.3.2

9.4.4 The answers papers of end-semester examination (theory) should be evaluated by the External Examiner.

9.4.5 For practical examinations, there will be a panel of examiners consisting of one external and one internal examiner.

Following shall be the distribution of marks in practical courses or the Board of Studies/Committee of Courses may modify it as per their requirements:

S. No.	Item	Maximum marks
1	Experimental work assigned during examination	60
2	Record	20
3	Viva voce	20

9.4.6 A panel of examiners consisting of one external (a faculty from the departments of MDS University, other than department of microbiology/faculty from local institutions/institutions from other cities) and one internal examiner (faculty from the department of microbiology) must evaluate short/medium term projects. Following shall be the distribution of marks for the short term projects or the Board of Studies/ Committee of Courses may modify it as per their requirements:

S. No.	Item	Maximum marks
1	Project report	70
2	Viva voce	30

9.4.7 Evaluation of long term projects/dissertation/research work shall also be done by the panel of examiners consisting of one external and one internal expert. Distribution of Marks for the evaluation of Long term projects may be as below or the Board of Studies/Committee of Courses may modify it as per their requirements:

S. No.	Item	Max Marks
1	Ground work/Review of literature	5
2	Plan of work	5
3	Conduction of Experiments	5
4	Presentation of data	5
5	Analysis of data	10
6	Presenting weekly reports (20 min seminars+5min discussion)	20
7	Report Writing	5

8	Presentation as Seminar (8 min+2 min discussion) and Presentation as Poster Paper	10
9	Popular writing on social/scientific issues/awareness/presenting on public platform	5
10	Presentation of seminar (10 min) in front of examination panel (One external, one internal)	10
11	Viva Voce	20
	Total (1-9)	100

10 Consolidation of Marks

10.1 The Head of the Department must send the award list of the internal assessment to the examination section. The examination section shall consolidate the Internal Assessment marks and End-Semester marks (average of both Internal and External Evaluation) and prepare a consolidated Statement of Marks.

10.2 In order to declare the pass, a Student should get a minimum of 40% marks in aggregate of Internal Assessment and End-Semester marks.

11 Supplementary Examination

11.1 A failed student who meets the attendance requirement and has a minimum of 40% in internal assessment marks may be permitted to register for the next end-semester examination in the semester in which the course is offered next.

11.2 Students who have failed due to insufficient attendance and/or less than 40% in the total of Internal Assessment and end term examination should repeat the course as and when it is offered.

12 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.

12.1 Letter Grades

24.1.1 Performances of students in each paper are expressed in terms of marks as well as in Letter Grades. In case of fractions the marks shall be rounded off to 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.

12.1.2 The grades may be awarded as given 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

12.1.3 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.

12.1.4 In courses where the number of students who have secured 40 marks and above is less than 10 then grading may be given based on the Table

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

12.1.5 The GPA and CGPA will be calculated as weighted average of points secured by the student in all the papers registered by him/her. The weights are the number of credits for each paper. 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 + 8x2 +10x3 + 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.

12.1.6 Student 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.

12.1.7 A CGPA of 6.0 and above shall be placed in First class.

12.1.8 Student who has secured less than 40% marks in any paper gets F Grade and he is treated as failed in that paper.

13. Grade Card

13.1 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) (Proforma VI).

13.2 The grade card shall list:

The title of the courses taken by the student.
The credits associated with the course.
The marks and grade secured by the student.
The total credits earned by the student in that semester
The GPA of the student.
The total credits earned by the students till that semester.
The CGPA of the student.

14. Conditions for the Award of the Degree/Diploma/Certificate

14.1 In case a student admitted to the Programme opts out of the Programme after successful completion of

- Semester I, he/she will be awarded PG Certificate in Basic Microbiology
- Semester II he/she will be awarded PG Diploma in Microbiology
- Semester III, he/she will be awarded Advanced PG Diploma in Applied Microbiology
- Semester IV, M.Sc. in Microbiology

14.2 Students opting out with the PG Certificate/PG Diploma/Advanced PG Diploma may be permitted to get lateral entry into the Programme within a maximum period of two years to complete their Master's Degree.

14.3 There will be a provision of Certificate of specialization or skills learnt which would be given away to a student by the Dean PG Studies for the University teaching departments (UTDs) on the recommendation of the Departmental Council of the UTDs, if a minimum of 9 credits have been completed by the student in a specific skill or field of specialization.

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