Proposed Scheme for Choice Based Credit System in B.Sc. Honours in Microbiology

Year	Semester	Core Course (14 Papers) 6 credits each	Ability enhancement compulsory course (AECC)(2 papers) (2 credits each)	Skill enhancement course (SEC)(any 2 papers) (2 Credits each)	Discipline Specific Elective Course (any 4 papers)(6 credits each	Generic Elective Course (any 4 papers) (6 credits each)
1	I	Paper 1 Paper 2	AECC-1			GE-1/2 Paper 1/2 (Any one)
	II	Paper 3 Paper 4	AECC-2			GE-1/2 Paper 3/4 (Any one)
2	III	Paper 5 Paper 6 Paper 7		SEC-Paper 1/2 (Any one)		GE-1/2 Paper 1/2 (Any one)
	IV	Paper 8 Paper 9 Paper 10		SEC-Paper 3/4 (Any one)		GE-1/2 Paper 3/4 (Any one)
3	V	Paper 11 Paper 12			DSE- Paper 1/2(Any one) DSE- Paper 3/4 (Any one)	
	VI	Paper 13 Paper 14			DSE- Paper 5/6 (Any one) DSE- Paper 7/8 (Any one)	

Overall distribution of credits and marks in B.Sc.(Hons.) In Microbiology

Course	Total papers	Credits /per		Total Credits
		Theory	Practical	
I.Core Courses	14	4	2	14X6=84
II.DSE	4	4	2	4X6=24
III.GE	4	4	2	4X6=24
IV.AECC	2	2	-	2x2=4
V.SEC	2	2	-	2x2=4
			Grand total	140

Structure of B. Sc. Honours Microbiology under CBCS

Core Course*[Theory+ Practical= 6 credit each paper, Theory = 4 credits, Practical= 2 credits]*
Paper -1: Introduction to Microbiology and Microbial Diversity
Paper -2: Bacteriology
Paper -3: Biochemistry
Paper -4: Virology
Paper -5: Microbial Physiology and Metabolism
Paper -6: Cell Biology
Paper -7: Molecular Biology
Paper -8: Microbial Genetics
Paper -9: Environmental Microbiology
Paper -10: Food and Dairy Microbiology
Paper -11: Industrial Microbiology
Paper -12: Immunology
Paper -13: Medical Microbiology
Paper -14: Recombinant DNA Technology

Discipline Specific Elective (Any Four)
[Theory+ Practical= 6 credit each paper, Theory = 4 credits, Practical= 2 credits]

DSE Paper -1: Instrumentation and Biotechniques
DSE Paper -2: Plant Pathology
DSE Paper -3: Advances in Microbiology
DSE Paper -4: Microbial Biotechnology
DSE Paper -5: Biosafety and Intellectual Property Rights
DSE Paper -6: Inheritance Biology
DSE Paper -7: Microbes in Sustainable Agriculture and Development
DSE Paper -8: Biomathematics and Biostatistics

Generic Electives (Any Four)
[Theory+ Practical= 6 credit each paper, Theory = 4 credits, Practical= 2 credits]

GE-1/2 Paper- 1: Introduction and Scope of Microbiology
GE-1/2 Paper- 2: Microbial Metabolism
GE-1/2 Paper- 3: Bacteriology and Virology
GE-1/2 Paper- 4: Medical Microbiology and Immunology

Ability Enhancement Compulsory Courses
[4 Credit each]

AECC-1: Environmental Sciences
AECC-2: English communication/Hindi communication /Bengali communication/Nepali communication

Skill Enhancement Elective Courses (Any Two)
[2 credit each]

SEC Paper-1: Microbial Quality Control in Food and Pharmaceutical Industries
SEC Paper-2: Biofertilizers and Biopesticides
SEC Paper-3: Microbial Diagnosis in Health Clinics
SEC Paper-4: Food Fermentation Techniques

A. CORE COURCES

Paper -1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (Theory)
Semester I

TOTAL HOURS: 60 CREDITS: 4

Unit 1 History of Development of Microbiology **No. of Hours: 18**

Development of microbiology as a discipline, Spontaneous generation*vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microbial World **No. of Hours: 42**

A. Systems of classification

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms

B. General characteristics of different groups: **Acellular** microorganisms (Viruses, Viroids, Prions) and **Cellular** microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

- **Algae**

General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles.

- **Fungi**

General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism.

- **Protozoa**

General characteristics with special reference to *Amoeba, Plasmodium*

Paper -1.1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (PRACTICAL)
Semester I

TOTAL HOURS: 60 CREDITS: 2

1. Microbiology Good Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, Autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the Microbiology laboratory.
3. Preparation of culture media for bacterial cultivation.
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Sterilization of heat sensitive material by membrane filtration and assessment for sterility
7. Demonstration of the presence of microflora in the environment by exposing nutrient agar Plates to air.
8. Study of *Rhizopus*, *Aspergillus* using temporary mounts

9. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Plasmodium*

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition.Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4.Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology.9th Edition. McGraw Hill International.
5. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology.5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005).General Microbiology.5th edition. McMillan.

Paper -2: BACTERIOLOGY (THEORY)
Semester I
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Cell organization **No. of Hours: 14**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.

Unit 2 Bacteriological techniques **No. of Hours: 5**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

Unit 3 Microscopy **No. of Hours: 6**

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope, Confocal microscopy, Scanning and Transmission Electron Microscope

Unit 4 Growth and nutrition **No. of Hours: 8**

Nutritional requirements in bacteria and nutritional categories; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media *Physical methods of microbial control*: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation *Chemical methods of microbial control*: disinfectants, types and mode of action

Unit 5 Reproduction in Bacteria **No. of Hours: 3**

Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate

Unit 6 Bacterial Systematics **No. of Hours: 8**

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing. Differences between eubacteria and archaebacteria

Unit 7 Important archaeal and eubacterial groups **No. of Hours: 16**

Archaebacteria: General characteristics, Overview to Nanoarchaeota, Crenarchaeota ,Euryarchaeota, thermophiles and Halophiles

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative:

General characteristics with suitable examples of Alpha proteobacteria, Beta proteobacteriaand Gamma proteobacteria

Gram Positive:

Low G+ C (Firmicutes): General characteristics with suitable examples High G+C (Actinobacteria): General characteristics with suitable examples

***Cyanobacteria*:** An Introduction

Paper -2.2: BACTERIOLOGY (PRACTICAL)

Semester I

TOTAL HOURS: 60 CREDITS: 2

1. Preparation of different media: synthetic media BG-11, Complex media-Nutrient agar, McConkey agar, EMB agar.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining-permanent slide only.
6. Capsule staining
7. Endospore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method/pour plate method.
11. Motility by hanging drop method.

SUGGESTED READINGS

1. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM.(2014). Brock Biology of Micro-organisms.14th edition.Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR.(2004). Microbiology.5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education.
9. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited

Paper -3: BIOCHEMISTRY (THEORY)
Semester –II
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Bioenergetics **No. of Hours: 8**

First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy,and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP

Unit 2 Carbohydrates **No. of Hours: 12**

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin

Unit 3 Lipids **No. of Hours: 12**

Definition and major classes of storage and structural lipids.Storage lipids.Fatty acids structure and functions.Essential fatty acids. Triacyl glycerols structure, functions and properties. Saponification Structural lipids. Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebrosides and gangliosides Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers

Unit 4 Proteins **No. of Hours: 12**

Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Titration curve of amino acid and its Significance, Classification, biochemical structure and notation of standard protein amino acids Ninhydrin reaction.Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D- glutamic acid Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame, Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins, Tertiary and quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure, Quaternary structures of proteins

Unit 5. Enzymes **No. of Hours: 12**

Structure of enzyme: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme NAD,metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, Km, and allosteric mechanism Definitions of terms – enzyme unit, specific activity and turnover number, Multienzyme complex : pyruvate dehydrogenase; isozyme: lactate dehydrogenase, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts

Unit 6. Vitamins **No. of Hours: 4**

Classification and characteristics with suitable examples, sources and importance

Paper -3.1: BIOCHEMISTRY (PRACTICALS)
SEMESTER –II

TOTAL HOURS: 60 CREDITS: 2

1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts
2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant
3. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non reducing sugars
4. Qualitative/Quantitative tests for lipids and proteins
5. Study of protein secondary and tertiary structures with the help of models
6. Study of enzyme kinetics – calculation of V_{max}, Km, Kcat values
7. Study effect of temperature, pH and Heavy metals on enzyme activity
8. Estimation of any one vitamin

SUGGESTED READING

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company,
6. Willey MJ, Sherwood, LM & Woolverton C J (2013) Prescott, Harley and Klein's Microbiology by. 9th Ed., McGrawHill
7. Voet,D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons,

Paper -4: VIROLOGY (THEORY)
SEMESTER –II
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Nature and Properties of Viruses **No. of Hours: 12**

Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses Isolation, purification and cultivation of viruses Viral taxonomy: Classification and nomenclature of different groups of viruses

Unit 2 Bacteriophages **No. of Hours**: **10**

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage

Unit 3 Viral Transmission, Salient features of viral nucleic acids and Replication

No. of Hours: **20**

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal Salient features of viral Nucleic acid : Unusual bases (TMV,T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV) Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of

viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna) , Assembly, maturation and release of virions

Unit 4 Viruses and Cancer **No. of Hours: 6**

Introduction to oncogenic viruses Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes

Unit 5 Prevention & control of viral diseases **No. of Hours: 8**

Antiviral compounds and their mode of action, Interferon and their mode of action
General principles of viral vaccination

Unit 6 Applications of Virology **No. of Hours: 4**

Use of viral vectors in cloning and expression, Gene therapy and Phage display

Paper -4.1: VIROLOGY (PRACTICAL)

SEMESTER –II

TOTAL HOURS: 60 CREDITS: 2

1. Study of the structure of important animal viruses (influenza, hepatitis B and retroviruses) using electron micrographs
2. Study of the structure of important plant viruses (Gemini, tobacco ring spot and alpha-alpha mosaic viruses) using electron micrographs
3. Study of the structure of important bacterial viruses (T4, λ) using electron micrograph.
4. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique
5. Study of cytopathic effects of viruses using photographs
6. Perform local lesion technique for assaying plant viruses.

SUGGESTED READING

1. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
2. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology, Molecular biology, Pathogenesis and Control.2nd edition. ASM press Washington DC.
4. Levy JA, Conrat HF, Owens RA. (2000). Virology.3rd edition. Prentice Hall publication, New Jersey.
5. Wagner EK, Hewlett MJ. (2004). Basic Virology.2nd edition.Blackwell Publishing.
6. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
7. Nayudu MV. (2008). Plant Viruses. Tata McGraw Hill, India.
8. Bos L. (1999) Plant viruses-A text book of plant virology by. Backhuys Publishers.
9. Versteeg J. (1985). A Color Atlas of Virology.Wolfe Medical Publication.

Paper -5: MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)

SEMESTER –III

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth **No. of Hours: 12**

Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve Microbial growth in response to environment -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative

anaerobe),barophilic. Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.

Unit 2 Nutrient uptake and Transport **No. of Hours: 10**

Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration **No. of Hours: 16**

Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation
No. of Hours: 6

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism **No. of Hours: 10**

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism – groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria

Unit 6 Nitrogen Metabolism - an overview **No. of Hours: 6**

Introduction to biological nitrogen fixation Ammonia assimilation Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

Paper -5.1: MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)

SEMESTER –III

TOTAL HOURS: 60 CREDITS: 2

1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of carbon and nitrogen sources on growth of *E.coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

SUGGESTED READINGS

1. Madigan MT, and Martinko JM (2014).Brock Biology of Microorganisms.14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology.4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism.2nd edition. Springer Verlag
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition.

McGraw Hill Higher Education.

Paper -6: CELL BIOLOGY (THEORY)
SEMESTER –III
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Structure and organization of Cell **No. of Hours: 12**

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic Plasma membrane: Structure and transport of small molecules Cell Wall: Eukaryotic cell wall, aspects) Mitochondria, chloroplasts and peroxisomes Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

Unit 2 Nucleus **No. of Hours: 4**

Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization Nucleolus

Unit 3 Protein Sorting and Transport **No. of Hours: 12**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus Lysosomes

Unit 4 Cell Signalling **No. of Hours: 8**

Signalling molecules and their receptors Function of cell surface receptors Pathways of intra-cellular receptors **–** Cyclic AMP pathway

Unit 5 Cell Cycle, Cell Death and Cell Renewal **No. of Hours: 12**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis,Development of cancer, causes and typesProgrammed cell death

Paper -6.1: CELL BIOLOGY (PRACTICAL)
SEMESTER –III

TOTAL HOURS: 60 CREDITS: 2

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Study of polyploidy in Onion root tip by colchicine treatment.
5. Identification and study of cancer cells by photomicrographs.
6. Study of different stages of Mitosis.
7. Study of different stages of Meiosis.

SUGGESTED READING

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell.8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons.Inc.
3. De Robertis, EDP and De Robertis EMF.(2006). Cell and Molecular Biology.8th edition. Lipincott Williams and Wilkins, Philadelphia.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition.ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

Paper -7: MOLECULAR BIOLOGY (THEORY)
SEMESTER –III
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Structures of DNA and RNA / Genetic Material No. of Hours: 12

DNA Structure: Miescher to Watson and Crick- historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves. DNA topology – linking number, topoisomerases; Organization of DNA Prokaryotes,Viruses, Eukaryotes.RNA Structure, Organelle DNA -- mitochondria and chloroplast DNA.

Unit 2 Replication of DNA (Prokaryotes and Eukaryotes) No. of Hours: 10

Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replication Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNApolymerases, DNA ligase, primase, telomerase – for replication of linear ends Various models of DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication and other accessory protein.

Unit 3 Transcription in Prokaryotes and Eukaryotes No. of Hours: 8

Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unitTranscription in Eukaryotes: RNA polymerases, general Transcription factors

Unit 4 Post-Transcriptional Processing No. of Hours: 8

Split genes, concept of introns and exons, RNA splicing, spliceosome machinery**,** concept of alternative splicing, Polyadenylation and capping, Processing of rRNA

Unit 5 Translation (Prokaryotes and Eukaryotes) No. of Hours: 10

Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation,elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation,Inhibitors of protein synthesis in prokaryotes and eukaryote

Unit 6 Regulation of gene Expression in Prokaryotes and Eukaryotes
No. of Hours: 12

Principles of transcriptional regulation, regulation at initiation with examples from *lac* operon, Sporulation in *Bacillus,*Changes in Chromatin Structure -DNA methylation and Histone Acetylation mechanisms.

Paper -7.1: MOLECULAR BIOLOGY (PRACTICAL)
SEMESTER –III
TOTAL HOURS: 60 CREDITS: 2

1. Study of different types of DNA and RNA using micrographs and model / schematic representations
2. Study of semi-conservative replication of DNA through micrographs / schematic representations
3. Isolation of genomic DNA from *E. coli*
4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement)
5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A_{260} measurement)
6. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
7. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

SUGGESTED READINGS

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication
2. Becker WM, Kleinsmith LJ, Hardin J and Bertoni GP (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco
3. De Robertis EDP and De Robertis EMF (2006) Cell and Molecular Biology, 8th edition. Lippincott

Williams and Wilkins, Philadelphia
4. Karp G (2010) Cell and Molecular Biology: Concepts and Experiments, 6th edition, John Wiley & Sons.Inc.
5. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
6. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
7. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India

Paper -8: MICROBIAL GENETICS (THEORY)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Genome Organization and Mutations **No. of Hours: 18**

Genome organization: *E. coli, Saccharomyces,* Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens;
Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of
Mutations Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutatorgenes

Unit 2 Plasmids **No. of Hours: 10**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids,
Plasmid replication and partitioning, Host range, plasmid-incompatibility,
, Regulation of copy number, curing of plasmids

Unit 3 Mechanisms of Genetic Exchange **No. of Hours: 12**

Transformation - Discovery, mechanism of natural competence Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique
Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates,

Unit 4 Phage Genetics **No. of Hours: 8**

Genetic basis of lytic *versus* lysogenic switch of phage lambda

Unit 5 Transposable elements **No. of Hours: 12**

Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Drosophila (P elements), Maize
(Ac/Ds) Uses of transposons and transposition

Paper -8.1: MICROBIAL GENETICS (PRACTICAL)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 2

1. Preparation of Master and Replica Plates
2. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light
4. Isolation of Plasmid DNA from *E.coli*
5. Study different conformations of plasmid DNA through Agaraose gel electrophoresis.
6. Demonstration of Bacterial Conjugation
7. Demonstration of bacterial transformation and transduction
8. Demonstration of AMES test

SUGGESTED READING

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning
4. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings
5. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
6. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings
7. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
8. Maloy SR, Cronan JE and Friefelder D(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers

Paper -9: ENVIRONMENTAL MICROBIOLOGY (THEORY)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microorganisms and their Habitats **No. of Hours: 14**

Structure and function of ecosystems Terrestrial Environment: Soil profile and soil microflora Aquatic Environment: Microflora of fresh water and marine habitats Atmosphere: Aeromicroflora and dispersal of microbes ,Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit 2 Microbial Interactions **No. of Hours: 12**

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, Predation Microbe-Plant interaction: Symbiotic and non symbiotic interactions Microbe-animal interaction: Microbes in ruminants, nematophagus fungi and symbiotic luminescent Bacteria

Unit 3 Biogeochemical Cycling **No. of Hours: 12**

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction Phosphorus cycle: Phosphate immobilization and solubilisation Sulphur cycle: Microbes involved in sulphur cycle

Unit 4 Waste Management **No. of Hours: 12**

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill)
Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment

Unit 5 Microbial Bioremediation **No. of Hours: 5**

Principles and degradation of common pesticides, organic (hydrocarbons, oil spills) and inroganic (metals) matter, biosurfactants

Unit 6 Water Potability **No. of Hours: 5**

Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive test/MPN test, confirmed and completed tests for faecalcoliforms (b) Membrane filter technique and (c) Presence/absence tests

Paper -9.1: ENVIRONMENTAL MICROBIOLOGY (PRACTICAL)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 2

1. Analysis of soil - pH, moisture content, water holding capacity, percolation, capillary action.
2. Isolation of microbes (bacteria & fungi) from soil (28ºC & 45ºC).
3. Isolation of microbes (bacteria & fungi) from rhizosphere and rhizoplane.
4. Assessment of microbiological quality of water.
5. Determination of BOD of waste water sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (amylase) in soil.
7. Isolation of *Rhizobium* from root nodules.

SUGGESTED READINGS

1. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
2. Madigan MT, Martinko JM and Parker J. (2014). Brock Biology of Microorganisms.14th edition. Pearson/ Benjamin Cummings
3. Maier RM, Pepper IL and Gerba CP. (2009).Environmental Microbiology. 2nd edition, Academic Press
4. Okafor, N (2011). Environmental Microbiology of Aquatic & Waste systems. 1st edition, Springer, New York
5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation. Volume 17, Springer-Verlag, Berlin Hedeilberg
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
Campbell RE.(1983). Microbial Ecology.Blackwell Scientific Publication, Oxford, England.
7. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
8. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
9. Martin A. (1977). An Introduction to Soil Microbiology.2nd edition.John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS.(1999). Soil Microbiology.4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education.

Paper -10: FOOD AND DAIRY MICROBIOLOGY (THEORY)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Foods as a substrate for microorganisms **No. of Hours: 10**

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general.

Unit 2 Microbial spoilage of various foods **No. of Hours: 10**

Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, canned Foods

Unit 3 Principles and methods of food preservation **No. of Hours: 15**

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit 4 Fermented foods **No. of Hours: 10**

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, cheese, other fermented foods: sauerkraut, tampeh, Probiotics: Health benefits,types of microorganisms used, probiotic foods available in market.

Unit 5 Food borne diseases (causative agents, foods involved, symptoms and preventive measures) **No. of Hours: 10**

Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins;
Food infections: *Bacillus cereus*, , Salmonellosis,
Shigellosis, ,*Listeria monocytogenes* and *Campylobacter jejuni*

Unit 6 Food sanitation and control **No. of Hours: 5**

HACCP, Indices of food sanitary quality and sanitizers

Paper -10.1: FOOD AND DAIRY MICROBIOLOGY (PRACTICAL)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 2

1. MBRT of milk samples and their standard plate count.
2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
3. Isolation of any food borne bacteria from food products.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt.

SUGGESTED READINGS

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology.1st edition. CBS Publishers and Distributors, Delhi, India.
3. Davidson PM and Brannen AL. (1993). Antimicrobials in Foods. Marcel Dekker, New York.
4. Dillion VM and Board RG. (1996). Natural Antimicrobial Systems and Food Preservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology.3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic and Professional, London.
7. Jay JM, Loessner MJ and Golden DA.(2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.
8. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods.Vol. 1-2, ASPEN Publication, Gaithersberg, MD.
9. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

Paper -11: INDUSTRIAL MICROBIOLOGY (THEORY)

SEMESTER –V

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Introduction to industrial microbiology **No. of Hours: 2**

Brief history and developments in industrial microbiology

Unit 2 Isolation of industrially important microbial strains and fermentation media

No. of Hours: 10

Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, cornsteepliquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates

Unit 3 Types of fermentation processes, bio-reactors and measurement of fermentationparameters **No. of Hours: 12**

Types of fermentation processes - Solid-state and liquid-state (stationary and submerged)fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentationsComponents of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and productionfermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentationparameters - pH, temperature, dissolved oxygen, foaming and aeration

Unit 4 Down-stream processing **No. of Hours: 6**

Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying

Unit 5 Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses) **No. of Hours: 18**

Citric acid, ethanol, penicillin, Glutamic acid,Vitamin B12,Enzymes (amylase, protease, lipase)Wine, beer

Unit 6 Enzyme immobilization **No. of Hours: 4**

Methods of immobilization, advantages and applications of immobilization, large scale applications ofimmobilized enzymes : amylase

Paper -11.1: INDUSTRIAL MICROBIOLOGY (PRACTICAL)

SEMESTER –V

TOTAL HOURS: 60 CREDITS: 2

1. Study different parts of fermenter
2. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
(a) Enzymes: Amylase
(b) Organic acid: Citric acid
3. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

SUGGESTED READINGS

1. Patel A.H. (1996). Industrial Microbiology. 1st edition, Macmillan India Limited
2. Okafor N. (2007). Modern Industrial Microbiology and Biotechnology.1st edition. Bios Scientific Publishers Limited. USA
3. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction.1st edition. Wiley – Blackwell
4. Glaze A.N. and Nikaido H. (1995). Microbial Biotechnology: Fundamentals of Applied Microbiology.1st edition. W.H. Freeman and Company
5. Casida LE. (1991). Industrial Microbiology.1st edition.Wiley Eastern Limited.
6. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.
7. Stanbury PF, Whitaker A and Hall SJ.(2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

Paper -12: IMMUNOLOGY (THEORY)

SEMESTER –V

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Immune Cells and Organs **No. of Hours: 7**

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone

Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT

Unit 2 Antigens **No. of Hours: 4**

Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes); T-dependent and T-independent antigens; Adjuvants

Unit 3 Antibodies **No. of Hours: 6**

Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies

Unit 4 Major Histocompatibility Complex **No. of Hours: 5**

Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways)

Unit 6 Generation of Immune Response **No. of Hours: 13**

Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response (Self MHC restriction, T cell activation, Co- stimulatory signals); Killing Mechanisms by CTL and NK cells, Introduction to tolerance

Unit 7 Immunological Disorders and Tumor Immunity **No. of Hours: 15**

Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, CGD; Types of tumors, tumor Antigens, causes and therapy for cancers.

Unit 8Immunological Techniques **No. of Hours: 10**

Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA,ELISPOT, Western blotting, Immunofluoresence, Flow cytometry, Immunoelectron microscopy.

Paper -12.1: IMMUNOLOGY (PRACTICAL)

SEMESTER –V

TOTAL HOURS: 60 CREDITS: 2

1. Identification of human blood groups.
2. Perform Total Leukocyte Count of the given blood sample.
3. Perform Differential Leukocyte Count of the given blood sample.
4. Separate serum from the blood sample (demonstration).
5. Perform immunodiffusion by Ouchterlony method.
6. Perform DOT ELISA.
7. Perform immunoelectrophoresis.

SUGGESTED READINGS

1. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
2. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
3. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
4. Murphy K, Travers P, Walport M. (2008). Janeway's Immunobiology. 7th edition Garland Science Publishers, New York.
5. Peakman M, and Vergani D. (2009).Basic and Clinical Immunology. 2nd edition Churchill Livingstone Publishers, Edinberg.
6. Richard C and Geiffrey S. (2009). Immunology.6th edition.Wiley Blackwell Publication.

Paper -13: MEDICAL MICROBIOLOGY (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Normal microflora of the human body and host pathogen interaction **No. of Hours: 8**

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS

Unit 2 Sample collection, transport and diagnosis **No. of Hours: 5**

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests,PCR, DNA probes).

Unit 3 Bacterial diseases **No. of Hours: 15**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control

Respiratory Diseases: *Mycobacterium tuberculosis*

Gastrointestinal Diseases: *Salmonella typhi*, *Vibrio cholerae*,

Others: *Bacillus anthracis, Clostridium tetani*

Unit 4 Viral diseases **No. of Hours: 14**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control

Polio, Hepatitis, AIDS, Influenza with brief description of Ebola,

Japanese Encephalitis

Unit 5 Protozoan diseases **No. of Hours: 5**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control

Malaria, Kala-azar

Unit 6 Fungal diseases **No. of Hours: 5**

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention

Cutaneous mycoses: Tinea pedis (Athlete's foot)

Systemic mycoses: Histoplasmosis

Opportunistic mycoses: Candidiasis

Unit 7 Antimicrobial agents: General characteristics and mode of action **No. of Hours: 8**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism

Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin

Antiviral agents: Mechanism of action of Amantadine, Azidothymidine

Antibiotic resistance, MDR, XDR, MRSA,

Paper -13.1: MEDICAL MICROBIOLOGY (PRACTICAL)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 2

TOTAL HOURS: 60 CREDITS: 2

1. Identify bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB

Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
7. Study of various stages of malarial parasite in RBCs using permanent mounts.

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ.(2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms.14th edition. Pearson International Edition

Paper -14: RECOMBINANT DNA TECHNOLOGY (THEORY)

SEMESTER –VI

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Introduction to Genetic Engineering **No. of Hours: 2**

Milestones in genetic engineering and biotechnology

Unit 2 Molecular Cloning- Tools and Strategies **No. of Hours: 20**

Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering

DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases

Cloning Vectors: Definition and Properties

Plasmid vectors: pBR and pUC series

Bacteriophage lambda and M13 based vectors

Cosmids, BACs, YACs

Use of linkers and adaptors

Expression vectors: *E.coli* lac and T7 promoter-based vectors,

mammalian ,SV40-based expression vectors

Unit 3 Methods in Molecular Cloning **No. of Hours: 16**

Transformation of DNA: Chemical method, Electroporation, Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viralmediated

delivery, *Agrobacterium* - mediated delivery

DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE and Western blotting.

Unit4 DNA Amplification and DNA sequencing **No. of Hours: 10**

PCR: Basics of PCR, RT-PCR, Real-Time PCR

Sanger's method of DNA Sequencing: traditional

Primer walking and shotgun sequencing

Unit 5 Construction and Screening of Genomic and cDNA libraries **No. of Hours: 6**

Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping

Unit 6 Applications of Recombinant DNA Technology **No. of Hours: 6**

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagenesis

Paper -14.1: RECOMBINANT DNA TECHNOLOGY (PRACTICAL)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 2

1. Preparation of competent cells for transformation
2. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
3. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis
4 Interpretation of sequencing gel electropherograms
5. Designing of primers for DNA amplification
6. Demonstration of Southern blotting

SUGGESTED READING

1. Brown TA. (2010). Gene Cloning and DNA Analysis.6th edition. Blackwell Publishing, Oxford, U.K.
2. Clark DP and Pazdernik NJ. (2009). Biotechnology: Applying the Genetic Revolution. Elsevier Academic Press, USA
3. Primrose SB and Twyman RM. (2006). Principles of Gene Manipulation and Genomics, 7th edition. Blackwell Publishing, Oxford, U.K.
4. Sambrook J and Russell D. (2001). Molecular Cloning-A Laboratory Manual. 3rd edition. Cold Spring Harbor Laboratory Press
5. Wiley JM, Sherwood LM and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. McGraw Hill Higher Education
6. Brown TA. (2007). Genomes-3. Garland Science Publishers
7. Primrose SB and Twyman RM. (2008). Genomics: Applications in human biology. Blackwell Publishing, Oxford, U.K.

B. Discipline specific Elective (Any Four)

DSE Paper -1: INSTRUMENTATION AND BIOTECHNIQUES (THEORY)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microscopy **No. of Hours: 10**

Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

Unit 2 Chromatography **No. of Hours: 14**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ionexchange chromatography and affinity chromatography, GLC, HPLC.

Unit 3 Electrophoresis **No. of Hours: 14**

Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis, Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis.

Unit 4 Spectrophotometry **No. of Hours: 10**

Principle and use of study of absorption spectra of biomolecules. Analysis of biomolecules using UV and visible range. Colorimetry and turbidometry.

Unit 5 Centrifugation **No. of Hours: 12**

Preparative and analytical centrifugation, fixed angle and swinging bucket rotors. RCF and sedimentation coefficient, differential centrifugation, density gradient centrifugation and ultracentrifugation.

DSE Paper -1.1: INSTRUMENTATION AND BIOTECHNIQUES (PRACTICAL)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 2

1. Study of fluorescent micrographs to visualize bacterial cells.
2. Ray diagrams of phase contrast microscopy and Electron microscopy.
3. Separation of mixtures by paper / thin layer chromatography.
4. Demonstration of column packing in any form of column chromatography.
5. Separation of protein mixtures by any form of chromatography.
6. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
7. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
8. Separation of components of a given mixture using a laboratory scale centrifuge.
9. Understanding density gradient centrifugation with the help of pictures.

SUGGESTED READINGS

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7th Ed., Cambridge University Press.
2. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5th Ed., W.H. Freeman and Company.
3. Willey MJ, Sherwood LM & Woolverton C J. (2013). Prescott, Harley and Klein's Microbiology.9thEd., McGraw Hill.
4. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons.Inc.
5. De Robertis EDP and De Robertis EMF. (2006). Cell and Molecular Biology.8th edition. Lipincott Williams and Wilkins, Philadelphia.
6. Cooper G.M. and Hausman R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington D.C., Sinauer Associates, MA.
7. Nigam A and Ayyagari A. 2007. Lab Manual in Biochemistry, Immunology and Biotechnology.Tata McGraw Hill.

DSE Paper -2: PLANT PATHOLOGY (THEORY)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Introduction and History of plant pathology **No. of Hours: 5**

Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant landmarks in the field of plant pathology- Contributions of Anton DeBary, Millardet, Burrill, E. Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists.

Unit 2 Stages in development of a disease **No. of Hours: 2**

Infection, invasion, colonization, dissemination of pathogens and perennation.

Unit 3 Plant disease epidemiology **No. of Hours: 5**

Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid,

forecasting of plant diseases and its relevance in Indian context.

Unit 4 Host Pathogen Interaction **No. of Hours: 19**

A. *Microbial Pathogenicity*

Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development. Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).

B. *Genetics of Plant Diseases*

Concept of resistance (R) gene and avirulence (avr) gene; gene for gene hypothesis, types of plant resistance: true resistance– horizontal & vertical, apparent resistance.

C. *Defense Mechanisms in Plants*

Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histologicalcork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts].

Unit 5 Control of Plant Diseases **No. of Hours: 10**

Principles & practices involved in the management of plant diseases by different methods, *viz.*

regulatory - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material

cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches

chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals.

biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants

genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes

Unit 6 Specific Plant diseases **No. of Hours: 19**

Study of some important plant diseases giving emphasis on its etiological agent, symptoms, epidemiology and control

A. Important diseases caused by fungi

White rust of crucifers - *Albugo candida*

Downy mildew of onion - *Peronospora destructor*

Late blight of potato - *Phytophthora infestans*

Powdery mildew of wheat - *Erysiphe graminis*

Ergot of rye - *Claviceps purpurea*

Black stem rust of wheat - *Puccinia graminis tritici*

Loose smut of wheat - *Ustilago nuda*

Wilt of tomato - *Fusarium oxysporum* f.sp. *lycopersici*

Red rot of sugarcane - *Colletotrichum falcatum*

Early blight of potato - *Alternaria solani*

B. Important diseases caused by phytopathogenic bacteria: Angular leaf spot of cotton, bacterial leaf blight of rice, crown galls, bacterial cankers of citrus

C. Important diseases caused by phytoplasmas: Aster yellow, citrus stubborn

D. Important diseases caused by viruses: Papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro

E. Important diseases caused by viroids: Potato spindle tuber, coconut cadang cadang

DSE Paper -2.1: PLANT PATHOLOGY (PRACTICAL)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 2

1. Demonstration of Koch's postulates in fungal, bacterial and viral plant pathogens.
2. Study of important diseases of crop plants by cutting sections of infected plant material - *Albugo, Puccinia*, *Ustilago, Fusarium, Colletotrichum.*

SUGGESTED READINGS

1. Agrios GN. (2006). Plant Pathology.5th edition. Academic press, San Diego,
2. Lucas JA. (1998). Plant Pathology and Plant Pathogens.3rd edition. Blackwell Science, Oxford.
3. Mehrotra RS. (1994). Plant Pathology. Tata McGraw-Hill Limited.
4. Rangaswami G. (2005). Diseases of Crop Plants in India.4th edition.Prentice Hall of India Pvt. Ltd., New Delhi.
5. Singh RS. (1998). Plant Diseases Management.7th edition.Oxford & IBH, New Delhi.

DSE Paper -3: ADVANCES IN MICROBIOLOGY (THEORY)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Evolution of Microbial Genomes **No. of Hours: 15**

Salient features of sequenced microbial genomes, core genome pool, flexible genome pool and concept of pangenome, Horizontal gene transfer (HGT), Evolution of bacterial virulence - Genomic islands, Pathogenicity islands (PAI) and their characteristics

Unit 2 Metagenomics **No. of Hours: 15**

Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.

Unit 3 Molecular Basis of Host-Microbe Interactions **No. of Hours: 15**

Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plant pathogens and its mechanism, Type three secretion systems (TTSS) of plant and animal pathogens, Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance

Unit 4 Systems and Synthetic Biology **No. of Hours: 15**

Networking in biological systems, Quorum sensing in bacteria, Co-ordinated regulation of bacterial virulence factors, Basics of synthesis of poliovirus in laboratory, Future implications of synthetic biology with respect to bacteria and viruses

DSE Paper -3.1: ADVANCES IN MICROBIOLOGY (PRACTICAL)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 2

1. Extraction of metagenomic DNA from soil
2. Understand the impediments in extracting metagenomic DNA from soil
3. PCR amplification of metagenomic DNA using universal 16s ribosomal gene primers
4. Case study to understand how the poliovirus genome was synthesized in the laboratory
5. Case study to understand how networking of metabolic pathways in bacteria takes place

SUGGESTED READING

1. Fraser CM, Read TD and Nelson KE. Microbial Genomes, 2004, Humana Press
2. Miller RV and Day MJ. Microbial Evolution- Gene establishment, survival and exchange, 2004,

ASM Press
3. Bull AT. Microbial Diversity and Bioprospecting, 2004, ASM Press
4. Sangdun C. Introduction to Systems Biology, 2007, Humana Press
5. Klipp E, Liebermeister W. Systems Biology – A Textbook, 2009, Wiley –VCH Verlag
6. Caetano-Anolles G. Evolutionary Genomics and Systems Biology, 2010, John Wiley and Sons
7. Madigan MT, Martink JM, Dunlap PV and Clark DP (2014) Brook's Biology of Microorganisms, 14th edition, Pearson-Bejamin Cummings
8. Wilson BA, Salyers AA Whitt DD and Winkler ME (2011)Bacterial Pathogenesis- A molecular Approach, 3rd edition, ASM Press,
9. Bouarab K, Brisson and Daayf F (2009) Molecular Plant-Microbe interaction CAB International
10. Voit EO (2012) A First Course in Systems Biology, Ist edition,Garland Science

DSE Paper -4: MICROBIAL BIOTECHNOLOGY (THEORY)

SEMESTER –V

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microbial Biotechnology and its Applications **No. of Hours: 10**

Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology

Use of prokaryotic and eukaryotic microorganisms in biotechnological applications

Genetically engineered microbes for industrial application: Bacteria and yeast

Unit 2 Therapeutic and Industrial Biotechnology **No. of Hours: 10**

Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine)

Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics

Microbial biosensors

Unit 3 Applications of Microbes in Biotransformations **No. of Hours: 8**

Microbial based transformation of steroids and sterols

Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute

Unit 4 Microbial Products and their Recovery **No. of Hours: 10**

Microbial product purification: filtration, ion exchange & affinity chromatography techniques

Immobilization methods and their application: Whole cell immobilization

Unit 5 Microbes for Bio-energy and Environment **No. of Hours: 12**

Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture.

Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents

Unit 6 RNAi No. of Hours: 6

RNAi and its applications in silencing genes, drug resistance, therapeutics and host pathogen interactions

Unit 7 Intellectual Property Rights **No. of Hours: 4**

Patents, Copyrights, Trademarks

DSE Paper -4.1: MICROBIAL BIOTECHNOLOGY (PRACTICAL)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 2

1. Study yeast cell immobilization in calcium alginate gels
2. Study enzyme immobilization by sodium alginate method
3. Pigment production from fungi (*Trichoderma* / *Aspergillus* / *Penicillium*)
4. Isolation of xylanase or lipase producing bacteria
5. Study of algal Single Cell Proteins

SUGGESTED READING

1. Ratledge, C and Kristiansen, B. (2001). Basic Biotechnology, 2nd Edition, Cambridge University Press.
2. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
3. Swartz, J. R. (2001). Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.
4. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ (2014), 9th edition, Mc Graw Hill Publishers.
5. Gupta PK (2009) Elements of Biotechnology 2nd edition, Rastogi Publications,
6. Glazer AN and Nikaido H (2007) Microbial Biotechnology, 2nd edition, Cambridge University Press
7. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
8. Stanbury PF, Whitaker A, Hall SJ (1995) Principles of Fermentation Technology 2nd edition., Elsevier Science
9. Crueger W, Crueger A (1990) Biotechnology: A text Book of Industrial Microbiology 2nd edition Sinauer associates, Inc.

DSE Paper -5: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 **No of Hours: 8**

Biosafety: Introduction; biosafety issues in biotechnology; Biological Safety Cabinets & their types; Primary Containment for Biohazards; Biosafety Levels of Specific Microorganisms

Unit 2 **No of Hours: 12**

Biosafety Guidelines: Biosafety guidelines and regulations (National and International); GMOs/LMOs- Concerns and Challenges; Role of Institutional Biosafety Committees (IBSC), RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication; Overview of International Agreements - Cartagena Protocol.

Unit 3 **No of Hours: 4**

AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions.

Unit 4 **No of Hours: 12**

Introduction to Intellectual Property: Patents, Types, Trademarks, Copyright & Related Rights, Industrial Design and Rights, Traditional Knowledge, Geographical Indications- importance of IPR – patentable and non patentables – patenting life – legal protection of biotechnological inventions – World Intellectual Property Rights Organization (WIPO).

Unit 5 **No of Hours: 12**

Grant of Patent and Patenting Authorities: Types of patent applications: Ordinary, PCT, Conventional, Divisional and Patent of Addition; An introduction to Patent Filing Procedures; Patent licensing and agreement; Patent infringement- meaning, scope, litigation, case studies, Rights and Duties of patent owner.

Unit 6 **No of Hours: 12**

Agreements and Treaties: GATT, TRIPS Agreements; Role of Madrid Agreement; Hague Agreement; WIPO Treaties; Budapest Treaty on international recognition of the deposit of microorganisms; UPOV & Brene conventions; Patent Co-operation Treaty (PCT); Indian Patent Act 1970 & recent amendments.

DSE Paper -5.1: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (PRACTICAL)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 2

1. Study of components and design of a BSL-III laboratory
2. Filing applications for approval from biosafety committee
3. Filing primary applications for patents
4. Study of steps of a patenting process
5. A case study

Suggested Reading

1. Bare Act, 2007.Indian Patent Act 1970 Acts & Rules, Universal Law Publishing Co. Pvt. Ltd., New Delhi.
2. Kankanala C (2007). Genetic Patent Law & Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd. New Delhi.
3. Mittal, D.P. (1999). Indian Patents Law, Taxmann, Allied Services (p) Ltd.
4. Singh K K (2015). Biotechnology and Intelectual Property Rights: Legal and Social Impliocations, Springer India.
5. Goel D & Prashar S (2013). IPR, Biosafety and Bioethics. Pearson
6. Senthil Kumar Sadhasivam and Mohammed Jaabir, M. S. 2008. IPR, Biosafety and biotechnology Management.Jasen Publications, Tiruchirappalli, India.

DSE Paper -6: INHERITANCE BIOLOGY (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Introduction to Genetics **No. of Hours: 5**

Historical developments
Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae, Neurospora crassa, Caenorhabditis elegans Drosophila melanogaster, Arabidopsis thaliana*

Unit 2 Mendelian Principles **No. of Hours: 13**

Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance, Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance, Multiple alleles, Epistasis, penetrance and expressivity

Unit 3 Linkage and Crossing over **No. of Hours: 9**

Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping

Unit 4 Extra-Chromosomal Inheritance **No. of Hours: 9**

Rules of extra nuclear inheritance, Organelle heredity - Chloroplast mutations in *Chlamydomonas*, mitochondrial, mutations in *Saccharomyces,* Maternal effects – Shell coiling in *Limnaea peregra* Infectious heredity - Kappa particles in *Paramecium*

Unit 5 Characteristics of Chromosomes **No. of Hours: 15**

Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes, Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polytene

and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities - Klinefelter syndrome, Turner syndrome, Down syndrome

Unit 6 Recombination **No. of Hours: 3**

Homologous and non-homologous recombination, including transposition, site-specific recombination.

Unit 7 Human genetics **No. of Hours: 3**

Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit 8 Quantitative genetics **No. of Hours: 3**

Polygenic inheritance, heritability and its measurements, QTL mapping.

DSE Paper -6.1: INHERITANCE BIOLOGY (PRACTICAL)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 2

1. Mendelian deviations in dihybrid crosses
2. Studying Barr Body with the temporary mount of human cheek cells
3. Studying *Rhoeo* translocation with the help of photographs
4. Karyotyping with the help of photographs
5. Chi-Square Analysis
6. Study of polytene chromosomes using temporary mounts of salivary glands of *Chiromonas / Drosophila* larvae
7. Study of pedigree analysis
8. Analysis of a representative quantitative trait

SUGGESTED READING

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
2. Snustad DP, Simmons MJ (2011). Principles of Genetics.6th Ed. John Wiley and Sons Inc.
3. Weaver RF, Hedrick PW (1997). Genetics. 3rd Ed. McGraw-Hill Education
4. Klug WS, Cummings MR, Spencer CA, Palladino M (2012). Concepts of Genetics.10th Ed. Benjamin Cummings
5. Griffith AJF, Wessler SR, Lewontin RC, Carroll SB. (2007). Introduction to Genetic Analysis. 9th Ed. W.H.Freeman and Co., New York
6. Hartl DL, Jones EW (2009). Genetics: Analysis of Genes and Genomes. 7th Ed, Jones and Bartlett Publishers
7. Russell PJ. (2009). *i* Genetics - A Molecular Approach. 3rd Ed, Benjamin Cummings

DSE Paper -7: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Soil Microbiology **No of Hours: 8**

Soil as Microbial Habitat, Soil profile and properties, Soil formation, Diversity and distribution of microorganisms in soil

Unit 2 Mineralization of Organic & Inorganic Matter in Soil **No of Hours: 8**

Mineralization of cellulose, hemicelluloses, lignocelluloses, lignin and humus, phosphate, nitrate, silica, potassium

Unit 3 Microbial Activity in Soil and Green House Gases **No of Hours: 5**

Carbon dioxide, methane, nitrous oxide, nitric oxide – production and control

Unit 4 Microbial Control of Soil Borne Plant Pathogens **No of Hours: 8**

Biocontrol mechanisms and ways, Microorganisms used as biocontrol agents against Microbial plant

pathogens, Insects, Weeds

Unit 5 Biofertilization, Phytostimulation, Bioinsecticides **No of Hours: 15**

Plant growth promoting bateria, biofertilizers – symbiotic (*Bradyrhizobium, Rhizobium, Frankia*), Non Symbiotic (*Azospirillum, Azotobacter*, Mycorrhizae, MHBs, Phosphate solubilizers, algae), Novel combination of microbes as biofertilizers, PGPRs

Unit 6 Secondary Agriculture Biotechnology **No of Hours: 10**

Biotech feed, Silage, Biomanure, biogas, biofuels – advantages and processing parameters

Unit 7 GM crops **No of Hours: 6**

Advantages, social and environmental aspects, Bt crops, golden rice, transgenic animals.

DSE Paper-7.1: MICROBES IN SUSTAINABLE AGRICULTURE AND DEVELOPMENT (PRACTICAL)

SEMESTER –VI

TOTAL HOURS: 60 CREDITS: 2

1. Study soil profile
2. Study microflora of different types of soils
3. *Rhizobium* as soil inoculants characteristics and field application
4. *Azotobacter* as soil inoculants characteristics and field application
5. Design and functioning of a biogas plant (Demonstration)
6. Isolation of cellulose degrading organisms

SUGGESTED READINGS

1. Agrios GN. (2006). Plant Pathology.5th edition. Academic press, San Diego,
2. Singh RS. (1998). Plant Diseases Management.7th edition.Oxford & IBH, New Delhi.
3. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press,
4. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
5. Maier RM, Pepper IL and Gerba CP. (2009).Environmental Microbiology. 2nd edition, Academic Press
6. Barton LL & Northup DE (2011). Microbial Ecology. 1st edition, Wiley Blackwell, USA
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Altman A (1998). Agriculture Biotechnology, Ist edition, Marcel decker Inc.
10. Mahendra K. Rai (2005). Hand Book of Microbial Biofertilizers, The Haworth Press, Inc. New York.
11. Reddy, S.M. et. al. (2002). Bioinoculants for Sustainable Agriculture and Forestry, Scientific Publishers.
12. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG

DSE Paper -8: BIOMATHEMATICS AND BIOSTATISTICS (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Biomathematics **No of Hours: 30**

Sets. Functions and their graphs : polynomial, sine, cosine, exponential and logarithmic functions. Motivation and illustration for these functions through projectile motion, simple pendulum, biological rhythms, cell division, muscular fibres etc.

Simple observations about these functions like increasing, decreasing and, periodicity.

Sequences to be introduced through the examples arising in Science beginning with finite sequences, followed by concepts of recursion and difference equations. For instance, the Fibonacci sequence arising from branching habit of trees and breeding habit of rabbits. Intuitive idea of algebraic relationships and convergence.

Infinite Geometric Series.Series formulas for ex, log (1+x), sin x, cos x. Step function. Intuitive idea of discontinuity, continuity and limits.

Differentiation. Conception to be motivated through simple concrete examples as given above from Biological and Physical Sciences. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions.

Integration as reverse process of differentiation.

Integrals of the functions introduced above. Differential Equations of first order, Linear Differential Equations.

Points in plane and space and coordinate form. Examples of matrices arising in Biological Sciences and Biological networks. Sum and Produce of matrices upto order 3.

Unit 2 Biostatistics **No of Hours: 30**

Measures of central tendency, Measures of dispersion; skewness, kurtosis; Elementary Probability and basic laws; Discrete and Continuous Random variable, Mathematical Expectation; Curve Fitting; Correlation and Regression. Emphasis on examples from Biological Sciences;

Mean and Variance of Discrete and Continuous Distributions namely Binomial, Poisson, Geometric, Weibull, Logistic and Normal distribution. Fitting of Distributions;

Statistical methods: Scope of statistics: utility and misuse. Principles of statistical analysis of biological data. Sampling parameters. Difference between sample and Population, Sampling Errors, Censoring, difference between parametric and non-parametric statistics;

Sampling Distributions, Standard Error, Testing of Hypothesis, Level of Significance and Degree of Freedom;

Large Sample Test based on Normal Distribution, Small sample test based on t-test, Z- test and F test; Confidence Interval; Distribution-free test - Chi-square test; Basic introduction to Multivariate statistics, etc.

DSE Paper -8.1: BIOMATHEMATICS AND BIOSTATISTICS (PRACTICAL)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 2

1. Word Problems based on Differential Equations
2. Mean, Median, Mode from grouped and ungrouped Data set
3. Standard Deviation and Coefficient of Variation
4. Skewness and Kurtosis
5. Curve fitting
6. Correlation
7. Regression
8. Finding area under the curve using normal probability
9. Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test
10. Confidence Interval

SUGGESTED READINGS

1. H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.
2. E. Batschelet : Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)
3. A. Edmondson and D. Druce : Advanced Biology Statistics, Oxford University Press; 1996.
4. W. Danial : Biostatistics : A foundation for Analysis in Health Sciences, John Wiley and Sons Inc; 2004.

C. Generic Elective (Any Four)

GE-1/2 Paper 1: INTRODUCTION AND SCOPE OF MICROBIOLOGY (THEORY)
SEMESTER –I/III
TOTAL HOURS: 60 CREDITS: 4

Unit 1 History of Development of Microbiology **No. of Hours: 12**

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming
Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman
Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microorganisms **No. of Hours: 10**

Systems of classification : Binomial nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility
General characteristics of different groups: Acellular microorganisms (Viruses, Viroids, Prions) and Cellular microorganisms (Prokarya: Archaea and Bacteria, Eukarya : Algae, Fungi and Protozoa) giving definitions and citing examples
Protozoa : Methods of nutrition, locomotion & reproduction - Amoeba*, Paramecium* and *Plasmodium*

Unit 3 Microscopy **No. of Hours: 7**

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope,Transmission Electron Microscope, Scanning Electron Microscope

Unit 4 Sterilization **No. of Hours: 5**

Moist Heat, Autoclave, Dry Heat, Hot Air Oven, Tyndallization, Filteration.

Unit 5 Microbes in Human Health & Environment **No. of Hours: 10**

Medical microbiology and immunology: List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody and their types
Environmental microbiology: Definitions and examples of important microbial interactions – mutualism, commensalism, parasitism, Definitions and microorganisms used as biopesticides, biofertilizers, in biodegradation, biodeterioration and bioremediation (*e.g.* hydrocarbons in oil spills)

Unit 6 Industrial Microbiology **No. of Hours: 8**

Definition of fermentation, primary and secondary metabolites, types of fermentations and fermenters and microbes producing important industrial products through fermentation.

Unit 7 Food and Dairy Microbiology **No. of Hours: 8**

Microorganisms as food (SCP), microorganisms in food fermentations (dairy and non dairy based fermented food products) and probiotics.Microorganisms in food spoilage and food borne infections.

GE-1 Paper 1.1: INTRODUCTION AND SCOPE OF MICROBIOLOGY (PRACTICALS)
SEMESTER –I/III
TOTAL HOURS: 60 CREDITS: 2

1. Microbiology Laboratory Management and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the microbiology laboratory
3. Preparation of culture media for bacterial cultivation
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Sterilization of heat sensitive material by filtration and assessment for sterility
7. Demonstration of presence of microflora in the environment by exposing nutrient agar plates to air.
8. Study of different shapes of bacteria using permanent slides
9. Study of *Rhizopus* and *Penicillium* using permanent mounts
10. Study of *Spirogyra* and *Chlamydomonas* using permanent Mounts
11. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Entamoeba*, *Paramecium* and *Plasmodium*

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition.Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4.Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology.9th Edition. McGraw Hill International.
5. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology.5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005).General Microbiology.5th edition. McMillan.

GE 1/2-Paper 2: MICROBIAL METABOLISM (THEORY)
SEMESTER – I/III
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth No. of Hours: 12
Definitions of growth, Batch culture, Continuous culture, generation time and specific growth rate
Temperature and temperature ranges of growth
pH and pH ranges of growth
Effect of solute and water activity on growth
Effect of oxygen concentration on growth
Nutritional categories of microorganisms

Unit 2 Nutrient uptake and Transport No. of Hours: 10
Passive and facilitated diffusion
Primary and secondary active transport, concept of uniport, symport and antiport
Group translocation
Iron uptake

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration **No. of Hours: 16**

Concept of aerobic respiration, anaerobic respiration and fermentation
Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway
TCA cycle
Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 6

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction)
Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism **No. of Hours: 10**

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction)
Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic*vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria and cyanobacteria

Unit 6 Nitrogen Metabolism - an overview **No. of Hours: 6**

Introduction to biological nitrogen fixation
Ammonia assimilation Assimilatory nitrate reduction

GE 1/2 Paper-2.1: MICROBIAL METABOLISM (PRACTICAL)
SEMESTER –I/III
TOTAL HOURS: 60 CREDITS: 2

1. Study and plot the growth curve of *E. coli* by tubidiometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of Nitrogen and Carbon sources on *E. Coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

SUGGESTED READINGS

1. Madigan MT, and Martinko JM (2014).Brock Biology of Microorganisms.14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology.4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism.2nd edition. Springer Verlag
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition.McGraw Hill Higher Education.

GE-1/2 Paper-3: BACTERIOLOGY AND VIROLOGY (THEORY)
SEMESTER –II/IV
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Cell organization **No. of Hours: 10**

Cell size, shape and arrangements, capsule, flagella and pili, Composition and detailed structure of gram- positive and gram- negative cell wall and archaeal cell wall, Structure, chemical composition and functions of bacterial and archaeal cell membranes, Ribosomes, inclusions, nucleoid, plasmids, structure, formation and stages of sporulation

Unit 2 Bacterial growth and control **No. of Hours: 8**

Culture media: Components of media, Synthetic or defined media, Complex media, enriched media, selective media, differential media, enrichment culture media

Pure culture isolation: Streaking, serial dilution and plating methods, cultivation, maintenance and stocking of pure cultures, cultivation of anaerobic bacteria

Growth: Binary fission, phases of growth

Unit 3 Bacterial Systematics and Taxonomy **No. of Hours: 12**

Taxonomy, nomenclature, systematics, types of classifications

Morphology, ecological significance and economic importance of the following groups:

Archaea: methanogens, thermophiles and halophiles

Eubacteria: Gram negative and Gram positive

Gram negative:

Non-proteobacteria– *Deinococcus, Chlamydiae,* Spirochetes

Alpha proteobacteria- *Rickettsia, Rhizobium, Agrobacterium*

Gamma proteobacteria –*Escherichia,Shigella,Pseudomonas*

Gram positive: Low G+C: *Mycoplasma*, *Bacillus, Clostridium, Staphylococcus* High G+C: *Streptomyces, Frankia*

Unit 4 Introduction to Viruses **No. of Hours: 8**

Properties of viruses; general nature and important features

Subviral particles; viroids, prions and their importance

Isolation and cultivation of viruses

Unit 5 Structure, and multiplication of viruses **No. of Hours: 12**

Morphological characters: Capsid symmetry and different shapes of viruses with examples

Viral multiplication in the Cell: Lytic and lysogenic cycle

Description of important viruses: salient features of the viruses infecting different hosts - Bacteriophages (T4 & Lambda); Plant (TMV & Cauliflower Mosaic Virus), Human (HIV & Hepatitis viruses)

Unit 6 Role of Viruses in Disease and its prevention **No. of Hours: 10**

Viruses as pathogens: Role of viruses in causing diseases Prevention and control of viruses: Viral vaccines, interferons and antiviral compounds

GE 1/2 Paper -3.1: BACTERIOLOGY AND VIROLOGY (PRACTICAL)
SEMESTER –II/IV
TOTAL HOURS: 60 CREDITS: 2

1. Preparation of different media: Nutrient agar, Nutrient broth
2. To perform simple staining and Gram's staining of the bacterial smear
3. To perform spore staining
4. Isolation of pure cultures of bacteria by streaking method
5. Enumeration of colony forming units (CFU) count by spread plate method/pour plate
7. Study the morphological structures of viruses (DNA and RNA) and their important characters using electron micrographs
8. Study of the methods of isolation and propagation of plant viruses
9. Study of cytopathic effects of viruses using photographs

SUGGESTED READING

1. Atlas RM. (1997).Principles of Microbiology.2nd edition. WM.T.Brown Publishers
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP (2014). Brock Biology of Micro-organisms. 14th edition. Pearson Education, Inc.
3. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition. McMillan
4. Carter J and Saunders V(2007). Virology; principles and Applications. John Wiley and Sons
5. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR Skalka, AM (2004) Principles of Virology, Molecular Biology, Pathogenesis and Control. 2nd edition.ASM Press
6. Shors Teri (2013) Understanding Viruses 2nd edition Jones and Bartlett Learning Burlington USA
7. Pelczar Jr MJ, Chan ECS, and Krieg NR.(2004). Microbiology.5th edition Tata McGraw Hill.
8. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
9. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education.
10. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
11. Cann AJ (2012) Principles of Molecular Virology, Academic Press Oxford UK

9. Martin A. (1977). An Introduction to Soil Microbiology.2nd edition.John Wiley & Sons Inc. New York & London.
10. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
11. Subba Rao NS.(1999). Soil Microbiology.4th edition. Oxford & IBH Publishing Co. New Delhi.
12. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition.McGraw Hill Higher Education.

GE 1/2-Paper 4: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (THEORY)
SEMESTER – II/IV
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Normal microflora of the human body and host pathogen interaction No. of Hours: 8

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection,

Unit 2 Sample collection, transport and diagnosis **No. of Hours: 5**
Collection, transport and culturing of clinical samples and their identification characteristics.
Unit 3 Bacterial diseases **No. of Hours: 3**
List of diseases of various organ systems and their causative agents.
Unit 4 Viral diseases **No. of Hours: 3**
List of diseases of various organ systems and their causative agents.
Unit 5 Protozoan diseases **No. of Hours: 2**
List of diseases of various organ systems and their causative agents.
Unit 6 Fungal diseases **No. of Hours: 2**
Brief description of various types of mycoses.
Unit 7 Antimicrobial agents: General characteristics and mode of action **No. of Hours: 7**
Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism
Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin
Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine
Unit 8 Immune Cells and Organs **No. of Hours: 7**
Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell; and Immune Organs – Bone Marrow, Thymus, Lymph Node, Spleen
Unit 9 Antigens and Antibodies **No. of Hours: 7**
Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes (T & B cell epitopes), Adjuvants, Structure, Types and Functions of antibodies.
Unit 10 Generation of Immune Response **No. of Hours: 6**
Primary and Secondary Immune Response; Generation of Humoral Immune Response (Plasma and Memory cells); Generation of Cell Mediated Immune Response
Unit 11 Immunological Disorders and Tumor Immunity **No. of Hours: 5**
Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice).
Unit 12 Immunological Techniques **No. of Hours: 5**
Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT.

GE 1/2 Paper-4.1: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (PRACTICAL)

SEMESTER –II/IV

TOTAL HOURS: 60 CREDITS: 2

1. Identify bacteria on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Identification of human blood groups.
6. To perform Total Leukocyte Count of the given blood sample.
7. To perform Differential Leukocyte Count of the given blood sample.
8. To separate serum from the blood sample (demonstration).
9. To perform immunodiffusion by Ouchterlony method.

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ.(2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Abbas AK, Lichtman AH, Pillai S. (2007). Cellular and Molecular Immunology. 6th edition Saunders Publication, Philadelphia.
6. Delves P, Martin S, Burton D, Roitt IM. (2006). Roitt's Essential Immunology.11th edition Wiley-Blackwell Scientific Publication, Oxford.
7. Goldsby RA, Kindt TJ, Osborne BA. (2007). Kuby's Immunology. 6th edition W.H. Freeman and Company, New York.
8. Richard C and Geiffrey S. (2009). Immunology.6th edition.Wiley Blackwell Publication.

D. Skill Enhancement Elective course (Any two)

SEC Paper -1: Microbial Quality Control in Food and Pharmaceutical Industries

SEMESTER – III

TOTAL HOURS: 30 CREDITS: 2

Unit 1 Microbiological Laboratory and Safe Practices **No. of Hours: 8**

Good laboratory practices - Good laboratory practices, Good microbiological practices
Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Unit 2 Determining Microbes in Food / Pharmaceutical Samples **No. of Hours: 10**

Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products
Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit 3 Pathogenic Microorganisms of Importance in Food & Water **No. of Hours: 8**

Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar
Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

Unit 4 HACCP for Food Safety and Microbial Standards **No. of Hours: 4**

Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations
Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking water

SUGGESTED READING

1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

SEC Paper -2: BIOFERTILIZERS AND BIOPESTICIDES
SEMESTER – III
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Biofertilizers **No of Hours: 10**

General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers.
Symbiotic N2 fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants
Frankia - Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis.
Cyanobacteria, *Azolla* - Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Unit 2 Non - Symbiotic Nitrogen Fixers **No of Hours: 4**

Free living *Azospirillum*, *Azotobacter* - free isolation, characteristics, mass inoculums, production and field application.

Unit 3 Phosphate Solubilizers **No of Hours: 4**

Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field Application

Unit 4 Mycorrhizal Biofertilizers **No of Hours: 5**

Importance of mycorrizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit 5 Bioinsecticides **No of Hours: 7**

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications.

Suggested Readings

1. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002). Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.
4. Subba Rao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

SEC Paper -3: MICROBIAL DIAGNOSIS IN HEALTH CLINICS
SEMESTER – IV

TOTAL HOURS: 30 CREDITS: 2

Unit 1 Importance of Diagnosis of Diseases **No of Hours: 5**

Bacterial, Viral, Fungal and Protozoan Diseases of various human body systems, Disease associated clinical samples for diagnosis.

Unit 2 Collection of Clinical Samples **No of Hours: 5**

How to collect clinical samples (oral cavity, throat, skin, Blood, CSF, urine and faeces) and precautions required. Method of transport of clinical samples to laboratory and storage.

Unit 3 Direct Microscopic Examination and Culture **No of Hours: 5**

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsastained

thin blood film for malaria
Preparation and use of culture media - Blood agar, Chocolate agar, Lowenstein-Jensen medium, MacConkey agar, Distinct colony properties of various bacterial pathogens.

Unit 4: Serological and Molecular Methods **No of Hours: 5**

Serological Methods - Agglutination, ELISA, immunofluorescence, Nucleic acid based methods - PCR, Nucleic acid probes

Unit 5: Kits for Rapid Detection of Pathogens **No of Hours: 5**

Typhoid, Dengue and HIV, Swine flu

Unit 6: Testing for Antibiotic Sensitivity in Bacteria **No of Hours: 5**

Importance, Determination of resistance/sensitivity of bacteria using disc diffusion method, Determination of minimal inhibitory concentration (MIC) of an antibiotic by serial double dilution method

SUGGESTED READING

1. Ananthanarayan R and Paniker CKJ (2009)Textbook of Microbiology, 8th edition, Universities Press Private Ltd.
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Randhawa, VS, Mehta G and Sharma KB (2009) Practicals and Viva in Medical Microbiology 2nd edition, Elsevier India Pvt Ltd
4. Tille P (2013) Bailey's and Scott's Diagnostic Microbiology, 13th edition, Mosby
5. Collee JG, Fraser, AG, Marmion, BP, Simmons A (2007) Mackie and Mccartney Practical Medical Microbiology, 14th edition, Elsevier.

SEC Paper-4: FOOD FERMENTATION TECHNIQUES
SEMESTER – IV
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Fermented Foods **No of Hours: 4**

Definition, types, advantages and health benefits

Unit 2 Milk Based Fermented Foods **No of Hours: 8**

Dahi, Yogurt, Buttermilk (Chach) and cheese: Preparation of inoculums, types of microorganisms and production process

Unit 3 Grain Based Fermented Foods **No of Hours: 6**

Soy sauce, Bread, Idli and Dosa: Microorganisms and production process

Unit 4 Vegetable Based Fermented Foods **No of Hours: 4**

Pickels, Saeurkraut: Microorganisms and production process

Unit 5 Fermented Meat and Fish **No of Hours: 4**

Types, microorganisms involved, fermentation process

Unit 6 Probiotic Foods **No of Hours: 4**

Definition, types, microorganisms and health benefits

Suggested Readings

1. Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press
2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.
3. Yadav JS, Grover, S and Batish VK (1993) A comprehensive dairy microbiology, Metropolitan 4.Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer

SCHEME AND SYLLABUS UNDER CHOICE BASED CREDIT SYSTEM
B.Sc. PROGRAMME COURSE WITH MICROBIOLOGY

Year		Discipline Specific Core Course (12)	Ability Enhancement Compulsory Course (2)	Skill Enhancement Course SEC (4)	Discipline Specific Elective course DSE (6)
1	I	DSC-1 Paper 1 DSC-2 Paper 1 DSC-3 Paper 1	AECC-1		
	II	DSC-1 Paper 2 DSC-2 Paper 2 DSC-3 Paper 2	AECC-2		
2	III	DSC-1 Paper 3 DSC-2 Paper 3 DSC-3 Paper 3		SEC-1/2 Paper -1/2 (Any one)	
	IV	DSC-1 Paper 4 DSC-2 Paper 4 DSC-3 Paper 4		SEC-1/2 Paper-3/4 (Any one)	
3	V			SEC-1/2 Paper-1/2 (Any one)	DSE-1 Paper 1/2 (Any one) DSE-2 Paper 1 DSE-3 Paper 1
	VI			SEC-1/2 Paper-3/4 (Any one)	DSE-1 Paper 3/4 (Any one) DSE-2 Paper 2 DSE-3 Paper 2

Overall distribution of credits and marks in B.Sc Programme Course With Microbiology

Course	Total papers	Credits /per		Total Credits
		Theory	Practical	
I.Core Courses	12	4	2	12X6=72
II.DSE	6	4	2	6X6=36
IV.AECC	2	2	-	2x2=4
V.SEC	4	2	-	4x2=8
			Grand total	120

Structure of B. Sc. Programme Course with Microbiology

Core Course in Microbiology *(4 papers)*
[Theory+ Practical= 6 credit each paper, Theory = 4 credits, Practical= 2 credits]

DSC1 Paper-1: Introduction to Microbiology and Microbial Diversity
DSC 1 Paper-2: Bacteriology
DSC 1 Paper-3: Biochemistry
DSC1 Paper-4: Microbial Physiology and Metabolism

Discipline Specific Elective course in Microbiology *(Two papers)*
[Theory+ Practical= 6 credit each paper, Theory = 4 credits, Practical= 2 credits]

DSE-1 Paper 1: Virology
DSE-1 Paper 2: Cell Biology
DSE-1 Paper 3: Microbial Genetics and Microbial Biotechnology
DSE-1 Paper 4: Medical Microbiology

Ability Enhancement Compulsory Course
[2Credit each]

AECC-1: Environmental Sciences
AECC-2: English Communication/Hindi Communication/Bengali Communication/ Nepali Communication

Skill Enhancement Elective Course in Microbiology
[2 credit each]

SEC -1/2- Paper 1: Microbial Quality Control in Food and Pharmaceutical Industries
SEC-1/2- Paper 2: Biofertilizers and Biopesticides
SEC-1/2- Paper 3: Food Fermentation Techniques
SEC-1/2- Paper 4: Microbiological Analysis of Air and Water

A. CORE COURCES

DSC1 Paper-1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (Theory)
Semester I

TOTAL HOURS: 60 CREDITS: 4

Unit 1 History of Development of Microbiology No. of Hours: 18

Development of microbiology as a discipline, Spontaneous generation*vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microbial World No. of Hours: 42

A. Systems of classification

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three kingdom classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms

B. General characteristics of different groups: Acellularmicroorganisms (Viruses, Viroids, Prions) and **Cellular** microorganisms (Bacteria, Algae, Fungi and Protozoa) with emphasis on distribution and occurrence, morphology, mode of reproduction and economic importance.

- **Algae**

General characteristics of algae including occurrence, thallus organization, algae cell ultra structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles.

- **Fungi**

General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism.

- **Protozoa**

General characteristics with special reference to *Amoeba, Plasmodium*

DSC1 Paper-1.1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (PRACTICAL)
Semester I

TOTAL HOURS: 60 CREDITS: 2

1. Microbiology Good Laboratory Practices and Biosafety.
2. To study the principle and applications of important instruments (biological safety cabinets, Autoclave, incubator, BOD incubator, hot air oven, light microscope, pH meter) used in the Microbiology laboratory.
3. Preparation of culture media for bacterial cultivation.
4. Sterilization of medium using Autoclave and assessment for sterility
5. Sterilization of glassware using Hot Air Oven and assessment for sterility
6. Sterilization of heat sensitive material by membrane filtration and assessment for sterility
7. Demonstration of the presence of microflora in the environment by exposing nutrient agar Plates to air.
8. Study of *Rhizopus*, *Aspergillus*using temporary mounts

9. Study of the following protozoans using permanent mounts/photographs: *Amoeba*, *Plasmodium*

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: An Introduction. 9th edition.Pearson Education
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited
4.Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology.9th Edition. McGraw Hill International.
5. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
6. Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology.5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005).General Microbiology.5th edition. McMillan.

DSC 1 Paper-2: BACTERIOLOGY (THEORY)
Semester II
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Cell organization **No. of Hours: 14**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili. Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall. Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes. Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids Endospore: Structure, formation, stages of sporulation.

Unit 2 Bacteriological techniques **No. of Hours: 5**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

Unit 3 Microscopy **No. of Hours: 6**

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluoresence Microscope, Confocal microscopy, Scanning and Transmission Electron Microscope

Unit 4 Growth and nutrition **No. of Hours: 8**

Nutritional requirements in bacteria and nutritional categories; Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media *Physical methods of microbial control*: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation *Chemical methods of microbial control*: disinfectants, types and mode of action

Unit 5 Reproduction in Bacteria **No. of Hours: 3**

Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate

Unit 6 Bacterial Systematics **No. of Hours: 8**

Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing. Differences between eubacteria and archaebacteria

Unit 7 Important archaeal and eubacterial groups **No. of Hours: 16**

Archaebacteria: General characteristics, Overview to Nanoarchaeota, Crenarchaeota,Euryarchaeota, thermophiles and Halophiles

Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:

Gram Negative:

General characteristics with suitable examples of Alpha proteobacteria, Beta proteobacteriaand Gammaproteobacteria

Gram Positive:

Low G+ C (Firmicutes): General characteristics with suitable examples High G+C (Actinobacteria): General characteristics with suitable examples

***Cyanobacteria*:** An Introduction

DSC 1 Paper-2.1: BACTERIOLOGY (PRACTICAL)

Semester II

TOTAL HOURS: 60 CREDITS: 2

1. Preparation of different media: synthetic media BG-11, Complex media-Nutrient agar, McConkey agar, EMB agar.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining-permanent slide only.
6. Capsule staining
7. Endospore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method/pour plate method.
11. Motility by hanging drop method.

SUGGESTED READINGS

1. Atlas RM. (1997).Principles of Microbiology.2nd edition.WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM.(2014). Brock Biology of Micro-organisms.14th edition.Parker J. Prentice Hall International, Inc.
4. PelczarJr MJ, Chan ECS, and Krieg NR.(2004). Microbiology.5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education.
9. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson

Education Limited

DSC 1 Paper-3: BIOCHEMISTRY (THEORY)
Semester –III
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Bioenergetics **No. of Hours: 8**

First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, enthalpy,and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP

Unit 2 Carbohydrates **No. of Hours: 12**

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses. Stereo isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose.Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin

Unit 3 Lipids **No. of Hours: 12**

Definition and major classes of storage and structural lipids.Storage lipids.Fatty acids structure and functions.Essential fatty acids.Triacylglycerols structure, functions and properties. Saponification Structural lipids.Phosphoglycerides: Building blocks, General structure, functions and properties. Structure of phosphatidylethanolamine and phosphatidylcholine, Sphingolipids: building blocks, structure of sphingosine, ceramide. Special mention of sphingomyelins, cerebrosides and gangliosides Lipid functions: cell signals, cofactors, prostaglandins, Introduction of lipid micelles, monolayers, bilayers

Unit 4 Proteins **No. of Hours: 12**

Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Titration curve of amino acid and its Significance, Classification, biochemical structure and notation of standard protein amino acids Ninhydrinreaction.Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D- glutamic acid Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame, Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins, Tertiary and quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure, Quaternary structures of proteins

Unit 5. Enzymes **No. of Hours: 12**

Structure of enzyme: Apoenzyme and cofactors, prosthetic group-TPP, coenzyme NAD,metal cofactors, Classification of enzymes, Mechanism of action of enzymes: active site, transition state complex and activation energy. Lock and key hypothesis, and Induced Fit hypothesis. Significance of hyperbolic, double reciprocal plots of enzyme activity, Km, and allosteric mechanism Definitions of terms – enzyme unit, specific activity and turnover number, Multienzymecomplex : pyruvate dehydrogenase; isozyme: lactate dehydrogenase, Effect of pH and temperature on enzyme activity. Enzyme inhibition: competitive- sulfa drugs; non-competitive-heavy metal salts

Unit 6. Vitamins **No. of Hours: 4**

Classification and characteristics with suitable examples, sources and importance

DSC 1 Paper-3.1: BIOCHEMISTRY (PRACTICALS)
SEMESTER –III

TOTAL HOURS: 60 CREDITS: 2

1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts
2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant
3. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non reducing sugars
4. Qualitative/Quantitative tests for lipids and proteins
5. Study of protein secondary and tertiary structures with the help of models
6. Study of enzyme kinetics – calculation of V_{max}, Km, Kcat values
7. Study effect of temperature, pH and Heavy metals on enzyme activity
8. Estimation of any one vitamin

SUGGESTED READING

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company,
6. Willey MJ, Sherwood, LM &Woolverton C J (2013) Prescott, Harley and Klein's Microbiology by. 9th Ed., McGrawHill
7. Voet,D. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons,

DSC 1 Paper-4: MICROBIAL PHYSIOLOGY AND METABOLISM (THEORY)
SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth No. of Hours: 12
Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve Microbial growth in response to environment -Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe),barophilic. Microbial growth in response to nutrition and energy – Autotroph/Phototroph, heterotrophy, Chemolithoautotroph, Chemolithoheterotroph, Chemoheterotroph, Chemolithotroph, photolithoautotroph, Photoorganoheterotroph.

Unit 2 Nutrient uptake and Transport No. of Hours: 10
Passive and facilitated diffusion Primary and secondary active transport, concept of uniport, symport and antiport Group translocation Iron uptake

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration No. of Hours: 16
Concept of aerobic respiration, anaerobic respiration and fermentation Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway TCA cycle Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors

Unit 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 6

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction) Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism **No. of Hours: 10**

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction) Introduction to phototrophic metabolism – groups of phototrophic microorganisms, anoxygenic*vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria, purple bacteria and cyanobacteria

Unit 6 Nitrogen Metabolism - an overview **No. of Hours: 6**

Introduction to biological nitrogen fixation Ammonia assimilation Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification

DSC 1 Paper-4.1: MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)

SEMESTER –IV

TOTAL HOURS: 60 CREDITS: 2

1. Study and plot the growth curve of *E. coli* by turbidometric and standard plate count methods.
2. Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data
3. Effect of temperature on growth of *E. coli*
4. Effect of pH on growth of *E. coli*
5. Effect of carbon and nitrogen sources on growth of *E.coli*
6. Effect of salt on growth of *E. coli*
7. Demonstration of alcoholic fermentation
8. Demonstration of the thermal death time and decimal reduction time of *E. coli.*

SUGGESTED READINGS

1. Madigan MT, and Martinko JM (2014).Brock Biology of Microorganisms.14th edition. Prentice Hall International Inc.
2. Moat AG and Foster JW. (2002). Microbial Physiology.4th edition. John Wiley & Sons
3. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India
4. Gottschalk G. (1986). Bacterial Metabolism.2nd edition. Springer Verlag
6. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
7. Willey JM, Sherwood LM, and Woolverton CJ.(2013). Prescott's Microbiology.9th edition. McGraw Hill Higher Education.

B.Discipline specific Elective

DSE-1 Paper 1: VIROLOGY (THEORY)
SEMESTER –V
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Nature and Properties of Viruses **No. of Hours: 12**

Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses Isolation, purification and cultivation of viruses Viral taxonomy: Classification and nomenclature of different groups of viruses

Unit 2 Bacteriophages **No. of Hours**: **10**

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage

Unit 3 Viral Transmission, Salient features of viral nucleic acids and Replication

No. of Hours: **20**

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal Salient features of viral Nucleic acid : Unusual bases (TMV,T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV) Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna) , Assembly, maturation and release of virions

Unit 4 Viruses and Cancer **No. of Hours: 6**

Introduction to oncogenic viruses Types of oncogenic DNA and RNA viruses: Concepts of oncogenes and proto-oncogenes

Unit 5 Prevention & control of viral diseases **No. of Hours: 8**

Antiviral compounds and their mode of action, Interferon and their mode of action
General principles of viral vaccination

Unit 6 Applications of Virology **No. of Hours: 4**

Use of viral vectors in cloning and expression, Gene therapy and Phage display

DSE 1 Paper -1.1: VIROLOGY (PRACTICAL)
SEMESTER – V
TOTAL HOURS: 60 CREDITS: 2

1. Study of the structure of important animal viruses (influenza, hepatitis B and retroviruses) using electron micrographs
2. Study of the structure of important plant viruses (Gemini, tobacco ring spot and alpha-alpha mosaic viruses) using electron micrographs
3. Study of the structure of important bacterial viruses (T4, λ) using electron micrograph.
4. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique
5. Study of cytopathic effects of viruses using photographs
6. Perform local lesion technique for assaying plant viruses.

SUGGESTED READING

1. Dimmock, NJ, Easton, AL, Leppard, KN (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
2. Carter J and Saunders V (2007). Virology: Principles and Applications. John Wiley and Sons.
3. Flint SJ, Enquist, LW, Krug, RM, Racaniello, VR, Skalka, AM (2004). Principles of Virology.

DSE-1 Paper 2: CELL BIOLOGY (THEORY)

SEMESTER – V

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Structure and organization of Cell **No. of Hours: 12**

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic Plasma membrane: Structure and transport of small molecules Cell Wall: Eukaryotic cell wall, aspects) Mitochondria, chloroplasts and peroxisomes Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules

Unit 2 Nucleus **No. of Hours: 4**

Nuclear envelope, nuclear pore complex and nuclear lamina Chromatin – Molecular organization Nucleolus

Unit 3 Protein Sorting and Transport **No. of Hours: 12**

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus Lysosomes

Unit 4 Cell Signalling **No. of Hours: 8**

Signalling molecules and their receptors Function of cell surface receptors Pathways of intra-cellular receptors **–** Cyclic AMP pathway

Unit 5 Cell Cycle, Cell Death and Cell Renewal **No. of Hours: 12**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis, Development of cancer, causes and types Programmed cell death

DSC 1 Paper-2.1: CELL BIOLOGY (PRACTICAL)

SEMESTER – V

TOTAL HOURS: 60 CREDITS: 2

1. Study a representative plant and animal cell by microscopy.
2. Study of the structure of cell organelles through electron micrographs
3. Cytochemical staining of DNA – Feulgen
4. Study of polyploidy in Onion root tip by colchicine treatment.
5. Identification and study of cancer cells by photomicrographs.
6. Study of different stages of Mitosis.
7. Study of different stages of Meiosis.

SUGGESTED READING

1. Hardin J, Bertoni G and Kleinsmith LJ. (2010). Becker's World of the Cell.8th edition. Pearson.
2. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons.Inc.
3. De Robertis, EDP and De Robertis EMF.(2006). Cell and Molecular Biology.8th edition.Lipincott Williams and Wilkins, Philadelphia.

4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition.ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.

DSE 1 Paper-3: MICROBIAL GENETICS AND MICROBIAL BIOTECHNOLOGY (THEORY)

SEMESTER –VI

TOTAL HOURS: 60 CREDITS: 4

Unit 1 Genome Organization and Mutations **No. of Hours: 8**

Genome organization: *E. coli,* Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens;

Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of Mutations Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes

Unit 2 Plasmids **No. of Hours: 7**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, Plasmid replication and partitioning, Host range, plasmid-incompatibility,

, Regulation of copy number, curing of plasmids

Unit 3 Mechanisms of Genetic Exchange **No. of Hours: 8**

Transformation - Discovery, mechanism of natural competence Conjugation - Discovery, mechanism, Hfr and F' strains, Interrupted mating technique

Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates,

Unit 4 Therapeutic and Industrial Biotechnology **No. of Hours: 7**

Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine)

Microbial polysaccharides and polyesters, ,bioplastics

Unit 5 Applications of Microbes in Biotransformations **No. of Hours: 5**

Microbial based transformation of steroids and sterols

Unit 6 Microbial Products and their Recovery **No. of Hours: 10**

Microbial product purification: filtration, ion exchange & affinity chromatography techniques

Immobilization methods and their application: Whole cell immobilization

Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents

Unit 7 Molecular Cloning- Tools and Strategies **No. of Hours: 15**

Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering

DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyl transferase, kinases and phosphatases, and DNA ligases

Cloning Vectors: Definition and Properties

Plasmid vectors: pBR and pUC series

Bacteriophage lambda and M13 based vectors

Cosmids, BACs, YACs

Use of linkers and adaptors

Expression vectors: *E.coli*lac and T7 promoter-based vectors,

mammalian , SV40-based expression vectors

DSE 1 Paper-3.1: MICROBIAL GENETICS AND MICROBIAL BIOTECHNOLOGY (PRACTICAL)
SEMESTER –VI

TOTAL HOURS: 60 CREDITS: 2

1. Preparation of Master and Replica Plates
3. Study survival curve of bacteria after exposure to ultraviolet (UV) light
4. Isolation of Plasmid DNA from *E.coli*
5. Study bacterial cell immobilization in calcium alginate gels
6. Study of algal Single Cell Proteins
7. Preparation of competent cells for transformation
8. Demonstration of Bacterial Transformation and calculation of transformation efficiency.
9 Interpretation of sequencing gel electropherograms
10. Designing of primers for DNA amplification

SUGGESTED READING

1. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
2. Krebs J, Goldstein E, Kilpatrick S (2013). Lewin's Essential Genes, 3rd Ed., Jones and Bartlett Learning
3. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning
4. Watson JD, Baker TA, Bell SP et al. (2008) Molecular Biology of the Gene, 6th Ed., Benjamin Cummings
5. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley-India
6. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings
7. Sambrook J and Russell DW. (2001). Molecular Cloning: A Laboratory Manual. 4th Edition, Cold Spring Harbour Laboratory press.
8. Maloy SR, Cronan JE and FriefelderD(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers
9. Ratledge, C and Kristiansen, B. (2001). Basic Biotechnology, 2nd Edition, Cambridge University Press.
10. Demain, A. L and Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology, 2nd Edition, ASM Press.
11. Swartz, J. R. (2001). Advances in Escherichia coli production of therapeutic proteins. Current Opinion in Biotechnology, 12, 195–201.
12. Prescott, Harley and Klein's Microbiology by Willey JM, Sherwood LM, Woolverton CJ (2014), 9th edition, McGraw Hill Publishers.
13. Glick BR, Pasternak JJ, and Patten CL (2010) Molecular Biotechnology 4th edition, ASM Press.

DSE 1 Paper-4: MEDICAL MICROBIOLOGY (THEORY)
SEMESTER –VI
TOTAL HOURS: 60 CREDITS: 4

Unit 1 Normal microflora of the human body and host pathogen interaction
No. of Hours: 8

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract
Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS

Unit 2 Sample collection, transport and diagnosis **No. of Hours: 5**

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests, PCR, DNA probes).

Unit 3 Bacterial diseases **No. of Hours: 15**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control
Respiratory Diseases: *Mycobacterium tuberculosis*
Gastrointestinal Diseases: *Salmonella typhi*, *Vibrio cholerae*,
Others: *Bacillus anthracis, Clostridium tetani*

Unit 4 Viral diseases **No. of Hours: 14**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control
Polio, Hepatitis, AIDS, Influenza with brief description of Ebola,
Japanese Encephalitis

Unit 5 Protozoan diseases **No. of Hours: 5**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control
Malaria, Kala-azar

Unit 6 Fungal diseases **No. of Hours: 5**

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention
Cutaneous mycoses: Tineapedis (Athlete's foot)
Systemic mycoses: Histoplasmosis
Opportunistic mycoses: Candidiasis

Unit 7 Antimicrobial agents: General characteristics and mode of action **No. of Hours: 8**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism
Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin
Antiviral agents: Mechanism of action of Amantadine, Azidothymidine
Antibiotic resistance, MDR, XDR, MRSA,

DSE 1 Paper-4.1: MEDICAL MICROBIOLOGY (PRACTICAL)
SEMESTER – VI
TOTAL HOURS: 60 CREDITS: 2

1. Identify bacteria (any three of *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus*) using laboratory strains on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
2. Study of composition and use of important differential media for identification of bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
3. Study of bacterial flora of skin by swab method
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Determination of minimal inhibitory concentration (MIC) of an antibiotic.
6. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms)
7. Study of various stages of malarial parasite in RBCs using permanent mounts.

SUGGESTED READING

1. Ananthanarayan R. and Paniker C.K.J. (2009) Textbook of Microbiology. 8th edition, University Press Publication
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013) Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication
3. Goering R., Dockrell H., Zuckerman M. and Wakelin D. (2007) Mims' Medical Microbiology. 4th edition. Elsevier
4. Willey JM, Sherwood LM, and Woolverton CJ.(2013) Prescott, Harley and Klein's Microbiology. 9th edition. McGraw Hill Higher Education
5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms.14th edition. Pearson International Edition

D. Skill Enhancement Elective course (Any two)

SEC-1/2 Paper 1: Microbial Quality Control in Food and Pharmaceutical Industries
SEMESTER – III/V
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Microbiological Laboratory and Safe Practices **No. of Hours: 8**
Good laboratory practices - Good laboratory practices, Good microbiological practices
Biosafety cabinets – Working of biosafety cabinets, using protective clothing, specification for BSL-1, BSL-2, BSL-3. Discarding biohazardous waste – Methodology of Disinfection, Autoclaving & Incineration

Unit 2 Determining Microbes in Food / Pharmaceutical Samples **No. of Hours: 10**
Culture and microscopic methods - Standard plate count, Most probable numbers, Direct microscopic counts, Biochemical and immunological methods: Limulus lysate test for endotoxin, gel diffusion, sterility testing for pharmaceutical products
Molecular methods - Nucleic acid probes, PCR based detection, biosensors.

Unit 3 Pathogenic Microorganisms of Importance in Food & Water **No. of Hours: 8**
Enrichment culture technique, Detection of specific microorganisms - on XLD agar, Salmonella Shigella Agar, Manitol salt agar, EMB agar, McConkey Agar, Saboraud Agar
Ascertaining microbial quality of milk by MBRT, Rapid detection methods of microbiological quality of milk at milk collection centres (COB, 10 min Resazurin assay)

Unit 4 HACCP for Food Safety and Microbial Standards **No. of Hours: 4**
Hazard analysis of critical control point (HACCP) - Principles, flow diagrams, limitations
Microbial Standards for Different Foods and Water – BIS standards for common foods and drinking Water

SUGGESTED READING
1. Harrigan WF (1998) Laboratory Methods in Food Microbiology, 3rd ed. Academic Press
2. Garg N, Garg KL and Mukerji KG (2010) Laboratory Manual of Food Microbiology I K International Publishing House Pvt. Ltd.
3. Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer
4. Baird RM, Hodges NA and Denyer SP (2005) Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices, Taylor and Francis Inc.

SEC-1/2 Paper 2: BIOFERTILIZERS AND BIOPESTICIDES
SEMESTER – III/V
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Biofertilizers **No of Hours: 10**
General account of the microbes used as biofertilizers for various crop plants and their advantages over chemical fertilizers.
Symbiotic N2 fixers: *Rhizobium* - Isolation, characteristics, types, inoculum production and field application, legume/pulses plants
Frankia- Isolation, characteristics, Alder, Casurina plants, non-leguminous crop symbiosis.
Cyanobacteria, *Azolla*- Isolation, characterization, mass multiplication, Role in rice cultivation, Crop response, field application.

Unit 2 Non - Symbiotic Nitrogen Fixers **No of Hours: 4**

Free living *Azospirillum*, *Azotobacter*- free isolation, characteristics, mass inoculums, production and field application.

Unit 3 Phosphate Solubilizers **No of Hours: 4**

Phosphate solubilizing microbes - Isolation, characterization, mass inoculum production, field Application

Unit 4 MycorrhizalBiofertilizers No of Hours: 5

Importance of mycorrizal inoculum, types of mycorrhizae and associated plants, Mass inoculum production of VAM, field applications of Ectomycorrhizae and VAM.

Unit 5 Bioinsecticides No of Hours: 7

General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, *Bacillus thuringiensis*, production, Field applications, Viruses – cultivation and field applications.

Suggested Readings

1. Kannaiyan, S. (2003). Bioetchnology of Biofertilizers, CHIPS, Texas.
2. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.
3. Reddy, S.M. et. al. (2002).Bioinoculants for sustainable agriculture and forestry, Scientific Publishers.
4. SubbaRao N.S (1995) Soil microorganisms and plant growth Oxford and IBH publishing co. Pvt. Ltd. NewDelhi.
5. Saleem F and Shakoori AR (2012) Development of Bioinsecticide, Lap Lambert Academic Publishing GmbH KG
6. Aggarwal SK (2005) Advanced Environmental Biotechnology, APH publication.

SEC -1/2- Paper-3: FOOD FERMENTATION TECHNIQUES
SEMESTER – IV/VI
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Foods as a substrate for microorganisms **No. of Hours: 5**

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods,

Unit 2 Microbial spoilage of various foods **No. of Hours: 5**

Principles, Spoilage of vegetables, fruits, meat, eggs, milk

Unit 3 Principles and methods of food preservation **No. of Hours: 7**

Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids,

Unit 4 Fermented foods **No. of Hours: 5**

Dairy starter cultures, fermented dairy products: yogurt, cheese, other fermented foods: tampeh, Probiotics: Health benefits,types of microorganisms used, probiotic foods available in market.

Unit 5 Food borne diseases (causative agents, foods involved, symptoms and preventive measures) **No. of Hours: 5**

Food intoxications: *Staphylococcus aureus*
Food infections: *Bacillus cereus*, *Listeriamonocytogenes*

Unit 5 Fermented Meat and Fish No of Hours: 3

Types, microorganisms involved, fermentation process

Suggested Readings

1. Hui YH, Meunier-Goddik L, Josephsen J, Nip WK, Stanfield PS (2004) Handbook of food and fermentation technology, CRC Press
2. Holzapfel W (2014) Advances in Fermented Foods and Beverages, Woodhead Publishing.

3. Yadav JS, Grover, S and Batish VK (1993) A comprehensive dairy microbiology, Metropolitan 4.Jay JM, Loessner MJ, Golden DA (2005) Modern Food Microbiology, 7th edition. Springer

SEC- 1/2- Paper-4: MICROBIOLOGICAL ANALYSIS OF AIR AND WATER
SEMESTER – IV/VI
TOTAL HOURS: 30 CREDITS: 2

Unit 1 Aeromicrobiology **No of Hours: 4**
Bioaerosols, Air borne microorganisms (bacteria, Viruses, fungi) and their impact on human health and environment, significance in food and pharma industries and operation theatres, allergens

Unit 2 Air Sample Collection and Analysis **No of Hours: 7**
Bioaerosol sampling, air samplers, methods of analysis, CFU, culture media for bacteria and fungi, Identification characteristics

Unit 3 Control Measures **No of Hours: 4**
Fate of bioaerosols, inactivation mechanisms – UV light, HEPA filters, desiccation, Incineration

Unit 4 Water Microbiology **No of Hours: 4**
Water borne pathogens, water borne diseases

Unit 5 Microbiological Analysis of Water **No of Hours: 7**
Sample Collection, Treatment and safety of drinking (potable) water, methods to detect potability of water samples: (a) standard qualitative procedure: presumptive/MPN tests, confirmed and completed tests for faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests

Unit 6 Control Measures **No of Hours: 4**
Precipitation, chemical disinfection, filtration, high temperature, UV light

Suggested Reading

1. da Silva N, Taniwaki MH, Junqueira VC, Silveira N, Nascimento MS, Gomes RAR (2012) Microbiological Examination Methods of Food and WaterA Laboratory Manual, CRC Press
2. Atlas RM and Bartha R. (2000). Microbial Ecology: Fundamentals & Applications. 4th edition. Benjamin/Cummings Science Publishing, USA
3. Maier RM, Pepper IL and Gerba CP. (2009).Environmental Microbiology. 2nd edition, Academic Press
4. Hurst CJ, Crawford RL, Garland JL, Lipson DA (2007) Manual of Environmental Microbiology, 3rd edition, ASM press