KUVEMPU UNIVERSITY

M.Sc., Microbiology (CBCS)

Syllabus

(Implemented from 2017-18)

DEPARTMENT OF STUDIES IN MICROBIOLOGY

Shankaraghatta – 577 451

KUVEMPU UNIVERSITY

DEPARTMENT OF MICROBIOLOGY

M.Sc., in Microbiology (From Academic Year 2011-12 on wards)

Choice –Based Credit System (CBCS) Course Structure

I Semester

Semester	Type	Paper Code	Paper Title	Hrs/Week	Total Hrs	Credits	Marks		Total
							Internal Assessment	Examination	
I	**Hard Core**	Theory MB-1.1	Basic Microbiology	4h.	64h.	4	25	75	**100**
		Theory MB-1.2	Environmental Microbiology	4h.	64h.	4	25	75	**100**
		Theory MB-1.3	Biochemistry and Biostatistics	4h.	64h.	4	25	75	**100**
		Practical MB-1.4	Microbiological Methods	4h.	64h.	2	-	50	**50**
		Practical MB-1.5	Environmental Microbiology	4h	64h.	2	-	50	**50**
		Practical MB-1.6	Biochemistry and Biostatistics	4h	64h.	2	-	50	**50**
I	**Soft Core**	Theory MB-1.7	A) Mycology	4h	64h.	4	25	75	**100**
			B) Principles of Genetics						
		Practical MB-1.8	Relevant Practical	4h	64h.	2	-	50	**50**
					Total Credits	**24**	**Total Marks**		**600**

<u>Additional Mandatory Credits</u>:

1. Communications Skills : 01 Credit

2. Computer Applications : 01 Credit

3. Personality Development : 01 Credit

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Syllabus- II Semester

Semester	Type	Paper Code	Paper Title	Hrs/ Week	Total Hrs	Credits	Marks		Total
							IA	Examination	
II	**Hard Core**	Theory MB-2.1	Microbial Physiology and Bioinformatics	5h.	80h.	5	25	75	**100**
		Theory MB-2.2	Microbial Genetics and Molecular Biology	5h.	80h.	5	25	75	**100**
		Practical MB-2.3	Microbial Physiology	4h.	64h.	2	-	50	**50**
		Practical MB-2.4	Microbial Genetics and Molecular Biology	4h	64h.	2	-	50	**50**
II	**Soft Core**	Theory MB-2.5	A) Plant –Microbe Interactions	4h.	64h.	4	25	75	**100**
			B) Microbial Enzymology					-	
		Practical MB-2.6	Relevant Practical	4h	64h.	2	-	50	**50**
II	**Elective**	Theory MB-2.7	A) Microbiological analysis of water	2h.	32h.	2	10	40	**50**
			B) Agricultural Microbiology	.					
Total Credits						**22**	**Total Marks**		**500**

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Syllabus- III Semester

Semester	Type	Paper Code	Paper Title	Hrs/ Week	Total Hrs	Credits	Marks		Total
							Internal Assessment	Examination	
III	**Hard Core**	Theory MB-3.1	Agricultural Microbiology and Phytopathology	5h.	80h.	5	25	75	**100**
		Theory MB-3.2	Immunology and Medical Microbiology	5h.	80h.	5	25	75	**100**
		Practical MB-3.3	Agricultural Microbiology and Phytopathology	4h.	64h.	2	-	50	**50**
		Practical MB-3.4	Immunology and Medical Microbiology	4h.	64h.	2	-	50	**50**
III	**Soft Core**	Theory MB-3.5	A) Immunotechnology	4h.	64h.	4	25	75	**100**
			B) Fermentation technology						
		Practical MB-3.6	Relevant Practical	4h	64h.	2	-	50	**50**
III	**Elective**	Theory MB-3.7	A) Diagnostic Microbiology	2h.	32h.	2	10	40	**50**
			B) Industrial Microbiology						
					Total Credits	**22**	**Total Marks**		**500**

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Syllabus- IV Semester

Semester	Type	Paper Code	Paper Title	Hrs/ Week	Total Hrs	Credits	Marks		Total
							Internal Assessment	Examination	
IV	Hard Core	Theory MB-4.1	Food and Industrial Microbiology	5h.	80h.	5	25	75	**100**
		Theory MB-4.2	Microbial Biotechnology and Nanotechnology	5h.	80h.	5	25	75	**100**
		Practical MB-4.3	Food and Industrial Microbiology	4h.	64h.	2	-	50	**50**
		Practical MB-4.	Microbial Biotechnology and Nanotechnology	4h.	64h.	2	-	50	**50**
		Theory MB.4.5	Project work	6h		7	25(Viva-voce)	75	**100**
					Total Credits	**21**		**Total marks**	**400**

1) Total Marks for the Course : 2000

2) Total Credits for the Course: 92

1. Project work should be based on experimental/review work and valued by two examiners (one external and one internal). The Candidate is required to present the work in open Viva-Voce examination in presence of examiners.

2. Each candidate shall have to complete 01 Credit each in Communications Skills, Computer applications and Personality development within first two semesters.
3. Examination duration: 03 hrs for both theory and practical of each paper.

Internal Assessment for papers:

1. Two session tests : 10 marks
2. Seminar/Tutorial /Group discussion : 05 marks
3. Assignment/Field work/Submission of specimen : 05 marks
4. Regularity and attendance : 05 marks

Total: 25 Marks

MB-1.1: Basic Microbiology 64 hrs

1**. Introduction to Microbiology:** **03 hrs**

a. The discovery of microorganisms; Spontaneous generation theory, Biogenesis theory, Germ theory of diseases, Discovery of microbial effects on organic and inorganic matter.

2. **Cell biology:** **03 hrs**

a. Cellular organization in prokaryotes and eukaryotes.
b. Molecular organization of cell: Structure of biological membranes, Singer and Nicholson model and other membrane molecular models, ion permeability, ion selectivity, ionophores, membrane potential.
c. Ultra structure and function of important cell organelles.

3. Classification concepts, taxonomic ranks, hierarchical organization and position of microorganisms in the living world, Universal phylogenetic tree. **02 hrs**

4. **Microbial Classification:** Identification and nomenclature; classification systems-artificial and phylogenetic, Haeckel's three-kingdom classification, Whittaker's five-kingdom classification, three-domain concept of Carl Woese. **03 hrs.**

5. Major characteristics used in taxonomy of microorganisms: Morphological, physiological, ecological, genetic analysis, molecular characteristics, comparison of proteins, nucleic acid hybridization, nucleic acid sequence comparison, DNA and RNA homology, G+C ratio, significance of rRNA in microbial taxonomy, Numerical Taxonomy and Chemotaxonomy**.** **05 hrs.**

6. Diversity and Structural organization of microorganisms:

a. **Viruses:** General characteristics, detailed structure of viruses, virion size, viral nucleic acids, viral envelops and enzymes, viruses with capsids and complex symmetry. Overview of viral classification, systematic position of viruses based on structure, nucleic acids and host, Methods of reproduction. **05 hrs**.
b. **Viroids:** General description and significance. **02 hrs.**
c. **Prions:** General description and significance**.** **02 hrs.**
d. **Bacteria:** General characteristics, morphological types, colony characteristics, biofilms, ultrastructure and chemical organization, fine structure of flagella, fimbriae; Spirochaetes, Rickettsiae, Chlamydiae, Mycoplasma, Cyanobacteria, Archaeobacteria, Actinomycetes. Reserve food materials, classification of bacteria according to Bergey's manual of Systematic bacteriology to the level of classes, Methods of reproduction. **05 hrs.**
e. **Fungi:** General characteristics, Structural details of unicellular and multicellular fungi, somatic structure, cell wall composition and mycelial organization, fine

structure of flagella, lomasomes, somatic nucleus; Heterothallism. Classification fungi to the level of classes, Methods of reproduction. **05 hrs.**

f. **Algae:** General characteristics, structure of unicellular and colonial forms. Classification of micro-algae to the level of divisions, Methods of reproduction**.** **02 hrs.**

g. **Protozoa:** General characteristics, morphology and structural details, encystment, excystment, locomotory organelles. Classification of protozoa to the level of orders, Methods of reproduction. **03 hrs.**

h. **Lichens:** General characteristics, Types and structural organization, Classification of lichens to the level of orders, Methods of reproduction**.** **02 hrs.**

7. Microbiological techniques:

a. **Microscopy:** Principles and applications of light, electron microscope (TEM, SEM), fluorescent, and phase-contrast **03 hrs.**

b. Staining techniques: Principles, protocols and applications of staining techniques. Simple, differential and vital staining techniques **02 hrs.**

c. **Sterilization:** Principles and applications of different sterilization techniques. Detailed process of physical and chemical methods of sterilization **03 hrs.**

d. Nutrition: Nutritional requirements, nutritional types of microorganisms, growth factors, uptake of nutrients by the microbial cell. **02 hrs.**

e. Isolation and sampling techniques: General isolation and sampling techniques for microorganisms from different sources. **03 hrs.**

f. Microbial culture media: Culture media, requirements, types and uses of different microbial culture media**.** **02 hrs.**

g. Microbial growth; Concept, growth type, Measurement of microbial growth-cell number, turbidity and biomass, determination of microbial growth curve, Continuous and synchronous culture, balanced and unbalanced growth, influence of environmental factors on growth, dioxy-growth curve, aerobic and anaerobic growth. **04 hrs.**

h. **Microbial culture preservation:** Concept, types of microbial culture preservation, type culture collections. Advantages and limitations of culture preservation techniques**.** **02 hrs.**

i. Microbial Safety measures: Concept, safety measures in handling microbiological samples and microorganisms**.** **02 hrs.**

References;

1. Alcamo, I.E. 1997. Fundamentals of Microbiology, 5th edition, An imprint of Addison Wesley Longman, New York.
2. Batzing, B.L. 2002. Microbiology (An Introduction), Brooks/Cole Thomson Learning, Canada.
3. Bauman, R. 2007. Microbiology (With diseases by Taxonomy), 2nd edition, Pearson Benjamin Cummings Publishers, San Francisco.
4. Cappacino, J.G. and Sherman, N. 2005.Microbiology, A Laboratory Manual, 7th edition, Pearson Education INC. Delhi, India

5. Cooper, G.M and Hausman, R.2009. The Cell A molecular Approach, 5th edition, ASM Press, Washington, D.C.
6. Willey, J.M., Sherwood, L.M and Woolverton, C.J.2008. Prescott, Harley, and Klein's Microbiology, 7th edition, McGraw-Hill, New York

MB-1.2: Environmental Microbiology 64 hrs

1. **Environment and Ecosystem:** **6 hrs.**

Physical, chemical and biological aspects of environment, natural habitats of microorganisms, microorganisms in ecosystem as producers and decomposers.

Biogeochemical cycles-role of microorganisms in transformation and maintenance of carbon, nitrogen, phosphorus and sulphur in nature.

2. Soil Microbiology **15 hrs.**

a. Historical development of soil microbiology.
b. Physical characteristics and nutrient status of soil.
c. Distribution of microorganisms in soil, their importance in maintaining soil fertility, organic matter and composting. Influence of environmental factors on soil microorganisms. Role of microorganisms in formation of different soils.
d. Enumeration and isolation of soil microorganisms.
e. Brief account of interactions among soil microorganisms-mutualism, commensalism, antagonism, competition, synergism, parasitism and predation.
f. Bioremediation of pollutants in soil, biodegradation of pesticides in soil.

3. **Aquatic microbiology:** **15 hrs.**

a. Aquatic environment: Temperature, hydrostatic pressure, light, salinity, turbidity, pH, nutrients.
b. Distribution of microorganisms in the aquatic environment.
c. Methods in the study of fresh and marine water microorganisms.
d. Role of aquatic microorganisms in food chain of aquatic environment.
e. Eutrophication-role of nitrogen and phosphorus in eutrophication, process and control of eutrophication.
f. Microorganisms and water pollution-Microflora of natural and polluted water, sources and characteristics of water pollutants; health hazards due to water pollution; microorganisms as indicators of water pollution; water quality criteria and assessment; bacteriological examination of water for potability.
g. The role of microorganisms in the purification of waste water: waste water treatment process, aerobic-anaerobic-design and functioning of treatment plant;

microbial ecology and application of trickling filters; activated sludge process, microbial treatment of sludges.

h. Water-borne diseases and their prevention.

4. **Microbiology of the atmosphere:** **10 hrs.**

a. Microorganisms in air, sources of air-borne microorganisms.
b. Techniques for microbiological sampling of air, impactors and impingers-Gravity slide, Plate exposure, vertical cylinder, Anderson's sampler, Hirst's trap, Burkard's 7-day volumetric sampler, rotarod sampler.
c. Brief account of air-borne diseases of humans and plants.
d. Brief account of air-borne allergens and their significance.

5. **Microorganisms in extreme environments:** **10 hrs.**

a. Extreme environments of temperature, salinity, pressure, pH.
b. Extreme thermopiles, psychrophiles, extreme halophiles, barophiles and other microorganisms in extreme environments.
c. Special sampling devices and techniques for isolation and culturing of microorganisms from extreme environments.
d. Biotic and a biotic factor influencing survival and adaptations of extremophiles, mechanisms of survival.
e. Radio sensitivity of microorganisms, effect of radiation on microorganisms, mechanisms of radio-tolerance in microorganisms.
f. Metal toxicity to microorganisms, importance of microorganisms in ore-leaching, use of microorganisms in metal extraction.

6. **Biodeterioration and Bioremediation**: **08 hrs.**

a. Microorganisms as biodeteriogens and their role in cycling of matter.
b. Microbial degradation of cellulose, lignin, pectin, chitin, synthetic polymers, xenobiotic compounds, petroleum and other hydrocarbons.
c. Importance of microbial biodeterioration of materials in tannery, paper and allied industries.
d. Solid wastes, chemical wastes, utilization of microorganisms in industrial effluent treatment technologies.
e. An overview of biogas production.
f. Bioremediation of xenobiotic pollutants. Factors influencing bioremediation.

References;

1. Atlas, R and Bartha, R.2005. Microbial Ecology Fundamental and Applications, 4th edition, Pearson Education (P) Ltd. Delhi, India
2. Bhatia, S.C. 2008. Hand Book of Environmental Microbiology, Atlantic Publishers Pvt. Ltd. New Delhi.
3. Gilman, J. 2001. A Manual of Soil Fungi, Biotech Books, Delhi.

4. Maier, R., Pepper, I and Gerba, C.P.2006. Environmental Microbiology, Reed Elsevier India Private Limited, New Delhi, India
5. Patnail, P. 1997. Hand Book of Environmental Analysis. CRC Press, Inc., USA.
6. Subba Rao, N.S.1999. Soil Microbiology, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi, India
7. Thakur, I.S. 2006. Environmental Biotechnology, I.K. International Pvt. Ltd. New Delhi.

MB-1.3: Biochemistry and Biostatistics 64hrs.

A. Biochemistry;

1. Concepts in Biochemistry: 04hrs.

An overview of macromolecules, properties of water as suitable solvent in biological system. Acids, Bases, pH, buffers, effects of pH on biological process, buffer solutions for biological investigations.

2. Brief account of Biomolecules: 20 hrs.

a. **Chemistry of carbohydrates:** Definition, classification, structure and general properties, importance and properties of sucrose, lactose, maltose, starch, cellulose, dextrins, hemicellulose, pectins, lignins, agar and bacterial cell wall polysaccharides.
b. **Chemistry of amino acids, peptides and proteins:** Definition, classification, structure, general properties, assay methods of amino acids and proteins.
c. **Chemistry of lipids and fats:** Definition, classification, structure and importance of lipids and fats.
d. **Chemistry of nucleotides:** Structure and properties of nucleotides and nucleosides.
e. **Vitamins:** Definition, classification, structure and importance.
f. **Porphyrins:** Definition, structure, properties and importance of chlorophyll, cytochrome and hemoglobin.

3. **Enzymes:** Classification, nomenclature, general properties, enzyme kinetics, coenzymes, activators, inhibitors, isoenzymes, multi-enzyme complex, allosteric enzymes, mechanism of enzyme action. **08 hrs.**

Biochemical techniques: 16 hrs.

1. Centrifugation techniques: Basic principles of sedimentation. Methods and applications of density-gradient centrifugation, preparative centrifugation, ultracentrifugation.

2. Chromatographic techniques: General principles and techniques. Methods and applications of paper chromatography, thin-layer chromatography, exclusion chromatography, affinity chromatography, ion-exchange chromatography, HPLC, Gas-liquid chromatography.

3. Electrophoretic techniques: General principles and application of electrophoresis and isoelectric focusing.

4. Spectroscopic techniques: General principles and laws of radiation, colorimetry, ultraviolet-visible spectrophotometry.

5. Radioisotopic techniques: General principles, nature of radio activity, detection and measurement of radioactivity, applications of radioisotopes in biological investigation.

B. Biostatistics: **16 hrs.**

1. Importance and application: Scope, sample and population concepts, sampling techniques, collection and organization of data, graphical presentation of data-frequency distribution, polygon, histogram, bar graph, pie diagram.

2. Measures of central tendency and dispersion: Mean, Median, Mode, Range, mean deviation, variance, standard deviation, coefficient of variance.

3. Correlation and regression analysis: Simple linear and multiple correlation, simple linear and multiple regression.

4. Probability distributions: Concepts of probability, binomial, poisson, normal distribution.

5. Tests of significance: Student's't' test, chi-square test, F-test, analysis of variance-one way and two way ANOVA, LSD.

6. Different Models of data presentation with special reference to biological samples. Software used in biostatistics analysis- SPSS, versions, graph pad prism.

References;

1. Cazes, J.2005. Ewing's Analytical Instrumentation Handbook, 3rd edition, Marcel Dekker.Inc., USA
2. Miller, J.M.2005. Chromatography concepts and contrasts, 2nd edition, John Wiley & Sons.Inc Publication, Canada
3. Mohan, J. 2003. Organic Analytical Chemistry (Theory and Practice), Narosa Publishing House, New Delhi.
4. Williard, Merritt, Deal and Settle. 1986. Instrumental methods of Analysis, 7th edition, CBS Publishers, New Delhi.

5. Wilson, K and Walker, J. 2000. Practical Biochemistry (Principles in Techniques), 5th edition, Cambridge University Press, UK.
6. Devlin, J.M. 2011. Text book of Biochemistry with clinical correlations, 7th edition, John wiley and sons, Inc. USA.
7. Voet, D.J., Voet, J.G. and Pratt, C.W. 2008. Principles of Biochemistry, 3rd edition, John wiley and sons.
8. Elliott, W.H and Elliott, D.C. 2009.Biochemistry and molecular biology, 4th edition, Oxford university press, New york.
9. Prasad, S. 2004. Elements of Biostatistics, Rastogi publications.

MB-1.7: (A) Mycology 64 hrs.

1. Introduction to fungi, developmental milestones in the field of mycology, development of mycology in India, Significance of fungi to humans. **04 hrs.**
2. **Ecology of fungi:** Distribution of fungi in nature, factors influencing fungal distribution. **03 hrs.**
3. Characteristics of fungi- Morphological, structural and ultrastructural details of fungi, chemistry of the fungal cell and cell organelles. **06 hrs.**
4. **Fungal biodiversity and systematics:** Diversity of fungi, systematic position of fungi, parameters for fungal systematics, classification of fungi to the level of Order (with suitable examples). **06 hrs.**
5. **Reproduction in fungi:** Asexual and sexual reproduction methods, reproductive structures and organs in different fungi, heterokaryosis, parasexuality and heterothallism**.** **09 hrs.**
6. **Physiology of fungi:** Fungal growth, nutritional requirements, assessment of fungal growth, effect of environmental factors on growth, primary and secondary metabolism; fungal enzymes, mycotoxins**.** **12 hrs.**
7. **Mycological techniques:** Isolation, culturing and maintenance of fungi. Mycological media and methods, culture collections**.** **08 hrs.**
8. **Application of fungi:** Usefulness of fungi and their metabolites in different fields. **05 hrs.**

Biology and significance of the following genera: *Aspergillus, Penicillium, Neurospora, Saccharomyces, Erysiphae, Xylaria, Polyporus, Peziza, Lycoperdon, Agaricus, Puccinia, Ustilago, Alternaria, Drechslera, Sclerotium, Saprolegnia, Rhizopus, Trichoderma.*

References;

1. Alexopoulos, C.J., Mims, C.W and Blackwell, M.2002. Introductory Mycology, 4th edition, John Willey & Sons (ASIA) Pte Ltd, Singapore.
2. Bhatnagar, D., Lillehej, E.B. and Arora, D.K., 1992. Hand Book of Applied Mycology, Mycotoxins in Ecological Systems. Vol. 5, Marcel Dekker, Inc. New York.
3. Bilgrami, K.S. and Verma, R.N.1997. Physiology of Fungi. Vikas publishing house Pvt. Ltd.
4. Carlile, M.G., Watkinson, S.C and Gooday, G.W. 1994. The Fungi, Academic Press, UK.
5. Gow, N.A.R and Gadd, G.M. 1996. The growing fungus, Chapman and Hall Publishers, London.
6. Griffin, D. 1993. Fungal Physiology, 2nd edition, Willy-Less Publisher, New York.
7. Mukadam, D.S. 2004. Modern Topic In Fungi, Saraswati Printing Press, Aurangabad, India.
8. Sharma, P.D. 2005. Fungi and Allied organisms. Narosa publishing house. New Delhi.
9. Vaughan, H.C.I.G. 2006. Fungi, 2nd edition, Biotech Books, Delhi.

MB-1.7: (B); Principles of Genetics 64 hrs.

1. **The science of Genetics** **07 hrs.**

Overview of genetics; genetics in medicine, modern agriculture and society. Prokaryotic and eukaryotic cells, chromosome, cell cycle, mitosis, meiosis, spermatogenesis, oogenesis, union of gametes, gamete formation in plants. Life cycles of model organisms, *Neurospora, Yeast, Arabidopsis, Drosophila, E-Coli*

2. **Mendelism and extension of Mendelism** **12 hrs.**

Mendel study of heredity: concept of phenotype and genotype, monohybrid (law of dominance and segregation), dihybrid(law of independent assortment). Applications of Mendel principles; punnet square, forked line and probability methods. Testing genetic hypothesis: chi-square test, pedigree analysis. Allelic variation and gene function; incomplete dominance, co dominance, multiple alleles. Allelic series, testing gene mutations for allelism, variation among the effects of mutations. Gene action; environmental effects on the expression of Human genes, penetrance and expressivity. Gene interactions; epistasis, pleiotropy.

3. **The chromosomal basis of Mendelism** **07 hrs.**

Chromosomes; chromosomal number, sex chromosomes, chromosome theory of

heredity. Chromosomes as arrays of genes, non-disjunction, the chromosomal basis of Mendel principles of segregation and independent assortment. Sex linked genes; hemophelia, blood clotting disorders, colorblindness, fragile X-syndrome and mental retardation, genes on Y chromosome, genes on both X and Y chromosomes. Sex determination in Human beings, *Drosophila* and other animals (birds, reptiles and butterflies). Dosage compensation of X-linked genes in Man and *Drosophila*.

4. **Variation in chromosome number and structure** **07 hrs.**

Cytological techniques; analysis of mitotic chromosomes, the Human karyotype. Cytogenetic variation; polyploidy (sterile, fertile, tissue specific polyploidy and polyteny). Aneuploidy; monosomy, trisomy, deletions and duplications of chromosome segments. Rearrangement of chromosome structure; inversions and translocations.

5. **Linkage, crossing over and chromosome mapping in Eukaryotes** **10 hrs.**

Exceptions to the Mendelian principle of independent assortment, frequency of recombination and linkage intensity. Gene mapping using the frequency of crossing over, recombination (two point and three point test cross), and chiasma formation. Tetrad analysis in fungi (Yeast). Specialized mapping techniques; centromere mapping with ordered tetrads in Neurospora, cytogenetic mapping with deletions and duplications in *Drosophila*. Linkage analysis in humans; detection of linked loci by pedigree analysis, somatic cell genetics.

6. **Genetics of mitochondria and chloroplast** **06 hrs.**

The classical genetics of organelles, leaf variegation in plants, antibiotic resistance in chlamydomonas, metabolic defects in yeasts. Mitochondrial DNA, the expression of mitochondrial genes, interplay between mitochondrial and nuclear gene products, mitochondrial DNA and human disease. Chloroplast DNA, chloroplast biogenesis, eukaryotic organelles as endosymbionts, the origin and evolution of mitochondria and chloroplast.

7. **Quantitative genetics** **06 hrs.**

Complex pattern of inheritance, analysis of quantitative traits, threshold traits, the multiple factor hypothesis, partitioning the phenotypic variance, broad sense heritability, narrow sense heritability, predicting phenotypes, artificial selection. Inbreeding; the effects of inbreeding and its analysis.

8. **Population and evolutionary genetics** **09 hrs**.

Darwin's theory of evolution, theory of allelic frequency; estimating allelic frequencies, relating genotype frequencies to allele frequencies. The Hardy-Weinberg principle and exceptions. Natural selection at the level of the gene, and phenotypes. Random genetic drifts; random changes in allele frequencies, the effects of population

size, populations in genetic equilibrium, balancing selection, mutation-selection balance, mutation-drift balance. Genetic variation in natural populations; phenotypic variation, polymorphism of chromosome structure, genetic variation at molecular level, speciation, modes of speciation, human evolution, humans and the great Apes, human evolution in the fossil record, DNA sequence variation and human origins.

References;

1. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. 2008. Introduction to Genetic Analysis. W.H. Freeman and Company, New York.
2. Hartt, D and Jones, E.N.2005. Genetics (Analysis of genes and genomes), 6th edition, Jones and Barlett Publishers.
3. Pierce, B.A. 2006. Genetics (A Conceptual Approach), 2nd edition, W.H. Freeman and Company, New York.
4. Russel, P.J. and Cumming, P.B. 2008. Genetics (A Molecular Approach), 2nd edition, Pearson Benjamin cummings Publishers, New York.
5. Strickberger, M.W.2006. Genetics, 3rd edition, Prentice-Hall of India Private Limited, New Delhi

MB-2.1: Microbial Physiology and Bioinformatics 80 hrs.

Chapter 1

1. **General Metabolic Pathways: 36 hrs.**

a. **Metabolism of carbohydrates:** Glycolysis, and gluconeogesis, Glyoxylate cycle, Tricarboxylic and cycle, Pentose phosphate pathway, Hexose monophosphate pathway, Entner-Doudoroff pathway, electron transport and oxidative phosphorylation, aerobic respiration, anaerobic respiration, fermentations, Pasteur effect and Crab tree effect.

b. **Photosynthesis**: Photosynthetic pigments, light reactions in eukaryotes, cyanobacteria, green and purple bacteria, process of photosynthesis with special reference to microorganisms.

c. **Metabolism of lipids:** Biosynthesis of lipids in yeasts and bacteria, beta-oxidation, biosynthesis of cholesterol and ergosterol.

d. **Metabolism of nitrogenous compounds:** Transamination, oxidative deamination, decarboxylation, ammonia transport and urea cycle. General biosynthetic pathways of amino acids, brief account of biosynthesis of purines, pyrimidines, nucleotides and porphyrins.

e. **Bioenergetics:** Introduction, Principles of thermodynamics, stoichiometry calculations, stoichiometry predictions based on Gibbs free energy change, high energy compounds- ATP, NAD, FAD, FMN, quinones, components and mechanisms of respiratory chain, mechanism of oxidative and substrate level phosphorylation.

f. Biochemistry and physiology of growth and metabolism; Introduction, metabolism, catabolic pathways, gluconeogenesis, energy production in aerobic microorganisms, anaerobic metabolism, biosynthesis, control of metabolic processes, efficiency of microbial growth.

2. Fungal and bacterial secondary metabolism: 24 hrs.

a. Secondary metabolites and regulation of secondary metabolism.
b. **Antibiotics:** Definition, Discovery, classification, structure and mode of action.
c. Biosynthesis of secondary metabolites -beta-lactum antibiotics, patulin, Aflatoxin, ergot alkaloids.
d. **Fungal toxins:** Bioassay, types of toxins (toxins derived from aminoacids, aromatic and phenolic toxins, terpeniod toxins, polysaccharides and glycoproteins, plant growth regulators).
e. **Bacterial toxins:** Exo and endotoxins, enterotoxins.
f. **Pigments:** Melanin, carotenoids.
g. **Fungal hormones:** Sirenin (*Allomyces*) Sterols (*Achlya*). Trisporic acid (Ascomycetes), peptide hormones (Basidiomycetes).
h. **Bioluminescence in microorganisms:** Mechanism and significance.

C. Bioinformatics 20 hrs.

1. An overview, introduction and scope of bioinformatics.

2. Biological databases: Types of databases (Entrez, SRS or Sequence Retrieval system. PIR or protein identification resource, GENE BANK, SWISS-PROT and other databases). Major bioinformatics databases and data analysis.

3. Sequence analysis: Models for sequence analysis, methods for alignment (data matrices), method for optimal alignment (gap penalties and scoring matrices). Tools for sequence alignment- FASTA, BLASTA, PSI-Blast.

4. Phylogenetic analysis: Phylogenetic trees, Methods of phylogenetic evaluation.

5. Proteomics: Proteome analysis, different structural proteins, protein classification. Tools for proteome analysis.

6. Gene Prediction: Methods and gene prediction tools. Gene mapping : DNA sequencing, Algorithms for alignment of sequencing fragments, DNA micro arrays.

References;

1. Batzing, B.L. 2002. Microbiology (An Introduction), Brooks/Cole Thamson Learining, Canada.
2. Cooper, G.M and Hausman, R.2009. The Cell A molecular Approach, 5th edition, ASM Press, Washington, D.C.
3. Moat, A.G., Foster, J.W and Spector, M.P. Microbial Physiology, 4th edition, A John Wiley & Sons, Inc., Publication.
4. Ratledge, C and Kristiansen, B. 2001. Basic Biotechnology, 2nd edition, Cambridge University Press, USA.

5. Willey, J.M., Sherwood, L.M and Woolverton, C.J.2008. Prescott, Harley, and Klein's Microbiology, McGraw-Hill, New York.
6. Rastogi,S.C., Menndiratta,N. and Rastogi, P. 2007. Bioinformatics methods and applications, 2nd edition, Printice-hall of India. Pvt.Ltd. New Delhi.
7. Rajan,S.S and Balaji, R. 2002. Introduction to bioinformatics, Himalaya Publishing house, Mumbai.

MB-2.2: Microbial Genetics and Molecular Biology

80 hrs.

1. **Brief history of the development of genetics and genetics concepts;** basic principles of heredity, over view of Mendelian principles, laws of inheritance; the genetic elements; chemical basis of heredity, chromosomal genes, extrachromosomal genetic elements, Transposable elements. **06 hrs.**
2. **Structure of nucleic acids:** Structure and types of DNA, Watson-Crick model of DNA, melting of DNA (tm, cot curve) structure and types of RNA **04 hrs.**
3. **DNA replication:** Semiconservative, origin, direction, rate of replication, termination, positive and negative control, enzymes in replication, DNA polymerase I, II and III **06 hrs**
4. **RNA biosynthesis:** - DNA dependent RNA polymerase, prokaryotic and eukaryotic RNA synthesis, mechanism of transcription; role of RNA polymerases; **05 hrs.**
5. **Genetic code:** Triplet codon, arrangement of condons, arrangement of initiation and termination codons. **04 hrs.**
6. **Protein synthesis:** mechanism of transcription and translation (initiation, elongation and termination), post translational modifications of proteins. **05 hrs**.
7. **Gene expression:** Gene organization, regulation of gene expression –Negative and positive regulation, operon concepts: Lac-operon and Tryp-operon. **05 hrs.**
8. **Mutation and mutagenesis:** Nature, type and effects, of mutations. Mutagenesis – physical and chemical mutagens, base and nucleoside analog, alkylating agents, interrelating agents, ionizing radiation, repair mechanisms, reversal of damage, excision repair, mis-match repair, post-replication repair. Biochemical mutations and pathways in microorganisms. Site directed mutagenesis. **07 hrs.**
9. **Recombination in fungi:** Linkage detection, linkage distance in two point crosses, three-point linkage distances, chromatid and chiasma interference, mitotic recombination, gene conversion, cytoplasmic gene mapping. Importance of *Neurospora* and yeasts in fungal genetics. **05 hrs.**

Recombination in bacteria: General principles and significance; Bacterial transformation; natural and artificial transformation, linkage and importance.

Bacterial conjugation: F factor, mechanism of bacterial conjugation, Hfr conjugation, conjugation mapping, recombination mapping, somatic hybridization.

Transduction: types and mechanisms, generalized and specialized transduction.

Bacteriophages: General characteristics, morphology and structure of prophage integration, excision and transduction, host restriction and modifications, restriction mapping. Overview of bacterial genetic map. **10 hrs.**

10. **Recombination in viruses:** Phage phenotypes, phenotype mixing, viral chromosome replication, recombination and mapping, circular map, temperate phages, negative interference. **06 hrs.**
11. **Recombinant DNA technology** **17 hrs.**

a. **Molecular tools:** Restriction endonucleases properties, classification and functions; General features of DNA polymerases, RNA polymerases, reverse tranusaiptase and ligases, Oligonucleotides as probes and primers, **Vectors:** General characteristics of vectors, size, ori site (s), selection/marker gene restriction sites, cosmids, animal and plant viruses. **Expression vectors**: Promoter requirement lac-z, T7, Tac.

b. Cloning of genes: cDNA library, genomic Library.

c. Transfer of recombinant DNA into host cells: Genetic transformation of bacterial, yeast, animal and plant cells.

d. Plating, screening and selection of recombinants.

e. DNA sequencing, DNA finger printing, RFLP, RAPD, PCR methods, protein engineering, southern and northern blotting: General principles and applications.

References;

1. Friedbreg, E.C., Walker, G.C., Siede, W., Wood, R.D., Schultz, R.A. and Ellenberger, T. 2006. DNA Repair and Mutagenesis, 2nd edition, ASM Press, Washington, D.C.
2. Nelson, D and Cox, M.M.2000. Lehiniger Principles of Biochemistry, 3rd edition, Worth Publishers, USA.
3. Strickberger, M.W.2006. Genetics, 3rd edition, Prentice-Hall of India Private Limited, New Delhi.
4. Tropp, B.E. 2008. Molecular Biology (Genes to Proteins), 3rd editions, Jones and Barlett Publishers, London.
5. Watson, Baker, Bell, Gall, Levina and Lorick. 2008. Molecular Biology of the Gene, 6th edition, Pearson Benjamin Cummings Publishers, Cold Spring Harbor Laboratory Press, New York,

MB-2.5: (A) Plant-Microbe interactions 64 hrs.

1. Introduction to microbial interactions with plants. **02hrs.**
2. Levels of interaction of microorganisms with plants. **03hrs.**

3. Nature of plant-microbe interaction
   a) **Symbiotic relationship of microorganisms with plants:** *Rhizobium* and mycorrhizal fungi. **05hrs.**
   b) **Plant-pathogen interactions:** Biology of *Agrobacterium*, *Peronospora*, *Alternaria* and TMV interactions with their hosts. **06 hrs.**
4. Role of receptors, elicitors, lectins, cell wall surface components, suppressors, enzymes, toxins, PR-proteins and other cellular mediators in plant-microbe interactions. **09 hrs.**
5. Molecular approaches in the study of plant-microbe interactions, genetic basis of pathogenicity and parasitism, signal transduction, compatibility and incompatibility, gene-for-gene concept. **07 hrs.**
6. Plant interaction with endophytic bacteria and fungi **03hrs.**
7. Use of Avirulent mutants in control of bacterial and fungal disease of plants **02hrs.**
8. Crop protection **01hrs.**
9. Use of Avirulent strains of plant viruses **02hrs.**
10. Interactions of plants, soil pathogens and their antagonists in natural ecosystem **02hrs.**
11. Fungal and oomycetes genetics **02hrs**.
12. Bacterial plant pathogenesis-host specificity and establishment of infection, secretary systems of bacteria **03hrs.**
13. Transgenic approaches for crop protection pathogen derived resistance, plantibodies, over expressing defence genes, use of cloned resistance genes, expression of vaccines in plants, engineering broad spectrum resistance. **08hrs.**
14. **Systemic acquired resistance in plants:** Hypersensitive response and associated defense reactions in plants, induced structural and biochemical defense mechanisms. **06hrs.**
15. Plant microbe interaction models and their significance. **03hrs.**

References;

1. Agrios, G. 2005. Plant Pathology, 5th edition, Reed Elsevier India Private Limited, New Delhi, India.
2. Ayres, P.G. 1992. Pests and Pathogens (Plant Responses to foliar Attack), Bioscientific Publishers.
3. Ayres, P.G. 1992. Pests and Pathogens (Plant Responses to foliar Attack), Bioscientific Publishers.
4. Carlile, M.g., Watkinson, S.C and Gooday, G.W. 1994. The Fungi, Academic Press, UK.
5. Geger, M.J. and Stence, M.J. 2001. Biotic interactions in plant pathogen association. CAB-International, United Kingdom.
6. Gow, N.A.R and Gadd, G.M. 1996. The growing fungus, Chapman and Hall Publishers, London.
7. Mehrotra, R.S.1980. Plant Pathology, Tata McGraw-Hill publishing Company Limited, New Delhi.
8. Pelczar, M.J, Chan, E.C.S and Krieg, N.R. 1986. Microbiology, 5th edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi.

9. Rangaswami, G and Bagyarai, D.J.2005. Agricultural Microbiology, 2nd edition, Prentice-Hall of India Private Limited, New Delhi.

Soft Core: MB.2.5 (B)-Microbial Enzymology 64 hrs.

1. Enzyme nomenclature, classification, general properties, enzyme structure, chemical modification by active site directed reagents, enzyme co-factors as redox carriers. **07 hrs.**
2. An introduction to bio energitics, and kinetics

   First and second law of thermo dynamics; enthalpy , entropy, and free energy; free energy and chemical reaction; factors affecting the rate of chemical reaction;- collision theory, activation energy and transition theory, catalysis**.** **06 hrs.**

3. **Enzyme kinetics**; General kinetic principles; steady-state enzyme kinetics, Michelis-Menton equation and linear transformation of MM- equation- reversible equations-fast reactions-and methods of steady- state by King and Altmann**.** **07 hrs.**
4. **Enzyme inhibition studies;** kinetics of competitive, non competitive, uncompetitive, and mixed inhibitors, Reaction of two substrates-isotopes exchange. **06 hrs.**
5. **Enzyme regulation;** Allosteric and cooperative effects: conquered model of Monod *et al*, and seqential model of Koshland *et al*, Principles of metabolic regulations; feed back regulations of multifunctional pathway, NAD/NADH ratio **06 hrs.**
6. **Mechanism of enzyme action:** Acid base catalysis, covalent catalysis, chymotrypsin, Metals in enzyme catalysis: pyruvate kinase, super oxide desmutase, creatine kinase, corboxy peptidase, Multi enzyme complex, Fatty acid synthatase complex: biological significance of multi enyme complex. **08 hrs.**
7. **Coenzymes:** Structure and functions of different coenzymes. **02 hrs.**
8. **Assay techniques for microbial enzymes**: Amylases, proteiases, cellulases, pectinases, and lipases, Basic principles of cell and enzyme immobilisation.**06 hrs.**
9. **Isolation and purification of enzymes:** enzyme extraction –soluble enzymes, membrane bound enzymes, purification-precipition methods, concentration of biomolecules: salting with ammonium sulphate, PEG precipation, flash evoparation, lyophilisation, dialysis, chromatographic methods, criteria of purity-total activity and specific activity, crystallization of enzymes **.** **08 hrs.**
10. Uses of enzymes in analysis – enzyme electrodes. Enzyme as biosensor, potentiometric biosensor, optical and industrial applications of enzymes .Commercial value: steriodical conversions, penicillin and antibiotic conversion, immunosensor. Recent advances and future prospects of enzyme engineering; artificial enzymes. Enzymes in organic solvents, enzyme targeting using liposomes, isoenzymes**.** **08 hrs.**

References;

1. Palmer, T.2004. ENZYMES Biochemistry, Biotechnology, Clinical chemistry, East West press, New Delhi.
2. Palmer, T and Bonner, P.L.2008. ENZYMES Biochemistry, Biotechnology and Clinical chemistry, 2nd edition, East West press, New Delhi.
3. Singh, S. 2007. A text Book of Enzymes, Campus Books International, New Delhi.

MB-2.7: (A) – Microbiological analysis of water 32 hrs.

1. Sources of Microbial contamination of water. Factors influencing microbial Contamination of water **05 hrs.**
2. Samlping of water for microbiological analyses. Types of water samples Collection, transport and processing of samples. **05 hrs.**
3. Detection of microbial populations in water – Phenotypic detection. **04 hrs.**
4. Determination of microbial members: Direct count and viable count procedures **03 hrs.**
5. Detection methods for water-borne pathogens-multiple tube fermentation Method, membrane filter method, P-A technique, rapid detection of coliforms. **05 hrs.**
6. Detection of indicators of pathogenic bacteria-enterococci, bacteriophages **05 hrs.**
7. Water disinfection methods. Safe limits for drinking water. Water Quality standards. **05 hrs.**

References;

1. Alcamo, I.E. 1997. Fundamentals of Microbiology, 5th edition, An imprint of Addison Wesley Longman, New York.
2. Batzing, B.L. 2002. Microbiology (An Introduction), Brooks/Cole Thamson Learining, Canada.
3. Bauman, R. 2007. Microbiology (With diseases by Taxonomy), 2nd edition, Pearson Benjamin Cummings Publishers, San francisco.
4. Cappucino, J.G. and Sherman, N. 2005. Microbiology, A Laboratory Manual, 7th edition, Pearson Education INC. Delhi, India
5. Patnail, P. 1997. Hand Book of Environmental Analysis. CRC Press, Inc., USA.
6. Willey, J.M., Sherwood, L.M and Woolverton, C.J.2008. Prescott, Harley, and Klein's Microbiology, McGraw-Hill, New York.

MB-2.7: (B) Agricultural Microbiology 32 hrs.

1. Concepts and scope of agricultural microbiology, importance of microorganisms in agriculture, influence of microorganisms in plant growth, modern concept of

microbial inoculants in agriculture; biological nitrogen fixation-symbiotic and non-symbiotic nitrogen fixation, mechanism of nitrogen fixation and importance. **06 hrs.**

2. Interaction of soil microorganisms with plants; Rhizosphere and phylloplane microorganisms. **04 hrs.**
3. *Rhizobium* inoculants: Brief account of production and application of *Rhizobium* inoculant; physiology and genetics pf nodulation and nitrogen fixation, strain selection and mass culturing. **05 hrs.**
4. Brief account of production and utility of *Azotobacter, Azospirillum*, cyanobacteria, *Azollo, Frankia* **05 hrs.**
5. Phosphate-solubilizing, microorganisms-importance, application of these microorganisms in agriculture. **03 hrs.**
6. Types and application of mycorrhizae. **04 hrs.**
7. Methods of biofertilizer application-seed inoculation, soil amendment and nursery application. **05 hrs.**

References;

1. Agrios, G. 2005. Plant Pathology, 5th edition, Reed Elsevier India Private Limited, New Delhi, India.
2. Carlile, M.G., Watkinson, S.C and Gooday, G.W. 1994. The Fungi, Academic Press, UK.
3. Gow, N.A.R and Gadd, G.M. 1996. The Growing Fungus, Chapman and Hall Publishers, London.
4. Mehrotra, R.S.1980. Plant Pathology, Tata McGraw-Hill publishing Company Limited, New Delhi.
5. Purohit, S.S. 2003. Agricultural Biotechnology, 2nd edition, Agrobios Publisher, Jodhpur, India.
6. Rangaswami, G and Bagyarai, D.J.2005. Agricultural Microbiology, 2nd edition, Prentice-Hall of India Private Limited, New Delhi.

MB-3.1: Agricultural Microbiology and Phytopathology 80 hrs.

A: Agricultural Microbiology

1. Concepts and scope of agricultural microbiology, importance of microorganisms in agriculture, influence of microorganisms in plant growth, modern concepts of microbial inoculants in agriculture; symbiotic and non-symbiotic nitrogen fixation, mechanisms of nitrogen fixation and importance. **06 hrs.**
2. **Interaction of soil microorganisms with plants:** Rhizosphere and phylloplane microorganisms. **02 hrs.**
3. Mass culturing and quality control of microbial inoculants-mother culture, shake culture and brief account of large scale production of biofertilizers, types of carrier materials, packing, storage, bench life and transportation of biofertilizers. ISI standards and quality testing at different levels. **06 hrs.**
4. Methods of biofertilizer application- seed inoculation, soil amendment and nursery application. **04 hrs.**
5. ***Rhizobium* inoculants:** Brief account of production and application of *Rhizobium* inoculant; strain selection and mass culturing. **03 hrs.**
6. Brief account of production and utility of *Azotobacter, Azospirillum,* cyanobacteria, *Azolla*, *Frankia*. Salient features and significance of strains and application of these organisms. **04 hrs.**
7. Phosphate-solubilizing microorganisms-importance, culturing and applications of these microorganisms in agriculture. **02 hrs.**
8. **Mycorrhizae:** types, importance and application of mycorrhizae, parameters for strain selection**.** **03 hrs.**

B: Phytopathology

1. Introduction and historical milestones, significance of plant diseases, types of plant diseases, basic procedure of plant disease diagnosis, parasitism, pathogenicity and plant disease development, disease cycle, infection cycle and plant disease triangle **03 hrs.**
2. **Levels of plant-pathogen interaction:** Prepenetration, host-recognition, role of host exudates, entry by plant pathogens through natural openings and wounds, direct penetration, process of pathogenesis, infection and establishment of pathogens in the host tissues**.** **04 hrs.**
3. Role of pathogen enzymes in pathogenesis- production of different enzymes and action of pathogen enzymes on host tissues and significance of these enzymes in disease development**.** **04 hrs.**
4. Role of phytotoxins in plant pathogenesis-types of toxins produced by plant pathogens, effect of toxins on disease development. **03 hrs.**
5. Role of plant growth regulators in plant pathogenesis. **1 hr.**
6. **Defense mechanisms in plants:** Structural and biochemical defense mechanisms role of elicitors, receptors and suppressors in disease development, molecular mechanisms in expression of plant disease resistance**.** **08 hrs.**

7. **Epidemiology of plant diseases:** Effect of environmental factors on disease development; Dissemination of plant pathogens; Disease forecasting and its Significance **02 hrs.**
8. **Seed Pathology:** Importance of seed-borne diseases and seed health testing methods. **05 hrs.**
9. **Plant Disease Management:** **10 hrs.**

a. Cultural methods-exclusion, eradication, crop rotation and sanitation.
b. Inspection and certification, quarantine regulations.
c. Physical methods-soil solarization, hot water treatment, mulching and other methods.
d. Chemical control of plant diseases-preparation and use of different chemicals, types of chemicals used in plant disease management; application of chemicals to soil, seeds, plant and store house problems and remedies for fungicidal resistance.
e. Biological control of plant disease-selection, testing and use of antagonistic microorganisms and their metabolites, application methodology and significance.
f. Breeding for disease resistance, systemic acquired resistance; protoplast, cell, tissue culture and somaclonal variation for disease resistance, biotechnological approaches in obtaining disease resistance plants, induced resistance, transgenic plants for plant disease management.
g. Integrated disease management practices.

10. Brief account of some important plant diseases (with one example for each group with description of pathogen, symptoms and management)-rots, damping-offs, downy mildews, white rust, powdery mildews, smuts, rusts, wilts, leaf spots, anthracnose, galls, ergots, bacterial diseases, viral diseases, phytoplasmal diseases, nematode diseases, protozoal diseases, viroid diseases, non-parasitic diseases and post-harvest diseases. **10 hrs.**

References;

1. Agrios, G. 2005. Plant Pathology, 5th edition, Reed Elsevier India Private Limited, New Delhi, India.
2. Ayres, P.G. 1992. Pests and Pathogens (Plant Responses to foliar Attack), Bioscientific Publishers.
3. Carlile, M.G., Watkinson, S.C and Gooday, G.W. 1994. The Fungi, Academic Press, UK.
4. Gow, N.A.R and Gadd, G.M. 1996. The growing fungus, Chapman and Hall Publishers, London.
5. Mehrotra, R.S.1980. Plant Pathology, Tata McGraw-Hill publishing Company Limited, New Delhi.
6. Purohit, S.S. 2003. Agricultural Biotechnology, 2nd edition, Agrobios Publisher, Jodhpur, India.
7. Rangaswami, G and Bagyarai, D.J.2005. Agricultural Microbiology, 2nd edition, Prentice-Hall of India Private Limited, New Delhi.
8. Agarwal, V.K and Sinclair, J.B. 1987. Principles of Seed Pathology, CBS Publishers, Delhi.

9. Srivastava, H.N. 2001. Plant Pathology, Pradeep Publications, Jalandhar.
10. Rao, N.S.S. 1993. Biofertilizers In Agriculture and Forestry, 3rd edition, Oxford & IBH Publishing Pvt. Ltd, New Delhi.
11. Dhingra, O.D and Sinclair, J.B. 1985. Basic Plant Pathology Methods, CBS Publishers, Delhi.
12. Nene, Y.L and Thapliyal, P.N. 1971. Fungicides In Plant Disease Control, 2nd edition, Oxford & IBH Publishing Co., New Delhi.
13. Nene, Y.L. 2001. Seed-borne Diseases Objectionable in Seed Production and their Management, Scientific Publishers, Jodhpur, India.

MB-3.2: Immunology and Medical Microbiology 80 hrs.

A: Immunology **42 hrs.**

1. **Overview of the immune system:** History, early theories of immunity, types of immunity-innate immunity and acquired immunity. **03 hrs.**
2. **Cells and organs of immune system:** Central lymphoid organs-bone marrow and thymus; peripheral lymphoid system-spleen, lymph nodes, gut associated lymphoid tissues; immunoreactive cells-development of T and B-lymphocytes, antigen processing and presenting macrophages, granulocytes and natural killer cells. **04 hrs.**
3. **Antigens;** Immunological properties of antigens, factors influencing immunogenicity, epitope, hapten, **03 hrs.**
4. **Immunoglobulins:** Immunoglobulin classes, basic structure and chemistry of IgG, IgM, IgA, IgE and IgD; Antigenic determinants of immunoglobulins-isotypic, allotypic and idiotypic determinants; diversity and specificity of antibodies. **05 hrs.**
5. **Immune response:** Primary antibody response, secondary antibody response and immunologic memory; antigen processing and presentation; cytokines; major histocompatibility complex; role of complements in immune response, hypersentivity-Type I, II, III and IV; autoimmune diseases, transplantation rejection;immunodeficiencies. **09 hrs.**
6. a) **Antigen-antibody reactions (*in vivo*):** Complement system, toxin neutralization, viral neutralization, opsonization, inflammation, immune complex formation, *in vivo* testing. **04 hrs.**
   b) **Antigen-antibody reactions (*in vitro*):** agglutination, complement fixation, precipitation, immunofluorescence, neutralization, immunoelectrophoresis, ELISA, RIA, Western blotting. **04 hrs.**
7. Production and applications of polyclonal and monoclonal antibodies for immunotherapy and disease diagnosis. **06hrs**
8. Different types of vaccines and their significance. **04 hrs.**

B: Medical Microbiology **38 hrs.**

1. Concepts and historical development of medical microbiology. **02 hrs.**

2. **Clinical microbiology;** outline, concepts, normal microflora of the human body, collection, handling and transport of Specimens; brief account of isolation and identification of microorganisms from specimens. **04 hrs**
3. **Antimicrobial chemotherapy:** outline, general characteristics of antimicrobial drugs, mechanisms of action of antimicrobial agents; Brief account of mechanisms and implications of drug resistance in microorganisms. **06 hrs.**
4. Pathogenesis, clinical conditions, laboratory diagnosis, epidemiology, chemotherapy and prevention of following infectious agents.

   a. Bacteria: *Staphylococcus, Streptococcus, Pneumococcus, Escherichia coli, Salmonella, Shigella, Neisseria, Corynebacterium, Pseudomonas, Vibrio, Yersinia Clostridium, Haemophilus, Bordetella, Pasturella, Brucella, Mycobacterium, Spirochaetes, Mycoplasma, Rickettsia, Chlamydia,* Actinomycetes. **09 hrs.**

   b. **Virus:** Measles, Mumps, Influenza, Yellow fever, HIV, Common cold, Herpes, Infectious mononucleosis, Rabies, Gastroenteritis, Hepatitis, Poliomyelitis, Dengue, Encephalitis **07 hrs.**

   c. Fungi: Superficial mycosis, cutaneous mycosis, subcutaneous mycosis, systemic mycosis, opportunisticmycosis **03 hrs**

   d. **Protozoa:**Ameobiasis,Giardiasis,Malaria,Leishmaniasis,Trypanosomiasis**.03hrs.**

   e. **Dental infections:** Dental plaque, dental caries, periodontal diseases. **02hrs.**

   f. Nosocomial infections: Bacteremia, burn wounds, respiratory tract infections, surgical site infections, urinary tract infections, miscellaneous infections. **02hrs.**

References;

1. Ananthanarayan, R and Paniker, C.K.J.2009.Text book of Microbiology, 8th edition, Universities press Private Limited, Hyderabad, India
2. Black, J.G. 1996. Microbiology Principles and Applications, 3rd edition, Prentice Hall Publictions, USA.
3. Coiw, R and Sunshine, G. Immunology (A short course), 6th edition, Wiley Blackwell.
4. Forbes, B., Sahm, D.F and Weissfeld, A.S.1998. Diagnostic Microbiology, 11th edition, Mosby, Inc.Missouri.
5. Janeway, Travers, Walport and Shlomchik.2005. Immunobiology (The immuno system in health and diseases), 6th editions, Garland Science Publishers, New York.
6. Kindt, T.J., Goldsby, R.A and Osborne, B.A.2007. Kuby Immunology, 6th edition, W.H. Freeman & Company, New York.
7. Male, D., Brostoff, J., Roth, D.B and Roitt, I.2006. Roitt Immunology, 7th edition, Mosby Elsevier Publishers.
8. Mims, C., Dockrell, H.M., Goering, R.V., Roitt, I., Wakelin, D. and Zucker, M. 2004. Medical Microbiology, 3rd edition, Elsevier Mosby, New York.

MB-3.5: (A) Immunotechnology 64 hrs.

1. **Immune system:** Brief account of immune system, types of immunity, immune response, cells and organs of the immune system; nature of immunogens, antigens and haptens. **05 hrs.**
2. **The nature and structure of antibodies**: Molecular structure of antibodies, physico-chemical properties of different classes of immunoglobulins, genetic variants of immunoglobulins, genetic basis of antibody diversity. **06 hrs.**

3. **Production of antibodies:** Biology and regulation of the immune response: cellular aspects of immune system, immunoregulation, tolerance. **03 hrs.**
4. **Production of polyclonal antisera:** Preparation of immunogens, adjuvants, immunization procedures, bleeding procedures and collection of serum and antibodies. **03 hrs.**
5. **Production of monoclonal antibodies**: Strategies, methodology for the production of hybridoma – cells, media, *in vitro* immunization, fusion, additives, ascites tumors, storage of hyridoma cells, *in vivo* immunization, initial growth, screening, selection and cloning. Recurrent problems in the hybridoma technique, T-cell cloning: principles and strategies. **07 hrs.**
6. Purification of immunoglobulins and preparation of Fab fragments: Preparation of immunoglobuins from polyclonal sera – principles and procedures of salting-out, purification with ion-exchangers, purification of IgA, Purifcation of IgM by gel filtration, electrophoresis, isoeletric focusing and isotachophoresis of immunoglobulins; preparative ultracentrifugation, affinity chromatography, purifications of IgY from egg yolk, purification of monoclonal antibodies, assessment of the purity and quality of immunoglobulins, preparation of Fab fragments- standard proteolytic cleavage methods, purification of Fab and Fab' fragments, production of recombinant antibodies **07 hrs.**

5. **Nature of antibody-antigen interactions:** Physico-chemical basis of antibody-antigen interaction, antibody specificity, cross reactivity, affinity and avidity, influence of the pH, ionic strength, temperature and organic solvents on the antibody-antigen interaction, measurements of the affinity of antibodies. **04 hrs.**
6. ***In vitro* techniques based on antigen-antibody interaction:** principles, methodology and applications of agglutination, complement fixation, precipitation, immunoelectrophoresis, immunofluorescence and HLA typing. **05 hrs.**
7. **Enzyme immunoassays(EIA):** Properties of enzymes used in EIA, Horse radish peroxidase, galactosidase, alkaline phosphatase, glucose oxidase, urease, enymes used in enzyme immunohistochemistry, preparation of enzyme-antibody conjugates, conjugation of haptens, immobilization of immunoreactants on solid phases, quantitative enzyme immunoassay techniques, substrates, chromogenic reagents, enzyme immunohistochemistry in light and electron microscopy, toxic hazards associated with EIA and applications. **07 hrs.**
8. **Radioimmunoassay (RIA) and Chemiluminiscent assays:** General principles, procedure and applications. **04 hrs**

9. **Immunohaemotology:** Overview, blood grouping, Rh factor determination, significance of blood cell based antigens. **04 hrs.**
10. **Immunotherapy:** Modulation of the immune and inflammatory response, antigen-specific therapy, antigen-nonspecific therapy **03 hrs.**
11. **Vaccinology:** Nature, types of vaccines, strategies for the production of whole organisms, purififed macromolecules, recombinant antigens, subunit, recombinant-vector based, peptide, multivalent, anti-idiotypic, DNA based, plant based vaccines. **06 hrs.**

References;

1. Coiw, R and Sunshine, G. Immunology (A short course), 6th edition, Wiley Blackwell.
2. Forbes, B., Sahm, D.F and Weissfeld, A.S.1998. Diagnostic Microbiology, 11th edition, Mosby, Inc.Missouri.
3. Janeway, Travers, Walport and Shlomchik.2005. Immunobiology (The immuno system in health and diseases), 6th editions, Garland Science Publishers, New York.
4. Kindt, T.J., Goldsby, R.A and Osborne, B.A.2007. Kuby Immunology, 6th edition, W.H. Freeman & Company, New York.
5. Male, D., Brostoff, J., Roth, D.B and Roitt, I.2006. Roitt Immunology, 7th edition, Mosby Elsevier Publishers.
6. Yadav, P.R. and Tyagi, R. 2005. Immuno-Biotechnology, Discovery Publishing House, New Delhi.

MB-3.5: (B) Fermentation Technology 64 hrs.

1. Basics of fermentation processes, definition, scope, history, chronological development of the fermentation industry. Component parts of fermentation process. **03 hrs.**
2. Microbial growth kinetics, batch and continuous, direct, dual or multiple fermentations; scale-up of fermentation, comparision of batch and continuous culture as investigative tools, examples of the use of fed batch culture. **06 hrs.**
3. Isolation, preservation and strain improvement of industrially important microorganism. Use of recombination system (parasexual cycle, protoplast fusion techniques), application of recombinant strains, the development of new fermentation products. **05 hrs.**
4. Screening (primary and secondary screening); detection and assay of fermentation products (physico-chemical assay, biological assays). **04 hrs.**
5. Inoculum development, criteria for transfer of inoculum, development of inoculum for yeast processes, bacterial fermentation and mycelial processes. **03 hrs**
6. Fermentation equipment and its use; (design of a fermentor, types of fermentor, agitation, aeration, antifoam, pH and temperature. Instrumentation and process variables control use of on-line, off line, on and off line control **05 hrs.**
7. Media formulation – raw materials, fermentation media, solid state, surface and submerged fermentation. **03 hrs.**

8. Fermentation type reactions (Alcoholic, bacterial, mixed acid, propionic acid, butanediol and acetone-butanol). **05 hrs.**
9. Microbial production of enzymes (amylases, Proteases, cellulases, pectinases and lipases) primary screening for producers, large scale production **05 hrs.**
10. Immobilization methods. techniques of immobilization,effect of immobilization on enzyme activity, applications of immobilized enzymes,commercial production of enzymes-amylases ,proteases, pectinases, cellulases and lipases, advantages and disadvantages of immobilization, Cell immobilization **06 hrs.**
11. Fermentative production of industrial alcohol, production of beverages**.** **03 hrs.**
12. Production of organic acids; citric acid, aminoacids; glutamic acid; production of vitamins. **04 hrs.**
13. Production of antibiotics; benzyl penicillin and tetracyclins, streptomycin production and applications, bacterial and fungal enzymes, (cellulases, amylases, xylanases, isomerases, proteases and lipases). **06 hrs.**
14. Single cell protein, production of uses; single cell oil, production and uses. **03 hrs.**
15. Biotransformations, Steroid transformations, industrial effluent treatment methods, waste water treatment. **03 hrs.**

References;

1. Casida, L.E.2007. Industrial microbiology, New age international (P) Ltd., New Delhi.
2. Clark, D.P and Pazdernik, N.J.2009. Biotechnology applying the genetic revolution, Elsevier Academic Press, UK.
3. Glazer, A and Nikaido.1995. Microbial biotechnology fundamentals of applied microbiology, W.H.Freemn and company, USA
4. Glick, B.R and Pasternak, J.J.2003. Molecular Biotechonology Principles and Applications of Recombinant DNA, 3rd edition, ASM Press, USA
5. Harider, S.I. and Ashok, A. 2009. Biotechnology, A Comprehensive Training Guide for the Biotechnology Industry, CRC Press, New York.
6. Sridhar, S.2010. Industrial Microbiology, Dominant Publishers, New Delhi
7. Tanuja.S and Purohit, S.S. 2008. Fermentation Technology, Agrobios Publication, Jodhpur, India

MB-3.7: (A) Diagnostic Microbiology 32 hrs.

1. An overview of medical microbiology, significance of microbial diseases of humans **04 hrs.**
2. **Medical Specimens:** collection procedure and transport of body fluid specimens, gastrointestinal specimens, genital specimens, respiratory specimens, urine specimens and wound specimens. **06 hrs.**
3. **Specimens processing:** General methods, microscopy, culture methods and serology. **05 hrs.**
4. Laboratory diagnosis of important bacterial, viral, fungal and protozoal infections. (*Mycobacterium*, *Staphylococcus*, *Treponema*, *Salmonella*, HIV, Hepatitis, *Aspergillus*, *Candida*, *Plasmodium*) **08 hrs.**
5. Antimicrobial drug testing procedures**.** **05 hrs.**

6. Laboratory safety measures and sample disposal. **04 hrs.**

References;

1. Coiw, R and Sunshine, G. Immunology (A short course), 6th edition, Wiley Blackwell.
2. Forbes, B., Sahm, D.F and Weissfeld, A.S.1998. Diagnostic Microbiology, 11th edition, Mosby, Inc.Missouri.
3. Janeway, Travers, Walport and Shlomchik.2005. Immunobiology (The immuno system in health and diseases), 6th editions, Garland Science Publishers, New York.
4. Kindt, T.J., Goldsby, R.A and Osborne, B.A.2007. Kuby Immunology, 6th edition, W.H. Freeman & Company, New York.
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MB-3.7: (B) Industrial Microbiology 32 hrs.

1. Concepts and scope of Industrial microbiology **03 hrs.**
2. Screening and strain improvement in industrial microbiology **04 hrs.**
3. **Industrial fermentors:** Basic functions, design and components.
   Different types of fermentors: Chemostat and turbiodstat, tower fermentors, membrance bioreactors, scale up of fermentation process **04 hrs**.
4. **Microbial growth kinetics:** Batch cultures, continuous cultures, fed-batch cultures, industrial production of biomass and metabolites **04 hrs.**
5. Fermentation media: desired qualities, sources of nutrition **03 hrs.**
6. Down stream processing: objectives and criteria **03 hrs.**
7. Industrial production of penicillin, alcohol, glutamic acid, vitamin A and alcoholic beverages. **04 hrs.**
8. Industrial enzymes: Production and applications of amylases, proteases, pectinases, cellulases and lipases **04 hrs.**
9. Immobilization of enzymes or cells. **03 hrs.**

References;

1. Casida, L.E.2007. Industrial microbiology, New age international (P) Ltd., New Delhi.
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MB-4.1: Food and Industrial Microbiology 80 hrs.

1. **Food Microbiology:**
   a. Introduction, development of food microbiology as a science. **01hrs.**
   b. Food as a substrate for microorganism; factors influencing the growth microorganisms (moisture, water activity, pH, nutrient content, inhibitory substances and biological structure**.** **03 hrs.**
   c. Source of food contamination-soil, water, air, sewage, plants and animals**. 02 hrs.**
   d. Microbial examination of foods-microscopic techniques and culture techniques.
   e. Food spoilage-general means of food spoilage, microorganisms involved in food spoilage of cereals, vegetables, meat, fish, egg and canned foods. Chemical changes caused by microorganisms. **04 hrs.**
   f. Food preservation-general principles, removal of microorganisms, maintenance of anaerobic conditions; preservation using high temperatures; factors affecting heat resistance; determination of heat resistance; thermal death time, determination of thermal processes, heat treatments employed in food processing, growth of microorganisms at low temperatures, low temperatures storage, effect of freezing temperatures on microorganisms; preservation by drying; microbiology of dry foods; food preservatives and factors influencing their effectiveness; preservation methods using radiations. **08 hrs.**
   g. **Food-borne illnesses:** General account of food borne bacterial diseases-*Clostridium*, Gasteroentitis, Vibrio, enteropathogenic *Escherichia coli*, *Bacillus*; Food poisoning-mycotoxins (aflatoxins, ochratoxins, trichothecines, zearalenones, ergot alkaloids); food borne viruses, parasites; seafood toxicants. **08 hrs.**
   h. Food fermentation-bread, malt beverages, vinegar, fermented vegetable, general principles in the production of cultures for food fermentation**.** **03 hrs.**
   i. **Microbial foods:** single cell proteins (*Spirulina*, yeast, *Fusarium*), fats from microorganisms, single cell oil (PuFas from fungi); mushroom-value, cultivation and preservation methods. **04 hrs.**
   j. Food control-Enforcement and control agencies, microbiological criteria for foods. **02 hrs.**
2. **Dairy Microbiology:** a. Nutritional level of milk, microbial flora of milk, sources of milk contamination **02 hrs.**

b. Bacteriology of milk: Incidence and characterization of pathogenic microorganisms in milk, bacteriological aspects of pasteurization, sterilization of milk; predominant types of microorganisms in chilled and refrigerated milk supplies and their importance; heat resistant types in milk and their role in milk spoilage; use of detergents and sanitizers in the cleaning and sanitation of dairy equipment's; principles of quality control tests for milk; bacteriological grading, market milk production and public health control. **04 hrs.**

c. **Microbiology of dairy products:** Microbiology of cream, butter, ice-cream and indigenous dairy products such as khoa, peda, yoghurth, acidophilus milk, dahi, kefir, koumiss, shrikhand, cultured butter milk, cheese and other fermented milk products; use of rennet and microbial rennet substitutes in cheese making. **04 hrs.**

d. Microbiology of dairy starter cultures: definition and properties of starter culture, criteria for starter selection, lactic and non-lactic starter cultures used in dairy industry; use of pure and mixed starter cultures in product manufacturing; production of flavour components by starter cultures; methods of starter maintenance, propagation and preservation; judging the quality of starter cultures; judging the quality of starter cultures. Defects associated with starter cultures – incidence, detection and control. **04 hrs.**

e. Microbial utilization of whey; composition of different dairy effluents, methods for treatment and disposal of dairy effluents; their significance and applications. **02 hrs.**

f. Current trends in microbiological quality control in dairy industry. **02hrs.**

3. Industrial Microbiology;

a) Concepts and scope of Industrial microbiology. **01 hrs.**
b) **Screening and strain improvement in industrial microbiology:** Industrial important species and strains, screening methods, strain development for improved yields, strain maintenance and preservation. **03hrs.**
c) **Industrial fermentors**: Basic functions, design and components-impellers, spargers, baffles, sterilization of fermentor, sterilization of air supply, inoculation methods, sampling methods, a brief account of monitoring and control devices.
d) **03 hrs.**
e) **Different types of fermentors:** Chemostat, turbidostat, gradostat, tabular fermentors, tower fermentors, membrane bioreactors, scale up of fermentation process-parameter and problems associated with scale up. **03 hrs.**
f) **Microbial growth kinetics:** Batch cultures, continuous cultures, fed-batch (variable volume, fixed volume, cyclic), comparison of batch and continuous cultures in industrial production of biomass and metabolites. **03 hrs.**
g) **Fermentation media:** desired qualities, sources of carbon, nitrogen, vitamins and minerals; role of buffers, precursors, inhibitors, inducers and antifoams**.** **02 hrs.**

h) **Down stream processing:** objectives and criteria, foam separation, precipitation methods, filtration devices, filter aids, industrial scale centrifugation and cell disruption methods, liquid-liquid extraction, solvent recovery, chromatography, microfiltration, ultrafiltration, drying devices, crystallization and whole broth processing. **04 hrs.**

i) Industrial fermentation of penicillin, lactic acid, glutamic acid, vitamin A and alcoholic beverages-wine, bear and whisky. **02 hrs.**

j) **Industrial enzymes:** production and applications of amylases, proteases, pectinases, cellulases and lipases. **02 hrs.**

k) **Immobilization of enzymes or cells:** methods, substrates, advantages and applications. **02 hrs.**

l) Modern approaches to industrial waste treatments. **02 hrs.**

References;

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2. Doy le, M.P., Beuchat, L.R. and Montville, T.J. 2001. Food Microbiology, Fundamentals and Frontiers, 2nd edition ASM Press Washington DC.
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4. Marth, E.H and Steele, J.L.2001. Applied Dairy Microbiology, r, Marcel Dekker AG Publishers, Switzerland.
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9. Stanbury, P.E, Whitaker, A. and Hall, S.J. Principles of fermentation technology.

MB-4.2: Microbial Biotechnology and Nanotechnology 80hrs.

1. Microbial Biotechnology: Introduction, Definition, Concepts, Microorganisms as tools, use of microorganisms and their products in biotechnology**.**

a. **Microorganisms for the production of macromolecules:**
   i. Production of proteins in bacteria-general methods and applications; production of chymosin in *Escherichia coli*.
   ii. Production of proteins in yeast-general protocols, enhancing the expression of foreign genes in yeast (Hepatitis B surface antigen); expression of foreign gene products in a secreted form (Prochymosin in yeast). **07hrs.**

b. **Microbial insecticides:** *Bacillus thuringensis*, *B. sphaericus*, *B. popilliae*, Baculoviruses, entomopathogenic fungi- *Beauveria*. **02 hrs.**

c. **Microbial polysaccharides and polyesters:** Bacterial polysaccharides, production of xanthan gum, microbial synthesis of rubber, microbial production of polyester-polyhydroxylkanoates. **03hrs.**

d. **Fungal biotechnology**: fungal useful products-alkaloids, antibiotics, ethanol, enzymes, gibberellins, organic acids, polysaccharides, vitamins. **02hrs.**

e. **Microbial production of useful products:** general principles and applications, production of insulin, human interferon, human growth hormone, DNAase I, alginate lyase, restriction endonucleases, vaccines. **04hrs.**

f. **Agricultural biotechnology**: use of symbionts and pathogens, development of insect-resistant, pathogen (fungal, bacterial viral)-resistant, herbicide-resistant and stress-tolerant plants; use of nitrogen fixing bacteria to improve crop yields, plants as bioreactors for the production of immunoglobulins, polymers and foreign proteins. Terminator seed technology. **05hrs.**

g. **Animal biotechnology:** General principles and applications; brief account of methodology for the production of transgenic mice, cattle, sheep, pigs **03hrs.**

h. **Gene therapy**: General principles of gene therapy, brief account of genetic diseases and techniques involved in gene therapy. Applications of human genome p r o j e c t. **03hrs.**

i. **Environmental Biotechnology:** Principles of degradative capabilities of microorganisms, genetic engineering for the control of pollutants. Bio gas production technology; Production of silage; microorganisms in mineral recovery and removal of heavy metals from aqueous effluents. **04hrs.**

j. **Biosensors:** Brief account of Amperometric, Potentiometric, Conductometric, Thermometric, Piezoelectric, Optical, Whole cell Biosensors. Immunosensors. **03 hrs.**

k. **Bioprocess engineering: Genome management and analysis in prokaryotes;** Introduction, Bacterial chromosomes and natural gene transfer, genetic engineering and uses, The basic tools of genetic engineering, cloning vectors and libraries, analysis of genomes/proteomes. **04hrs**.

l. **Genetic engineering; yeasts and filamentous fungi**; Introduction, Introducing DNA into fungi, gene cloning, gene structure, organization and expression, special methodologies, biotechnological applications of fungi. **04hrs**.

m. **Biotransformations**; Introduction, biocatalytic selection, biocatalytic immobilization and performance, Immobilized enzyme reactors, biocatalysis in non-conventional media. **04hrs.**

n. **Microbial process kinetics**; Nomenclature, Introduction, kinetic modeling of cell growth, mass balances for ideal bioreactors. **06hrs**.

o. **Recombinant proteins of high value;** Applications of high value proteins, analytical enzymes, therapeutic proteins, regulatory aspects of therapeutic proteins, outlook to the future of protein therapies. **04hrs**.

p. **Regulations and patenting in Biotechnology:** Regulating the use of biotechnology, deliberate release of genetically engineering organisms, regulation policies of human gene therapy. Patenting of biotechnological inventions, organisms and protocols. Social and ethical aspects of biotechnology. **04 hrs.**

l. **Medical biotechnology:** Recombinant vaccines, diagnostics-molecular tools in diagnosis. **03hrs**.

2. Nanotechnology: 15hrs.

1. Microorganisms for synthesis of nanomaterials and for toxicity detection: Natural and artificial synthesis of nanoparticles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of nanoparticles using microorganisms.

2. Drug Delivery, Therapeutic action of nanoparticles and nanodevices: Targeted, non-targeted delivery; controlled drug release; exploiting novel delivery routes using nanoparticles; gene therapy using nanoparticles; Nanostructures for use as antibiotics; Diseased tissue destruction using nanoparticles;

3. Biological Methods of Synthesis: Use of bacteria, fungi, Actinomycetes for nanoparticle synthesis, Magnetotactic bacteria for natural synthesis of magnetic nanoparticles; Mechanism of formation; Viruses as components for the formation of nanostructured materials; Synthesis process and application, Role of plants in nanoparticle synthesis, Biosensor and Biochips.

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2. Clark, D.P and Pazdernik, N.J.2009. Biotechnology applying the genetic revolution, Elsevier Academic Press, UK.
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