Department of Microbiology

Syllabus

M.Sc Microbial Biotechnology

Maharshi Dayanand University
Rohtak 124001

Choice Based Credit System

Examination scheme of M.Sc. Microbial Biotechnology (Semester system) w.e.f. the academic session 2011-12

S. No	Course No.	Title	Type	L	T	P	Credits	Marks Th.	Marks Int. Ass.
FIRST SEMESTER									
1.	MBT-101	General Microbiology	CP	4	0	0	4	80	20
2.	MBT-102	Principles of Biochemistry	CP	4	0	0	4	80	20
3.	MBT-103	Microbial Metabolism	CP	4	0	0	4	80	20
4.	MBT-104	Basics of Microbial Biotechnology	CP	4	0	0	4	80	20
5.	MBT-105	Mycology and Phycology	PE	4	0	0	4	80	20
6.	P1-MBT	Microbiology, Biochemistry, Basics of Microbial Biotechnology, Microbial Metabolism and Mycology& Phycology Lab			0	5x4 =20	10	150	
Sub Total							**30**	**650**	
SECOND SEMESTER									
1.	MBT-201	Techniques in Microbial Biotechnology	CP	4	0	0	4	80	20
2.	MBT-202	Production of Microbial Biomass	CP	4	0	0	4	80	20
3.	MBT-203	Fundamentals of Microbial Remediation	CP	4	0	0	4	80	20
4.	MBT-204	Molecular Biology	CP	4	0	0	4	80	20
5.	MBT-205	Biostatistics and Bioinformatics	PE	4	0	0	4	80	20
6.	MBT-206	Seminar			0	0	1		50
7.	P2-MBT	Techniques in Microbial Biotechnology, Bioremediation, Biomass Production, Biostatistics & Bioinformatics and Molecular Biology Lab		0	0	5x4 =20	10	150	
Sub Total							**31**	**700**	
THIRD SEMESTER									
1.	MBT-301	Biochemical Engineering	CP	4	0	0	4	80	20
2.	MBT-302	Downstream Processing	CP	4	0	0	4	80	20
3.	MBT-303	Bioprocess Plant design	CP	4	0	0	4	80	20
4.	MBT-304	Microbial Metabolites	CP	4	0	0	4	80	20
5.	MBT-305	Genetic Engineering of Microorganisms	PE	4	0	0	4	80	20
6.	MBT-306	Communication Skills development	OE	2	0	0	2	50	00
7.	MBT-307	Seminar			0	0	1		50
8.	MBT-308	Self study paper*		0	0	0	1	Qualifying	
9.	P3-MBT	Biochemical Engineering, Genetic Engineering, Downstream Processing, Bioprocess plant design and Microbial Metabolites Lab		0	0	5x4 =20	10	150	
Sub Total							**34**	**750**	
FOURTH SEMESTER									
1.	MBT-401	Fermented Foods	CP	4	1	0	5	80	20
2.	MBT-402	Basic Virology	CP	4	1	0	5	80	20
3.	MBT-500	Dissertation		0	0	0	20	300	
Sub Total							**30**	**500**	
G. Total							**125**	**2600**	

***Grading: Excellent, Very Good, Good, Satisfactory, Unsatisfactory**

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)

MBT-101 General Microbiology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History of development of Microbiology; Development of fields of Microbiology in 20^{th} century; The spontaneous generation controversy; Germ theory of disease; Microbes and fermentation; Physical and chemical methods of sterilization.

Unit II

Binomial nomenclature; Haeckel's three kingdom classification; Woese's three kingdom classification systems and their utility – Archaea, Eubacteria, Eukarya; Organization of prokaryotic and eukaryotic cell; Cell Division Cycle in *E. coli* and Yeast; Different groups of acellular microorganisms-Viruses, Viriods.

Unit III

General characters of microorganisms- Bacteria, Algae, Fungi and Protozoa. Classification of bacteria; Bacterial growth and metabolism. Microbes in Extreme Environment – Special features of the thermophilic, methanogenic and halophilic archaea; Photosynthetic bacteria, Cyanobacteria; microbes in other extreme conditions – deep ocean, and space.

Unit IV

Scope of Microbiology- Cycle of matter in nature. Microbial interactions- mutualism, symbiosis, commensalisms, predation, parasitism, amensalism, competition, bioluminescence, biodegradation, biofilms. Cleaning oil spills, microbes in composting, landfills, biopesticides, bioremediation, bioleaching; SCP; Microbial enzymes and fermented foods. Human diseases and their causative agents. Definition of aeromicrobiology, air-borne pathogens and allergens Phytopathogenic bacteria: Angular leaf spot of cotton, crown galls, bacterial cankers of citrus. Diseases caused by Phytoplasmas: Aster yellow, citrus stubborn.

Suggested readings:

4. Brock TD., Milestones in Microbiology, Infinity Books.
5. Pelczar M.J., Chan E.C.S. & Kreig N.R., Microbiology: Concepts and Application.,Tata McGraw Hill.
3. Stainier RY, Ingraham JL, Wheelis ML & Painter PR General Microbiology. Publisher: MacMillan.
4. Madigan M.T., Martinko J.M. and Parker J., Brock Biology of Microorganisms: Prentice-Hall , Inc USA.
5. Atlas R.M., Principles of Microbiology, Wm C. Brown Publishers.
6. Vandenmark P.V. and Batzing B.L., The Microbes – An Introduction to their Nature and Importance: Benjamin Cummings.Microbiology.

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
MBT-102 Principles of Biochemistry

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Scope and importance of biochemistry; Fundamental principles governing life; Structure of water; Acid base concept and buffers; pH; Hydrogen bonding; Hydrophobic, Electrostatic and Vander Waals forces. General introduction to physical techniques for determination of structure of biopolymers.

Unit II

Classification, structure and function of carbohydrates; Biomembranes and lipids. Structure and function of amino acids and vitamins; Structure and function of proteins; Types of nucleic acid- their structure and functions.

Unit III

Enzymes classification, mechanism of action; Factors affecting enzyme action; Immobilized enzymes; Hormones; Thermodynamic principles and biological processes; Bioenergetics.

Unit IV

Metabolism of carbohydrates; photosynthesis and respiration; Oxidative phosphorylation; Lipids; Proteins and Nucleic acids; DNA replication; Transcription and Translation in Prokaryotes and Eukaryotes; Recombinant DNA technology.

Suggested readings:

1. Mathews C.K.,Van Holde K.E. and Ahern K.G., Biochemistry, Benjamin /Cummings.
2. Stryer L., Biochemistry. ,W.H. Freeman and Company.
3. Devlin's Textbook of Biochemistry with Clinical correlations. John Wiley and Sons Inc.
4. Lehninger A.L., Nelson D.L., Principles of Biochemistry, M.M. Cox. Worth Publishing.
5. Robert K., Murray M.D., Granner D.K., Mayes P.A. and Rodwell V.I. Harper's Biochemistry. McGraw-Hill/Appleton and Lange.

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
MBT-103 Microbial Metabolism

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Nutritional Categories of microorganisms based on carbon; energy and electron sources; Metabolite Transport: Diffusion: Passive and facilitated; Primary active and secondary active transport; Group translocation (phosphotransferase system) electro neutral transport; transport of Iron.

Unit II

Microbial Growth: Definition; salient features of growth curve; generation time; specific growth rate; batch and continuous culture; synchronous growth; diauxic growth curve. Measurement of cell numbers; cell mass and metabolic activity. Environment and microbial growth.

Unit III

Brief account of photosynthesis - oxygenic-anoxygenic photosynthesis; fixation of $C0_2$- Calvin cycle - C3-C4 pathway. Chemolithotrophy - sulphur - iron - hydrogen - nitrogen oxidations; methanogenesis; luminescence. Respiratory metabolism – Embden-Mayer Hoff pathway - Entner Doudroff pathway - glyoxalate pathway - Krebs cycle - oxidative and substrate level phosphorylation - reverse TCA cycle; homo and heterolactic fermentation.

Unit IV

Biosynthesis of peptidoglycan; Biosynthesis of biopolymers; Assimilation of nitrogen, sulpher, phosphorus etc.; Biosynthesis of amino acids, vitamins and nucleotides and their regulation.

Suggested readings

1. Doelle H.W. 1969. Bacterial Metabolism. Academic Press.
2. Gottschalk G. 1979. Bacterial Metabolism. Springer Verlag. Moat AG. 1979. Microbial Physiology. John Wiley & Sons.
3. Sokatch JR. 1969. Bacterial Physiology and Metabolism. Academic Press.
4. Moat A G., Foster J W., Spector M P. Microbial Physiology, 4th Ed: Wiley India Pvt Ltd 2009.

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
MBT-104 Basics of Microbial Biotechnology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit-I

Brief history of fermentation; Fermentation- general concepts, Applications of fermentation; Range of fermentation process- Microbial biomass, enzymes, metabolites, recombinant products, transformation process; Component parts of a fermentation process.

Unit-II

Types of fermentations- Aerobic and anaerobic fermentation, Submerged and solid state fermentation; Factors affecting submerged and solid state fermentation; Substrates used in SSF and its advantages; Culture media- types, components and formulations. Sterilization: Batch and continuous sterilization.

Unit-III

Process development, Optimization of a process, Classical and statistical methods of optimization, Immobilization: different matrices, whole cell and enzyme immobilization; Scale up of bioprocess General concept of a fermenter- Batch, fed-batch and continuous fermentation.

Unit-IV

Aeration and agitation- Effect of aeration and agitation on fermentation, Oxygen requirement and oxygen supply, Oxygen transfer kinetics; Determination of KLa value; Effect of agitation and microbial biomass on KLa value; Newtonian and non-Newtonian fluids; Foam and antifoams, their effect on oxygen transfer; Fermentation economics.

Suggested readings:

10. Stanbury, P. F., Whitaker and Hall, A. S. J., Principles of Fermentation Technology. Butterworth-Heinemann
11. Shuler, M.L. and Karg, I F., Bioprocess Engineering Basic Concepts , Prentice Hall.
12. Vogel, H.C. Todaro, C.L. and Todaro C.C., Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment, Noyes Data Corporation/ Noyes Publications.
13. Crueger W. and Crueger, A., Biotechnology. A Textbook of Industrial Microbiology, Sinauer Associates.
14. Reed, G., Prescott and Dunn's Industrial Microbiology, AVI publication
15. Casida L. E. J. R., Industrial Microbiology, New Age (1968)

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)
MBT-105 Mycology and Phycology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Introduction of algae: Occurrence and distribution, thallus structure, characteristics, nutrition, classification and reproduction. Introduction of fungi: Occurrence and distribution, somatic structure, hyphal growth, nutrition, heterothallism, sex hormones in fungi, physiological specialization in fungi, fungi and ecosystem; saprophytic parasitic, mutualistic and symbiotic relationship with plants and animals. Classification of fungi. Reproduction in fungi: asexual, sexual and parasexual.

Unit II

Study of the different classes with reference to occurrence, somatic structure and life cycle and economic importance representing the following genera: Acrasiomycetes (*Dictyosteluim*), Myxomycetes (Endosporus and exosporus), Chytridiomycetes (*Neocallimastrix*), Oomycetes (*Phytopthora*), Zygomycetes (*Rhizopus*), Ascomycotina (Hemiascomycetes- *Saccharomyces*, Plectomycetes - *Penicillium* Pyrenomycetes – *Xylaria*, Discomycetes - *Peziza*), Basidiomycotina (Hymenomycetes *Agaricus*, Teliomycetes - *Puccinia*), Deuteromycetes (*Alternaria*

Unit III

Algae as pollution indicators, eutrophication agent and role in bioremediation, algae in global warming and environmental sustainability,cyanobacteria and selected microalgae in agriculture- biofertilizer and algalization, importance of algae in production of algal pigments, biofuels, hydrogen production, important bioactive molecule.

Unit IV

Lichens: ascolichens, basidiolichens, deuterolichens, Mycorrhiza: ecto-, endo-, ectendo-, VAM, Fungi as insect symbionts, fungi as biocontrol agents, attack of fungi on other microorganisms, potential application in Agriculture, environment, industry, food. Role of fungi in Biodeterioration of wood, paper, textile. Myxotoxins, quorum sensing in fungi

Suggested Readings:

1. Alexopoulos, C.J. and C.W. Mims 1979. Introduction to Mycology (3rd Ed.) Wiley Eastern Ltd., New Del
2. Charlile M. & Watkinson S.C. The Fungi, Publisher: Academic Press.
3. E.Moore –Landeekeer: Fundamentals of the fungi, Publisher: Prentice Hall.
4. L. Barsanti, Paolo Gualtieri: Algae: anatomy, biochemistry, and biotechnology
5. Ayhan Demirbas, M. Fatih Demirbas: Algae Energy: Algae as a New Source of Biodiesel (2010)
6. Linda E. Graham, James Graham, James M. Graham: Algae (2009)
7. Burnett J.H., Publisher: Edward, Arnold Crane Russak: Fundamentals of Mycology

M.Sc. (Microbial Biotechnology)
(SEMESTER-I)

P1-MBT: Microbiology, Biochemistry, Basics of Microbial Biotechnology, Microbial Metabolism and Mycology&Phycology Lab

Time: 6 hrs **M. Marks: 150**

Microbiology: Microscopic examination of bacteria, actinomycetes, algae, fungi and protozoa; Differential staining methods; Study of shape and arrangement of bacterial cells; Preparation of microbiological media; Sterilization: principles & operations; Preparation of specific media for isolation of bacteria, actinomycetes and fungi from natural sources; Sampling and quantification of microorganisms in air, soil and water; Isolation of thermophiles from compost.

Biochemistry: Preparation of standard and buffer solutions; Use of simple techniques in laboratory (spectrophotometery-verification of Beer's law, relation between O.D. and percentage transmission; Centrifugation) Estimation of sugars, Estimation of Proteins by Lowry's method; Estimation of DNA and RNA by diphenylamine and orcinol methods; Determination of enzyme activity and study of enzyme kinetics; Separation of biomolecules by electrophorosis.

Basics of Microbial Biotechnology: Design and Preparation of Media for Bioprocesses; Isolation of industrially importanat microorganism from different sources using specific substrates; To study the various methods of biomass measurement; Production of ethanol from sucrose by yeast; Determination of yield coefficient and Monod's constant and metabolic quotient of *E. coli* culture on glucose.; To study the design of fermenter and its working; Production of extracellular enzymes; Ethanol production using immobilized yeast culture.

Mycology and Phycology: Isolation and identification of fungi from different environmental samples, Study the nutritional requirement of fungi, Cultivation of fungi in submerged and solid state fermentation, Production of enzymes, organic acids and other metabolites by fungi, Collection and study of basidiomycetous fungi, Study and culturing of yeasts, study yeast dimorphism, Isolation and identification of algae from different habitats, Culturing of algae under lab conditions, Study hydrogen and bioethanol production by algae, Algae as a source of SCP, study pollution control by algae.

Microbial Energetics: Determination of viable and total number of cells, Measurement of cell size, Growth – types of growth (synchronous, diauxic, batch), study factors affecting growth, Sporulation and spore germination in bacteria; Induction and repression of enzymes; Study of bacterial growth under aerobic, micro, aerophilic and anaerobic conditions; Morphological, Physiological and Biochemical tests of selected bacterial cultures. Production of amino acids and vitamins by microorganisms.

Suggested Readings:

1. Benson H. J. Microbiology Applications – (A Laboratory Manual in General Microbiology), Wm C Brown Publishers.
2. Cappuccino J.G. and Sherman N., A Laboratory Manual, Addison-Wesley.
3. Work T.S. and Work R.H.E., Laboratory Techniques in Biochemistry and Molecular Biology. Elsevier Science.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
MBT-201 Techniques in Microbial Biotechnology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Sterilisation; Pure cultures and aseptic techniques; Nutritional Types; Bacterial growth curve, Metagenomics for the isolation of genes for novel enzymes; Types of PCR, Light microscopy.

Unit II

Purification of microbial protein; Electrophoretic separation of protein; Characterization using- PAGE/ gel filtration method, native and SDS-PAGE; 2D-PAGE; capillary electrophoresis; IEF; Differential centrifugation and purification by density gradient centrifugation; Chromatographic methods of separation; Principles and applications of Paper; Thin layer; Gas-liquid; HPLC and FPLC; Spectrophotometry- Principles and applications UV-Visible, Mass Spectrometry, MALDI-TOF, Atomic Absorption Spectrometer.

Unit III

Antisense and RNAi technology; Protein and DNA sequencing techniques- Maxam–Gilbert sequencing, Chain-termination methods, Massively Parallel Signature Sequencing (MPSS), Pyrosequencing, Illumina (Solexa) sequencing, Solid sequencing; Genomic and cDNA library preparation; RFLP; RAPD and AFLP techniques.

Unit IV

Tracer techniques in biology: Concept of radioactivity; radioactivity counting methods with principles of different types of counters; Concept of α, β and γ emitters, scintillation counters; γ-ray spectrometers; autoradiography; applications of radioactive tracers in biology, FACS.

Suggested Readings:

1. Friefelder. D. (1982) Physical Biochemistry, Application to Biochemistry and Molecular Biology, 2 nd ed. W.H. Freemen and Company, San Fransisco.
2. Griffiths, O. M. (1983). Techniques of Preparative, Zonal and Continuous Flow Ultracentrifugation.
3. William, B.L. and Wilson, K. (1986). A Biologist Guide to Principles and Techniques Practical Biochemistry, 3 rd ed., Edward Arnold Publisher, Baltimore, Maryland (USA).
4. Slater, R.J. (1990).Radioisotopes in Biology-A Practical Approach, Oxford University Press, NewYork.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
MBT-202 Production of Microbial Biomass

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Microbial cells as products for commercial use; Selection and Improvement of Strains for biomass production; Characteristics of Single-Cell Biomass: Composition; Nutritional Value and Toxicological Status. Formulation of medium Composition for Biomass Production; Types of fermentation system fir Biomass Production: Batch Culture; Continuous Culture; Fed-Batch Culture; Mixed culture; General principle of culture maintenance and preparation: bacterial culture (lactic acid cultures; propionic acid culture; acetic acid bacteria);

Unit II

Single cell protein: microorganisms used; raw material used as substrate; condition for growth and production; nutritive value and uses of SCP. Baker's yeast; Production of probiotic biomass; and mold cultures. Mushroom production: cultivation of different types of mushroom; edible mushroom; diseases of mushrooms therapeutic value of an edible mushroom; production of pectin and microbial conversion of woody biomass.

Unit III

Microbial inoculants- Selection and establishment of nitrogen fixing bacteria. Production of Rhizobium, Azotobacter, Azospirilla, cyanobacteria and other nitrogen fixing bacterial cultures. Quality control of bio inoculants; Phosphate solubilizing bacteria; mycorrhiza; plant growth promoting rhizobacteria (PGPR); Biocontrol microbial inoculants.

Unit IV

Cyanobacterial and algal fuels; Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology; Bioweapons and Bioshields.

Suggested reading:

1. Robert A Andersen. 2005. *Algal Culturing Techniques.* Academic Press.
2. L. M. Prescott, J. P. Harley and D. A. Klein. Microbiology-, McGraw Hill
3. N. J. Pelczar, S. Chand, R. Krieg. Microbiology- Tata McGraw Hill
4. Casida, Industrial microbiology-, L.E. New age international Ltd, Publishers. New Delhi:
5. Frazier, Food microbiology. W.C. Tata McGraw Hill.
6. Carr NG & Whitton BA. 1982. The Biology of Cyanobacteria. Blackwell.
7. Bergerson F J. 1980. Methods for Evaluating Biological Nitrogen Fixation. John Wiley & Sons.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
MBT-203 Fundamentals of Microbial Remediation

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit-I

Bioremediation- process and organisms involved; Constraints and priorities of bioremediation. Major pollutants and polluted sites. Bioaugmentation; Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Pollutants and associated risks; Polyaromatic hydrocarbon pollution; organic pollutant dergradation- Microbial aspects and metabolic aspects; Factors affecting the process; Recent developments.

Unit-II

Microbes involved in aerobic and anaerobic processes in nature; Water treatment- BOD, COD, dissolved gases, removal of heavy metals, total organic carbon removal; secondary waste water treatments; use of membrane bioreactor; aquaculture effluent treatment; Aerobic sludge and landfill leachate process; aerobic digestion.

Unit-III

Composting of solid wastes, treatment of organic pollutants, anaerobic digestion: methane production and important factors involved, sulphur, iron and nitrate reduction, hydrocarbon degradation, dechlorination, nitroaromatic compounds degradation, bioremediation of dyes, bioremediation in paper and pulp industries; Aerobic and anaerobic digesters: design; various types of digester for bioremediation of industrial effluents; Pros and cons of anaerobic process.

Unit-IV

Microbial leaching of ores- process, microorganisms involved and metal recovery with special reference to copper and iron, Biotransformation of heavy metals and xenobiotics, Petroleum biodegradation; reductive and aerobic dechlorination. A brief account of biodegradable plastics and super bug.

Suggested readings:

1. Pandey A, Lasroche C, Soccol C. R and Dussop C. G. Advances in Fermentation technology (2008). Asiatech publishers Inc.
2. Mathuriya A. S. Industrial Biotechnology (2009) Ane Books Pvt. Ltd.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
MBT-204 Molecular Biology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History of molecular biology; Nucleic acids as hereditary material; Structure of nucleic acid; Secondary and tertiary structure of nucleic acids; Types of RNA- rRNA, tRNA and mRNA; structure of ribosomes; Nucleases; Restriction and modification; Nucleic acid sequencing; DNA replication and DNA polymerases of *E. coli*.

Unit II

Transcription; RNA polymerases; Types of promoters; Reverse transcriptase and RNA replicase; Genetic code; Translation; Gene regulation at transcriptional and translational level; Operon- positive and negative control; Attenuation; Molecular mechanism of mutation; Mechanism of DNA repair.

Unit III

Molecular organization of eukaryotic genome- Structure of genomes, Chromatin; Types of DNA polymerases, DNA replication; Types of RNA polymerases- Transcription, Structure of primary transcript; Ribozyme, RNA processing and alternate splicing; Structure of ribosomes and translation in eukaryotes; Development and differentiation; Molecular evolution.

Unit IV

Cell division cycle- Check points in cell cycle; apoptosis and its pathways; Oncogenes- Retroviruses, Tumor suppressor p53, Telomere shortening, Ras oncogenes; Oncoproteins and gene expression; Genetic instability and cancer.

Suggested readings:

1. Lewin, B. Gene X, Oxford University Press.
2. Brown, T.A. Genomes, John Wiley and Sons Inc.
3. Brown. T.A. Molecular Biology LabFax, Bios Scientific Ltd. Oxford.
4. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. and Watson, J.D. Molecular Biology of the Cell, Garland Publishing.
5. Watson, J.D, Weiner, A.M and. Hopkins, N.H Molecular Biology of the Gene Addison-Wesley Publishing.
6. Lodish, H., Berk, A., Zipursky, S., Matsudaira, P., Baltimore, D. and Darnell, J.E Molecular Cell Biology, W.H. Freeman and Company.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)
MBT-205 Biostatistics and Bioinformatics

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Principles and practice of statistical methods in biological research; Samples and Populations; Probability distributions- addition and multiplication theorems, Baye's theorem, Binomial, Poisson, and Normal distribution; Data presentation- Types of data, Methods of data representation.

Unit II

Measures of central tendency- Mean, Median, Mode; Measures of dispersion- Range, Mean deviation and Coefficient of variation, Standard deviation, Standard error; Correlation and regression; Statistical inference- Hypothesis testing, Significance level, Test of significance for large and small samples; Parametric tests; Non parametric tests; Experimental design, Use of biostatistic softwares.

Unit-III

Bioinformatics basics; Application and research; Present global bioinformatics scenario. Databases- characteristic of bioinformatics databases, navigating databases, information retrieval system and database collaboration; Sequence databases- nucleotide sequence databases, protein sequence database, information retrieval system e.g. Entrez and SRS; Structure databases- Structure file format, Protein structure database collaboration, PDB, MMDB, FSSP, SCOP, BRENDA, AMENDA and FRENDA, Pathway databases e.g. CAZy.

Unit-IV

Tools- Need for tools, data mining tools, data submission tools e.g. nucleotide submission tools and protein sequence submission tools; Data analysis tools- nucleotide sequence analysis and protein sequence analysis tools e.g. BLAST & FASTA. Prediction tools- multiple nucleotide alignment, phylogenetic tree, gene prediction, protein structure & functions prediction. Modeling tools: 2D and 3D protein modeling.

Suggested Readings:

1. Casella G. and Berger R. L., Statistical Inference (The Wadsworth and Brooks/Cole Statistics/Probability Series) b, Brooks/Cole Pub Company.
2. Grant G. R., Ewens W.J. ,Statistical Methods in Bioinformatics: An Introduction. Springer Verlag.
3. Jagota A. Data Analysis and Classification for Bioinformatics, Bioinformatics By The Bay Press.
4. Spiegel M. R., Schiller J.J., Srinivasan R. A. , A. Srinivasan Schaum's Outline of Probability and Statistics. McGraw-Hill Trade.

M.Sc. (Microbial Biotechnology)
(SEMESTER-II)

P2-MBT: Techniques in Microbial Biotechnology, Bioremediation, Biomass Production, Biostatistics and Bioinformatics and Molecular Biology Lab

Time: 6 hrs **M. Marks: 150**

Techniques in Microbial Biotechnology: Isolation of industrially important microorganism from different sources using specific substrates; Design and Preparation of Media for Bioprocesses; Growth curve studies of bacteria/Yeasts in batch culture and calculation of maximum specific growth rate; To study the various methods of biomass measurement; Production of ethanol from sucrose by yeast; Determination of yield coefficient and Monod's constant and metabolic quotient of *E.coli* culture on glucose.; To study the design of fermenter and its working; Production of citric acid using sucrose and molasses; Production of extracellular enzymes ; Ethanol production using immobilized yeast culture.

Bioremediation: Isolations of nitrogen fixating bacteria; nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc; Bioinoculant production and quality control. Cultivation of mushrooms. Isolation of xenobiotic degrading microorganisms, Anaerobic waste water treatment of industrial dyes and effluent; Estimation of BOD & COD levels of different water systems; Bacteriological analysis of water by presumptive, confirmatory and completed tests.

Biostatistics and Bioinformatics: Software handling, BLAST: finding scores an; E-values; Sequence alignment, nucleotide restriction-site determination,; Dendrogram making (both rooted and unrooted); gene prediction, primer and oligos development using different softwares; Retrival of gene, finding specific gene from whole-genome sequence; Developing protein structure using Ras Mol; Finding hydrophobicity in protein sequence e.g. Kitte & Doolittle; Developing a vector map using a software.

Molecular Biology: To study agarose gel electrophoresis of genomic DNA, To study genomic DNA isolation from bacteria and fungi, DNA isolation from humus rich soil samples and diversity study using 16s rDNA primers, To study restriction profile of isolated DNA and plasmid samples, Isolation of plasmids from *E.coli DH5α* cells, Isolation of DNA fragments which carry promoter sequence, Synthesis and codon modification of bacterial hemoglobin gene, Agrobacterium mediated gene transformation studies in fungi, To prepare chemically competent cells of *E. coli* DH5α and determine their transformation efficiency, To amplify the laccase/phytase/xylanase gene by Polymerase Chain Reaction, To clone the laccase/cellulase/phytase/xylanase amplicon into the TA cloning vector pGEM-T.

Biomass Production: Production of algae, fungi and yeasts as biomass, Fed batch and continuous fermentation for production of microbial biomass, Mushroom cultivation, Microbial biomass in bioremediation

Suggested Readings

1. Hsu H.P., Schaum's Outline of Probability, Random Variables and Random Processes., McGraw-Hill Trade.
2. David W. Mount, Bioinformatics: Sequence and Genome analysis, Cold Spring Harbor Laboratory Press.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-301 Biochemical Engineering

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Material balances; Energy balances; Material and Energy balance together; Kinetics of enzyme catalyzed reactions.

Unit II

Growth stoichiometry; Kinetics of microbial growth and product formation in batch, Fed batch and continuous cultures; Sterilization of air and medium.

Unit III

Heat Conduction and Molecular Diffusion; Fluid Flow and Momentum Transfer; Laminar versus Turbulent Flow; Aeration and agitation; Power requirements for mixing; Mass and heat transfer in Biological reactions; Scale-up Principles.

Unit IV

Types and of Bioreactors- Bioreactor design for microbial culture, animal cell culture, enzymatic reactions and waste treatment; Instrumentation and control of bioprocess.

Suggested Readings:

1. Principles of Fermentation Technology by P. F. Stanbury, A. Whitaker, S. J. Hall. Publisher: Butterworth-Heinemann
2. Biochemical Engineering by S. Aiba, A.E. Humphrey and N.F. Millis. Publisher: University of Tokyo Press.
3. Bioreaction Engineering Principles by J. Nielson and J. Villadsen Publisher: Plenum Press.
4. Bioprocess Engineering Basic Concepts by M.L. Shuler and F. Kargi. Publisher: Prentice Hall.
5. Bioprocess Engineering Principles by P. Doran. Publisher: Academic Press.
6. Biochemical Engineering Fundamentals by J.E. Baily and D.F. Ollis. Publisher: McGraw Hill.
7. Chemical Engineering by J.M. Coulson, and J.F. Richardson. Publisher: Butterworth Heinemann.
8. Introduction to Chemical Engineering by W.L. Badger, and J.T. Banchero, Publisher: Tata McGraw Hill
9. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-302 Downstream processing

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Role and importance of downstream processing in biotechnological processes. An overview of bioseparation; Problems and requirements of bioproduct purification; Characteristics of biological mixtures; Downstream process economics.

UNIT-II

Physico-chemical basis of bio-separation processes. Removal of particulate matter; biomass; and insolubles: flocculation and sedimentation; centrifugation and filtration methods; Cell disruption methods; Enrichment Operations: precipitation methods (with salts; organic solvents; and polymers; extractive separations; aqueous two-phase extraction; supercritical extraction); adsorption method.

Unit III

Membrane separations: Membrane based seperation theory; Types of membranes; Types of membrane processes (Dialysis; Ultrafiltration; microfiltration and Reverse Osmosis). Chromatographic separations: Paper; TLC; Adsorption; Ion exchange; Gel filtration; affinity chromatographic separation processes; GC; HPLC; FPLC; Electrophoretic separation.

Unit IV

Final product polishing and Case studies: Products polishing: Crystallization and drying; Purification of cephalosporin; aspartic acid; Recombinant Streptokinase; Monoclonal antibodies; Tissue plasminogen activator; Taq polymerase; Insulin.

Suggested readings:

1. Chromatographic and Membrane Processes in Biotechnology by C.A. Costa and J.S. Cabral. Publisher: Kluwer Academic Publishers
2. Bioseparations: Downstream Processing for Biotechnology by P.A. Belter et al. Publisher: John Wiley and Sons Inc
3. Bioseparations by P.A. Belter, E.L. Cussler and W.S. Hu. Publisher: John Wiley and Sons Inc.
4. Biochemical Engineering Fundamentals by J.E. Bailey and D.F. Ollis. Publisher : McGraw-Hill.
5. Downstream Processing by J.P. Hamel, J.B. Hunter and S.K. Sikdar. Publisher: American Chemical Society.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-303 Bioprocess Plant Design

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Introduction and plant layout plan: Introduction; General design information; Material and energy balance calculations; Process Flowsheeting; Site Selection- factors influencing the selection, rural and urban locations of sites, optimum decision on choice of site and analysis; Plant Layout- Types of production, types of layouts, advantages and disadvantages of layout, factor affecting layout, systematic layout planning.

Unit II

Bioprocess plant design- Bioreactor design; Selection and specification of bioprocess equipment (upstream and downstream); Piping and valves for biotechnology; Pressure relief system; Materials of construction and properties; Facilities design; Material handling: importance, principles of material handling; Utilities for plant and their design introduction

Unit III

Process economics: General fermentation process economics; materials usage and cost; capital investment estimate; production cost estimate. Case studies – Traditional product and recombinant product; Bioprocess validation: Introduction, why validation, when does validation occur, validation structure, resources for validation, validation of systems and processes including SIP and CIP.

Unit IV

Good manufacturing practices and safety- Quality management, personal, premises and equipment, documentation, production, quality control, contract manufacturing and analysis, complaints and product recall, self inspection. Introduction to GLP and its principles; Safety guidelines.

Suggested Readings

1. Perry, R.H. and Green, D.W., Chemical Engineers Handbook, McGraw-Hill.
2. Meyers, F.E. and Stephens, M.P., Manufacturing Facilities Design and Material Handling, Prentice Hall.
3. Peter, Max S. and Timmerhaus, Klaus D, Plant Design and Economics for Chemical Engineers, McGraw Hill.
4. Sinnott, R.K., Coulson, J.M. and. Richardsons, J.F Chemical Engineering, Butterworth-Heinemann.
5. Peters M. and Timmerhaus K, Plant Design and Economics for Chemical McGraw-Hill.
6. Process Plant Layout and Piping Design by E. Bausbacher and R. Hunt. Publisher: Prentice Hall PTR.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-304 Microbial Metabolites

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Microbial products as primary and secondary metabolites; trophophase- Ideophase relationships in production of secondary metabolite; Role of secondary metabolites in physiology of organisms producing them; Pathways for the synthesis of primary and secondary metabolites of commercial importance; Metabolic control mechanisms: substrate induction; catabolic regulation; feedback regulation; amino acid regulation of RNA synthesis; Energy charge regulation and permeability control; Bypassing/ disorganization of regulatory mechanisms for overproduction of primary and secondary metabolites

Unit II

Organic feedstock: ethanol; Acetone; Ethanol Organic acids: Production of Citric acid; Acetic acid; Lactic acid; Gluconic acid; Kojic acid; itaconic acid; Amino acids: Use of amino acids in industry; methods of production; Production of individual aminoacids (L-Glutamic acid; L Lysin; L-Tryptophan).

Unit III

Enzymes: commercial applications; production of Amylases; Glucose Isomerase; L Asparaginase Proteases Renin; Penicillin acylases; Lactases; Pectinases; Lipases; Structure and biosynthesis Nucleosides Nucleotides and related compounds.

Unit IV

Vitamins- Vitamin B12; Riboflavin; B carotene; Antibiotics: beta-Lactam antibiotics; aminoacid and peptide antibiotics; Carbohydrate antibiotics; Tetracycline and antracyclines; Nucleoside antibiotics; Aromatic antibiotics; bioplastics (PHB; PHA); biotransformation of steroids.

Suggested Readings:

1. Biotechnology. A Textbook of Industrial Microbiology, by W. Crueger and A. Crueger. Publisher : Sinauer Associates.
2. IIndustrial microbiology by G. Reed, Publishers: CBS
3. Biology of Industrial microorganisms By A. L. Demain.
4. Stanbury P.F.A. Whitaker and Hall. Principles of fermentation technology
5. Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by H.C. Vogel, C.L. Todaro, C.C. Todaro. Publisher: Noyes Data Corporation/ Noyes Publications.
6. New Products and New Areas of Bioprocess Engineering (Advances in Biochemical Engineering/Biotechnology, 68) by T. Scheper. Publisher : Springer Verlag.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-305 Genetic Engineering of Microorganisms

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit-I

Value addition in industrially important microorganisms using recombinant DNA technology; Basic techniques involved; Essential enzymes used in recombinant DNA technology; Cloning vectors; Cloning strategies. Cloning and selection of individual genes, gene libraries: cDNA and genomic libraries; Design of vectors for the over expression of recombinant proteins: selection of suitable promoter sequences, fusion protein tags, protease cleavage sites and enzymes, inducible expression systems; organelle specific expression of cloned gene.

Unit-II

Mutagenesis and directed evolution of microbes. Different expression systems- Cloning in bacteria other than *E. coli*; cloning in *Saccharomyces cerevisiae*; cloning in GRAS microorganism; Gene regulation- RNA interference: antisense RNA technology. Bioethics, Biosafety and IPR issues.

Unit-III

PCR methods, PCR optimization, PCR cloning, real-time PCR, and PCR application in diagnostics; DNA sequencing methods. *In vitro* mutagenesis of cloned gene; Proteomics- basic concept and importance. Metagenome: DNA isolation from diverse sources, library formation, screening of clones: functional screening, sequence based and high-throughput screening.

Unit-IV

Nucleic acid sequences as diagnostic tools: Detection of sequences at the gross level, single nucleotide polymorphisms (SNPs), importance of SNPs, forensic applications of VNTRs. New drugs and new therapies for genetic diseases: recombinant proteins for therapeutic use. Recombinant bacterial vaccines, Recombinant viruses as vaccines, Plants as edible vaccines, DNA vaccines, selecting targets for new antimicrobial agents, *In vivo* expression technology (IVET), and signature-tagged mutagenesis.

Suggested Reading:

1. Nicholl D. S. T. 2008. An Introduction to Genetic Engineering, Cambridge University Press.
2. Glick BR, Pasternak JJ. 2003. Molecular Biotechnology. ASM Press Washington D.C.
3. Old and Primrose 2008. Principles of Gene Manipulation. Blackwell Scientific Publication.
4. Brown T.A. 2010. Gene Cloning. Blackwell Publishing.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)
MBT-306 Communication Skill Development

Time: 3hrs **Marks: 50**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Lectures : preparation, objectives, concepts, contents, sequence, formal proof, interrelationships, logic, conclusions, time management using audiovisual aids Giving a talk : body language : extempore and prepared talks.
Preparation for interviews, CV/ biodata.
Vocabulary : word power, pronunciations, guessing the meaning of words from the context an body language and using a dictionary Review of basic grammar Punctuation marks comma, colon, semicolon, full stop, inverted comma. Avoiding repetitious statements, double positive, double negatives, circular arguments. Dealing with questions, avoiding circumvention and circular arguments, answering after breaking down long question into parts.
MS power point -based presentations, Analysis of formal presentations in the course in terms of actual presentations.

M.Sc. (Microbial Biotechnology)
(SEMESTER-III)

P3-MBT: Biochemical Engineering, Genetic Engineering, Downstream Processing, Bioprocess plant design and Microbial Metabolites Lab

Time: 6 hrs **M. Marks: 150**

Biochemical Engineering: Study of the Rheology of Fermentation Fluids and determining their flow parameters, Production of biomass in a bioreactor (Batch/ fed batch/ continuous mode), to study the product synthesis kinetics, To study the mixing and the residence time in bioreactor.

Detrmination of KLa value of fermenter, to study effects of Physiochemical factors on microbial growth, Determination of thermal death rate constant and decimal reduction time for *E. coli.* Cell disruption for endoenzymes by sonication, Preservation of industrially important bacteria by lyophilization, Extraction of Citric acid/Lactic acid by salt precipitation.

Downstream Processing: Separation of microbial biomass from culture medium, Isolation of cell bound and intracellular product, Cell lysis and different methods, Isolation and purification of a protein by salt and solvent precipitation, Study the application of dialysis in downstream processing of a product, Product recovery and purification by different chromatography techniques such as gel filtration, ion exchange and other chromatography, Determination of molecular mass of a protein using SDS-PAGE and gel filtration chromatography, Ultrafiltration and its application in purification.

Genetic Engineering: Estimation of protein, RNA and DNA; SDS-PAGE of proteins; DNA isolation; Purification; polymerase chain reaction; DNA restriction analysis; RFLP and RAPD analysis; Transformation of *E. coli* using plasmid DNA, Genetic improvement of Isolated industrially important microorganisms for production of microbial metabolites. Comparative studies of ethanol production using different substrates, Production of antibiotics and microbial enzymes.

Bioprocess plant design: Bioprocess plant design and its applications

Microbial Metabolites: Primary and secondary metabolites, Production of citric acid, acetic acid, amino acids and vitamins by microbial cultures using sucrose and molasses; Production of extracellular enzymes; Ethanol production using immobilized yeast culture. Production of antibiotics and pigments by microbial cultures.

Suggested Readings:

1. Molecular Cloning : A Laboratory Manual (3-Volume Set) by J. Sambrook, E.F. Fritsch and T. Maniatis. Publisher : Cold spring Harbor Laboratory Press
2. Introduction to Practical Molecular Biology by P.D. Dabre. Publisher:: John Wiley and Sons Inc.

M.Sc. (Microbial Biotechnology)
(SEMESTER-IV)
MBT-401 Fermented Foods

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

History and scope of fermented foods; definition and importance of fermented foods; Organisms used for production of fermented food products; Environmental parameters for fermentation process; Classification of fermentation processes for fermented foods.

Unit II

Fermented beverages- production of different types of wine and beer; Fermented foods of vegetables and fruits- Processing, microbiology, starter cultures, biochemistry, food safety of sauerkraut, pickles, Kimchi; Cereal and legume based fermented products- bread, Soya Sauce, Koji, Tempeh, Miso, Natto, Tofu, Angkkak; Indian products like Idly, Dosa, Bada.

Unit III

Microbiology of Fermented Dairy Products (Product Characteristics, Processing, Starter culture, Growth, Genetics) Buttermilk; Yogurt (probiotics, prebiotics, synbiotics); Acidophilus Milk; Bifidus Milk, Bulgarian milk; acidophilus milk; Kefir; Kumiss; Cheeses; Properties and beneficial effects of probiotic and prebiotic.

Unit IV

Fermented meat and fish products; Microbial fermentation of tea, coffee and cacao. health aspects of fermented foods.

Suggested readings

1. Kosikowski, F.V. 1997. Cheese and fermented milk foods. Frank Kosikowski and Vikram Mistry, Brooktondale, N. Y.
2. Fox, P.F. 1993. Cheese : chemistry, physics, and microbiology, London ; New York: Chapman & Hall,.
3. Wood, J. B. 1985. Microbiology of fermented foods. Volumes I and II. . Elsevier Applied Science Publishers. London, England
4. Joshi, V.K. and Pandey, A. Ed. 1999. Biotechnology. Food Fermentation, (2 Vol. set). Education Publ. New Delhi
5. R.C. Dubey and D.K. Maheshwari. Practical Microbiology
6. Jay, J.M. (2008) Modern Food Microbiology **(**Sixth Edition).Aspen Publishers, Inc. Gaithersburg, Maryland

M.Sc. (Microbial Biotechnology)
(SEMESTER-IV)
MBT-401 Basic Virology

Time: 3hrs **Marks: 80**

Note: The question paper will consist of 9 questions. Students will have to attempt 5 questions in total - Question no. 1 will comprise of short answer questions covering the entire syllabus and will be compulsory. Two questions to be set from each Unit and students will have to attempt one from each Unit.

Unit I

Brief outline on discovery of viruses, nomenclature and classification of viruses; Viral genome, their types and structures; virus related agents; Viral cultivation, assay and diagnosis; primary & secondary cell cultures; Assay of viruses, physical and chemical methods (protein, nucleic acid, radioactivity tracers, electron microscopy), Infectivity assay (plaque method, end point method) – Infectivity assay of plant viruses. Haemagglutination & HAI; complement fixation; immunofluorescence methods, ELISA and Radioimmunoassays.

Unit II

Bacterial Viruses- Classification and nomenclature, Bacteriophage structural organization; life cycle: lytic and lysogenic cycle, application of bacteriophages; brief details on M13, Mu, T3, T4, and Lamda P1. Viruses of cyanobacteria, algae, fungi.

Unit III

Plant Viruses- Classification and nomenclature; Structureand life cycle of plant viruses. Propagation, purification, characterization, identification and genomics of plant viruses like TMV, Cauliflower Mosaic Virus ,Gemini virus and Potato Virus X Symptoms of plant virus diseases, Transmission of plant viruses, Viral diseases and their control. Some common viral diseases of plants. Viral and Viriod diseases: Papaya ring spot, rice tungro, tomato yellow leaf curl, Potato spindle tuber, coconut cadang.

Unit IV

Animal Viruses-Classification and nomenclature; Structure and lifecycle of animal viruses. Replicative strategies employed by DNA and RNA viruses. Epidemiology, pathogenicity, diagnosis, prevention and treatment of Picorna,Ortho myxo, Paramyxo, Toga, Rhabdo, Rota, Pox, Herpes, Adeno, Hepatitis, HIV and other Oncogenic viruses; viral vaccines (conventional vaccines, genetic recombinant vaccines used in national immunisation programmes with examples, newer generation vaccines including DNA Vaccines with examples) interferons, and antiviral drugs.

Suggested Readings

1. Morag C and Timbury M. C (1994) Medical virology-X Edition. Churchill Livingstone, London.
2. Dimmock N. J, Primrose SB (1994). Introduction to Modern Virology, IV Edition, Blackwell Scientific Publications, Oxford

3. Conrat H F, Kimball P C and Levy J A (1994) Virology-Ill Edition Prentice Hall, Englewood cliff, New Jersey.
4. Mathews, R E.,(1992) Functionals of Plant virology, Academic press, San Diego.
5. Topley and Wilson's (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 association, NY.
7. William Hayes (1985) The genetics of Bacteria and their Viruses. Blackwell Scientifi Publishers, London.
8. U.Winkler and W. Ruhr: Bacteria, Phage and Molecular Genetics

M.Sc. (Microbial Biotechnology)
(SEMESTER-IV)

MBT-500 Dissertation in Microbial Biotechnology

M.M. 300

Note: The Dissertation will be based upon research and actual bench work. It will be carried out IVth Semester, but will be started in the IIIrd Semester. The dissertation will be submitted at the end of semester and will be evaluated by external and internal examiners.

M. Sc. Dissertation Rules (w.e.f. 2013-14)

Distribution/Allotment of student: to be done at Department level but ratio of distribution to be done as per Ph. D. Seats *i.e.* in 8:5:3 ratio. The dissertation is to be innovative work based on small piece of research with duration in 3rd and 4th semesters. Scheme of chapters of dissertation is as follows-

Acknowledgement

Certificate by Supervisor

(i) Introduction with objectives
(ii) Review of Literature (Brief)
(iii) Materials & methods
(iv) Results
(v) Discussion
(vi) Summary
(vii) Bibliography

Pattern of References/Typing/Figures as per Ph. D. Thesis. Last date of submission will usually be 30th June. The evaluation of dissertation will be done by external examiner (Approved by the VC from panel approved by PGBOS) and internal examiner (Guide). Final marks will be mean of Internal + External.

The written part of Dissertation report shall account for 250 of marks and the viva-voice will be conducted by a duly constituted Board of Examiners for the remaining 50 of marks. Dissertation report will be evaluated on the basis of below given criteria:

Performance Evaluation Parameter	Score
Writing quality	50
Novelty/Scientific significance of aim	50
Project design	50
Publication potential	50
Aim-Results concurrence	50

No. of copies of Dissertation will be-One copy for Deptt. record, One copy for Guide record. One copy for candidate and soft copy to library. Any pattern/IPR based on Dissertation will be in the name of MDU student & Guide as inventor. Publication based on Dissertation will be under control of guide.