B.Sc. (H) Microbiology

THREE-YEAR FULL-TIME PROGRAMME

Choice based credit system

(Six-Semester Course)

COURSE CONTENTS

APPROVED IN COMMITTEE OF COURSES HELD ON JUNE 5, 2015

PREAMBLE

The B.Sc. (Hons.) Microbiology is presently being run in different colleges of the University of Delhi. It was converted from annual system to six-semester mode course in 2009. A new system, **Choice Based Credit System (CBCS)** is being introduced based on the recommendations of University Grants Commission (UGC) to create uniformity in teaching at various central universities and to facilitate seamless mobility of students across various universities based on the credits. This credit based semester system will provide flexibility in designing curriculum and assigning credits based on the course contents and number of hours of teaching. In this system students have the option to take courses of their choice, learn at their own pace, take additional courses and acquire more than the required credits, making it an interdisciplinary approach of learning. This new syllabus has been prepared keeping in view the unique requirements of B.Sc. (Hons.) Microbiology students. The contents have been drawn to accommodate the widening horizons of the Microbiology discipline and reflect the changing needs of the students. The semester wise course distribution and detailed syllabus for each paper is appended with a list of suggested readings.

Under this system, there will be 14 core course papers (C1 to C14). These are compulsory to be studied by a student to complete the requirement of B.Sc. (Hons) Microbiology programme. The students will study two core papers per semester in first year, three core papers per semester in the second year and two core papers per semester in the third year. The core papers (6 credits each) will comprise of theory (4 credits) and practicals (2 credits). Each practical batch will be of 15 students. A number exceeding 15 (at least ten) will be divided into two equal batches.

Elective courses can be chosen from a pool of papers. There are two kinds of electives: a) **Discipline Specific Elective (DSE)**: There are nine such papers (DSE: 1-9), out of which microbiology student will choose any two in fifth and sixth semester each. The Discipline specific elective papers (6 credits each) will comprise of theory (4 credits) and practicals (2 credits) like the core papers. A particular option of DSE paper will be offered in V and VI semesters, only if the minimum number of students opting for that paper is 10. One of the electives in DSE is project work which can be opted in lieu of one of the elective and will also carry 6 credits. Number of students who will be offered project work will vary from college to college depending upon the infrastructural facilities and may vary each year. The college shall announce the number of seats for project work well in advance and may select the students for the same based on merit. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes. The final evaluation of the project work will be through a committee involving internal and external examiners. In this regard guidelines provided by University of Delhi for executing and evaluation of project work will be final. Students will be asked their choice for Project

work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

b) **Generic Elective (GE)**: Different generic elective papers will be offered to students of other departments of the college and the student will have the option to choose one generic elective paper each in the first four semesters. The generic elective will be of six credits each. The Department of Microbiology is offering eight generic elective papers (GE: 1-8) for students of other departments. These generic elective papers (6 credits each) will comprise of theory (4 credits) and practicals (2 credits).

Besides the core and elective courses, there are two ability enhancement compulsory courses, AE1 (Environmental Sciences) and AE2 (English communication) of two credits each. The student is supposed to take one in each semester of the first year.

The students will also undertake two Skill Enhancement (SE) courses of two credits each in III and IV semester of second year which they can choose from the list of SE courses offered by their college. The Department of Microbiology is offering seven such papers (SE:1-7).

In the CBCS system, a credit is unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week. A minimum of 140 credits are required to obtain degree in B.Sc. (Hons.) Microbiology.

Structure of B. Sc. Honours Microbiology under CBCS

Core Courses

C-1: Introduction to Microbiology and Microbial Diversity
C-2: Bacteriology
C-3: Biochemistry
C-4: Virology
C-5: Microbial Physiology and Metabolism
C-6: Cell Biology
C-7: Molecular Biology
C-8: Microbial Genetics and Genomics
C-9: Environmental Microbiology
C-10: Food and Dairy Microbiology
C-11: Industrial Microbiology
C-12: Immunology
C-13: Medical Microbiology
C-14: Recombinant DNA Technology

Discipline Centric Elective (Four)

Semester – V (Any Two)	DSE-1: Bioinformatics, DSE-2: Plant Pathology, DSE-3: Inheritance Biology DSE-4: Biomathematics and Biostatistics
Semester – VI (Any Two)	DSE-5: Microbial Biotechnology, DSE-6: Advances in Microbiology, DSE-7: Instrumentation and Biotechniques, DSE-8: Biosafety and Intellectual Property Rights (IPR), DSE-9: Project Work

Generic Electives (Four) Offered to the students of other Departments

Semester – I	GE-1: Introduction and Scope of Microbiology
Semester – II	GE-2: Bacteriology and Virology
Semester – III (Any One)	GE-3: Microbial Metabolism GE-4: Microbial Genetics and Molecular Biology
Semester-IV (Any One)	GE-5: Industrial and Food Microbiology GE-6: Microbes in Environment GE-7: Medical Microbiology and Immunology GE-8: Genetic Engineering and Biotechnology

Ability Enhancement Compulsory Courses

AE-1: Environmental Sciences
AE-2: English/MIL Communication

Skill Enhancement Elective Courses (Any Two)

SE-1: Microbial Quality Control in Food and Pharmaceutical Industries
SE-2: Microbial Diagnosis in Health Clinics
SE-3: Biofertilizers and Biopesticides
SE-4: Food Fermentation Techniques
SE-5: Management of Human Microbial Diseases
SE-6: Microbiological Analysis of Air and Water
SE-7: Fundamentals of Bioinformatics

SCHEME FOR CHOICE BASED CREDIT SYSTEM IN B.Sc. MICROBIOLOGY HONOURS

Semester	CORE COURSE(14)	Ability Enhancement Compulsory Course (2)	Skill Enhancement Course (SEC) (2)	Discipline Specific Elective DCE (4)	GENERIC ELECTIVE: (GE) (4)
I	Introduction to Microbiology and Microbial Diversity	English communication			GE-1
	Bacteriology				
II	Biochemistry	Environmental Science			GE-2
	Virology				
III	Microbial Physiology and Metabolism		SEC -1		GE-3
	Cell Biology				
	Molecular Biology				
IV	Microbial Genetics and Genomics		SEC -2		GE-4
	Environmental Microbiology				
	Food and Dairy Microbiology				
V	Industrial Microbiology			DSE-1	
	Immunology			DSE-2	
VI	Medical Microbiology			DSE -3	,
	Recombinant DNA Technology			DSE-4	

SEMESTER	COURSE OPTED	COURSE NAME	Credits
I	**Ability Enhancement Compulsory Course-I**	English communications/ Environmental Science	2
	Core course-I	Introduction to Microbiology and Microbial Diversity	4
	Core Course-I Practical	Introduction to Microbiology and Microbial Diversity	2
	Core course-II	Bacteriology	4

	Core Course-II Practical	Bacteriology	2
	Generic Elective -1	GE-1	4
	Generic Elective -1 Practical	GE-1	2
II	**Ability Enhancement Compulsory Course-II**	English communications/ Environmental Science	2
	Core course-III	Biochemistry	4
	Core Course-III Practical	Biochemistry	2
	Core course-IV	Virology	4
	Core Course-IV Practical	Virology	2
	Generic Elective -2	GE-2	4
	Generic Elective -2 Practical	GE-2	2
III	**Core course-V**	Microbial Physiology and Metabolism	4
	Core Course-V Practical	Microbial Physiology and Metabolism	2
	Core course-VI	Cell Biology	4
	Core Course-VI Practical	Cell Biology	2
	Core course-VII	Molecular Biology	4
	Core Course-VII Practical	Molecular Biology	2
	Skill Enhancement Course-1	SEC-1	2
	Generic Elective -3	GE-3	4
	Generic Elective -3 Practical	GE-3	2
IV	**Core course-VIII**	Microbial Genetics and Genomics	4
	Course-VIII Practical	Microbial Genetics and Genomics	2
	Core course-IX	Environmental Microbiology	4
	Course-IX Practical	Environmental Microbiology	2
	Core course-X	Food and Dairy Microbiology	4
	Core Course- X Practical	Food and Dairy Microbiology	2
	Skill Enhancement Course-2	SEC-2	2
	Generic Elective -4	GE-4	4
	Generic Elective - 4 Practical	GE-4	2
V	**Core course-XI**	Industrial Microbiology	4

	Core Course-XI Practical	Industrial Microbiology	2
	Core course-XII	Immunology	4
	Core Course-XII Practical	Immunology	2
	Discipline Specific Elective -1	DSE-1	4
	Discipline Specific Elective -1 Practical	DSE-1	2
	Discipline Specific Elective -2	DSE-2	4
	Discipline Specific Elective- 2 Practical	DSE-2	2
VI	**Core course-XIII**	Medical Microbiology	4
	Core Course-XIII Practical	Medical Microbiology	2
	Core course-XIV	Recombinant DNA Technology	4
	Core Course-XIV Practical	Recombinant DNA Technology	2
	Discipline Centric Elective -3	DSE-3	4
	Discipline Centric Elective -3 Practical	DSE-3	2
	Discipline Centric Elective-4	DSE-4	4
	Discipline Centric Elective -1 Practical	DSE-4	2
			Total: 140

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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: 15**

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 2Diversity of Microbial World **No. of Hours: 43**

A. Systems of classification

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

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

• **Algae**

Generalcharacteristics of algae including occurrence, thallus organization, algae cell ultra-structure, pigments, flagella, eyespot food reserves and vegetative, asexual andsexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic,Diplontic, Diplobiontic and Diplohaplontic life cycles. Type studies: *Chlamydomonas, Volvox* and *Spirogyra*. Applications of algae in agriculture, industry, environment and food.

• **Fungi**

General characteristics of fungi includinghabitat, distribution, nutritional requirements, fungal cell ultra-structure, thallusorganization and aggregation, fungal wall structure and synthesis, asexualreproduction, sexual reproduction, heterokaryosis, heterothallism and parasexualmechanism. Type studies: *Rhizopus, Aspergillus, Saccharomyces* and *Agaricus*. Economic Importance of Fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration, mycotoxins.

• **Protozoa**

General characteristics with special reference to *Amoeba, Paramecium and Plasmodium.*

Unit 3 An overview of Scope of Microbiology **No. of Hours: 2**

C-1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (PRACTICALS)
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. Sterilization of medium using Autoclave and assessment for sterility.
4. Sterilization of glassware using Hot Air Oven and assessment for sterility.
5. Sterilization of heat sensitive material by membrane filtration and assessment for sterility.

6. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air.
7. Study of *Rhizopus*, *Penicillium*, *Aspergillus*, *Saccharomyces* using temporary mounts.
8. Study of *Spirogyra* and *Chlamydomonas*, *Volvox* using temporarymounts
9. 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.BrownPublishers.

6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGrawHill Book Company.

7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). GeneralMicrobiology. 5th edition. McMillan.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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: 2**

Bright Field Microscope: Principle and functions.

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: 4**

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, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria.

Unit 7 Important archaeal and eubacterial groups **No. of Hours: 19**

Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*), and Halophiles (*Halobacterium*, *Halococcus*)].
Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:
Gram Negative:
Non proteobacteria: General characteristics with reference to *Deinococcus*, *Chlamydia*, *Chlorobium* and *Spirochaetes*,
Alpha proteobacteria: General characteristics with reference to *Rhizobium*, *Ricketssia* and *Agrobacterium*.

Beta proteobacteria: General characteristics with reference to *Neisseria, Burkholderia* and *Thiobacillus*.
Gamma proteobacteria: General characteristics with reference to *Pseudomonas*, Purple Sulfur bacteriaand Enterobacteriaceae family.
Delta proteobacteria: General characteristics with reference to Myxobacteria and *Bdellovibrio*.
Epsilon proteobacteria: General characteristics with reference to *Helicobacter* and *Campylobacter*.
Zeta proteobacteria: General characteristics with reference to *Mariprofundus ferrooxydans*.
Gram Positive:
Low G+C (Firmicutes): General characteristics with reference to *Lactobacillus, Bacillus, Clostridium, Mycoplasma, Staphylococcus, Streptococcus* and *Heliobacterium.*
High G+C (Actinobacteria): General characteristics with reference to *Corynebacterium, Streptomyces, Bifidobacterium, Propionibacterium, Frankia, Mycobacterium*and *Nocardia*.
***Cyanobacteria*:** General characterstics.

C-2: BACTERIOLOGY (PRACTICAL)
SEMESTER –I

TOTAL HOURS: 60 **CREDITS: 2**

1. Preparation of different media: Synthetic Media, Complex media (Nutrient Agar, McConkey agar).
2. Simple staining.
3. Negative staining.
4. Gram's staining.
5. Acid fast staining (permanent slide only).
6. Capsule staining.
7. Spore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. Estimation of CFU count by spread plate method/pour plate method.
10. Demonstration of Motility by hanging drop method.

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.BrownPublishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. PrenticeHall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14thedition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition TataMcGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer AcademicPublishers, Dordrecht.
6. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). GeneralMicrobiology. 5th edition McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9thedition 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. 9$_{th}$ edition. Pearson Education Limited.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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 and bilayers.

Unit 4 Proteins **No. of Hours: 15**

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.

Unit 5. Enzymes **No. of Hours: 13**

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 hypothesisand 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.

C-3: 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. Handling of micropipettes and checking their accuracy.
3. Standard Free Energy Change of coupled reactions.
4. Qualitative tests for carbohydrates, reducing sugars, non reducing sugars.
5. Qualitative tests for lipids and proteins.
6. Study of protein secondary and tertiary structures with the help of models.
7. Study of enzyme kinetics – calculation of V_{max}, Km, Kcat values.

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. VoetD. and Voet J.G (2004) Biochemistry 3rd edition, John Wiley and Sons.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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 with example of Polio virus and T4 phage, 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, Phage display and phage therapy.

C-4: VIROLOGY (PRACTICAL)
SEMESTER –II

TOTAL HOURS: 60 **CREDITS: 2**

1. Study of the structure of important animal viruses (rhabdo, influenza, paramyxo, hepatitis B and retroviruses) using electron micrographs.
2. Study of the structure of important plant viruses (caulimo, Gemini, tobacco ring spot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.
3. Study of the structure of important bacterial viruses (ϕX 174, T4, λ) using electron micrograph.
4. Isolation and enumeration of bacteriophages (PFU) from water/sewage sample using double agar layer technique.
5. Studying isolation and propagation of animal viruses by chick embryo technique by photographs.
6. Study of cytopathic effects of viruses using photographs.
7. Performing 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 pressWashington 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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, Batch culture, Continuous culture, generation time and specific growth rate
Effect of temperature and pH on microbial 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.

C-5: MICROBIAL PHYSIOLOGY AND METABOLISM (PRACTICAL)
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 2**

1. Study and plot the growth curve of *E. coli* by tubidometric method.
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. Demonstration of alcoholic fermentation.
6. 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.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-6: CELL BIOLOGY (THEORY)
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Structure of Cell **No. of Hours: 16**

Plasma membrane: Structure and transport of small molecules.
Cell Wall: Eukaryotic cell wall, Extracellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural 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: 6**

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

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

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: 12**

Signalling molecules and their receptors.
Function of cell surface receptors.
Pathways of intracellular receptors – Cyclic AMP pathway, cyclic GMP and MAP kinase pathway.

Unit 5 Cell Cycle, Cell Death and Cell Renewal **No. of Hours: 14**

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis.
Development of cancer, causes, types, Diagnosis and therapy.
Programmed cell death.
Stem cells. Types: Embryonic stem cell, induced pluripotent stem cells.

C-6: 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. Demonstration of the presence of mitochondria in striated muscle cells/ cheek epithelial cell using vital stain Janus Green B.
5. Study of polyploidy in Onion root tip by colchicine treatment.
6. Identification and study of cancer cells by photomicrographs.
7. Study of different stages of Mitosis.
8. Study of different stages of Meiosis by permanent slides.

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-7: MOLECULAR BIOLOGY (THEORY)
SEMESTER –III

TOTAL HOURS: 60 **CREDITS: 4**

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

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 –DNA polymerases, 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, Mismatch and excision repair.

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 unit.
Transcription 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, RNA interference: si RNA, miRNA and its significance.

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* and *trp* operons, Sporulation in *Bacillus,*Yeast mating type switching, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.

C-7: 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 / schematicrepresentations.
3. Isolation of genomic DNA from *E. coli*.
4. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) and UV spectrophotometer (A_{260} measurement).
5. Estimation of RNA using colorimeter (orcinol reagent) and 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-8: MICROBIAL GENETICS AND GENOMICS (THEORY)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 4**

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

Genome organization: *E. coli, Saccharomyces, Tetrahymena*.
Organelle genome: Chroloroplast and Mitochondria.
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: 10**

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast-2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, 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 and time of entry mapping.
Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates,Mapping by recombination and co-transduction of markers.

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

Features of T4 genetics,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, Mu transposon.
Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds).
Uses of transposons and transposition.

C-8: MICROBIAL GENETICS AND GENOMICS (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 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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.
Microbial succession in decomposition of plant organic matter.

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: termite gut microflora, 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.
Other elemental cycles: Iron and manganese.

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 faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

C-9: 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 (dehydrogenase, amylase, urease) 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.
7. Campbell RE. (1983). Microbial Ecology. Blackwell Scientific Publication, Oxford, England.
8. Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.
9. Lynch JM & Hobbie JE. (1988). Microorganisms in Action: Concepts & Application in Microbial Ecology. Blackwell Scientific Publication, U.K.
10. Martin A. (1977). An Introduction to Soil Microbiology. 2nd edition. John Wiley & Sons Inc. New York & London.
11.. Stolp H. (1988). Microbial Ecology: Organisms Habitats Activities. Cambridge University Press, Cambridge, England.
12. Subba Rao NS. (1999). Soil Microbiology. 4th edition. Oxford & IBH Publishing Co. New Delhi.
13. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-10: FOOD AND DAIRY MICROBIOLOGY (THEORY)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Foods as a substrate for microorganisms **No. of Hours: 8**
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, cannedfoods.

Unit 3 Principles and methods of food preservation **No. of Hours: 12**
Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processingand aseptic packaging, chemical methods of food preservation: salt, sugar, organicacids, 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, kumiss,kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce andtampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

Unit 5 Food borne diseases (causative agents, foods involved, symptoms andpreventive measures) **No. of Hours: 10**
Food intoxications: *Staphylococcus aureus*, *Clostridium botulinum* and mycotoxins;
Food infections: *Bacillus cereus*, *Vibrio parahaemolyticus*, *Escherichia coli*,Salmonellosis, Shigellosis, *Yersinia enterocolitica*, *Listeria monocytogenes* and*Campylobacter jejuni*.

Unit 6 Food sanitation and control **No. of Hours: 5**
HACCP, Indices of food sanitary quality and sanitizers.

Unit 7 Cultural and rapid detection methods of food borne pathogens in foods and introduction to predictive microbiology. **No. of Hours: 5**

C-10: 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 and detection of food borne bacteria (*Staphylococcus* or *Salmonella*) from different foodsamples.
4. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
5. Isolation of spoilage microorganisms from bread.
6. Preparation of Yogurt/Dahi.

SUGGESTED READINGS

1. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New AgeInternational (P) Limited Publishers, New Delhi, India.
2. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers andDistributors, 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 FoodPreservation. CAB International, Wallingford, Oxon.
5. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. TataMcGraw-Hill Publishing Company Ltd, New Delhi, India.
6. Gould GW. (1995). New Methods of Food Preservation. Blackie Academic andProfessional, 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 Safetyand 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-11: INDUSTRIAL MICROBIOLOGY (THEORY)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to industrial microbiology and fermentation processes No. of Hours: 10
Brief history and developments in industrial microbiology.
Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations.

Unit 2 Types of bio-reactors and measurement of fermentation parameters No. of Hours: 12
Components of a typical bio-reactor, Types of bioreactors-Laboratory, pilot- scale and production fermenters, constantly stirred tank and air-lift fermenters, Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

Unit 3 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, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.

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, , glutamic acid, Vitamin B12.
Enzymes (amylase, protease, lipase).
Wine, beer.
Antibiotics – Penicillin, Streptomycin.

Unit 6 Enzyme immobilization **No. of Hours: 4**
Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

C-11: 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 and Protease.
(b) Amino acid: Glutamic acid.
(c) Organic acid: lactic acid/ Acetic Acid
(d) Alcohol: Ethanol.
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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-12: IMMUNOLOGY (THEORY)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction **No. of Hours: 4**
Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.

Unit 2 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 3 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 4 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 5 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 Complement System **No. of Hours: 4**
Components of the Complement system; Activation pathways (Classical, Alternative and Lectin pathways); Biological consequences of complement Activation.

Unit 7 Generation of Immune Response **No. of Hours: 10**
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 8 Immunological Disorders and Tumor Immunity **No. of Hours: 10**
Types of Autoimmunity and Hypersensitivity with examples; Immunodeficiencies - Animal models (Nude and SCID mice), SCID, DiGeorge syndrome, Chediak- Higashi syndrome, Leukocyte adhesion deficiency, CGD; Types of tumors, tumor Antigens, causes and therapy for cancers.

Unit 9 Immunological Techniques **No. of Hours: 10**
Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA, ELISPOT, Western blotting, Immunofluoresence, Flow cytometry, Immunoelectron microscopy.

C-12: 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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,Complement fixation, 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: *Streptococcus pyogenes*, *Haemophilus influenzae*, *Mycobacterium tuberculosis*.

Gastrointestinal Diseases: *Escherichia coli*, *Salmonella typhi*, *Vibrio cholerae*, *Helicobacter pylori*.

Others: *Staphylococcus aureus, Bacillus anthracis, Clostridium tetani*, *Treponema pallidum, Clostridium difficile*.

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, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine flu, Ebola, Chikungunya, 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 6 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, Acyclovir, Azidothymidine

Antibiotic resistance, MDR, XDR, MRSA, NDM-1.

C-13: MEDICAL MICROBIOLOGY (PRACTICAL)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Identify bacteria, *E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus* (any three)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, 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. Study symptoms of the diseases with the help of photographs: Polio, anthrax, herpes, chicken pox, HPV warts, AIDS (candidiasis), dermatomycoses (ring worms).
6. Study of various stages of Malarial parasite in RBCs using permanent mounts/Photomicrographs.

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
C-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 deoxynucleotidyltransferase, 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, yeast YIp, YEp and YCp vectors, Baculovirus 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 viral-mediated delivery, *Agrobacterium* - mediated delivery.
DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, Gel Shift Assay 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 and automated sequencing. Introduction to new generation sequencing.
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 mutagensis.

C-14: 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. Ligation of DNA fragments.
5. Cloning of DNA insert and Blue white screening of recombinants.
6. Interpretation of sequencing gel electropherograms.

7. Designing of primers for DNA amplification.
8. Demonstration of Amplification of DNA by PCR.
9. 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.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-1: BIOINFORMATICS (THEORY)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to Computer Fundamentals **No. of Hours: 8**
RDBMS - Definition of relational database.
Mode of data transfer (FTP, SFTP, SCP), advantage of encrypted data transfer.

Unit 2 Introduction to Bioinformatics and Biological Databases **No. of Hours: 14**
Biological databases - nucleic acid, genome, protein sequence and structure,gene expression databases, Database of metabolic pathways, Mode of data storage - File formats - FASTA, Genbank and Uniprot, Data submission & retrieval from NCBI, EMBL, DDBJ, Uniprot, PDB.

Unit 3 Sequence Alignments, Phylogeny and Phylogenetic trees **No. of Hours: 16**
Local and Global Sequence alignment, pairwise and multiple sequence alignment.
Scoring an alignment, scoring matrices, PAM & BLOSUM series of matrices.
Types of phylogenetic trees, Different approaches of phylogenetic tree construction-UPGMA, Neighbour joining, Maximum Parsimony, Maximum likelihood.

Unit 4 Genome organization and analysis **No. of Hours: 10**
Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes.
Genome, transcriptome, proteome, 2-D gel electrophoresis, MALDI- TOF spectrometery.
Major features of completed genomes: *E.coli, S.cerevisiae, Arabidopsis,* Human.

Unit 5 Protein Structure Predictions **No. of Hours: 12**
Hierarchy of protein structure - primary, secondary and tertiary structures, modeling
Structural Classes, Motifs, Folds and Domains.
Protein structure prediction in presence and absence of structure template.
Energy minimizations and evaluation by Ramachandran plot.
Protein structure and rational drug design.

DSE-1: BIOINFORMATICS (PRACTICAL)
SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

1. Introduction to different operating systems - UNIX, LINUX and Windows.
2. Introduction to bioinformatics databases (any three): NCBI/PDB/DDBJ, Uniprot, PDB.
3. Sequence retrieval using BLAST.
4. Sequence alignment & phylogenetic analysis using clustalW & phylip.
5. Picking out a given gene from genomes using Genscan or other softwares (promoter region identification, repeat in genome, ORF prediction). Gene finding tools (Glimmer, GENSCAN), Primer designing, Genscan/Genetool.
6. Protein structure prediction: primary structure analysis, secondary structure prediction using psi-pred, homology modeling using Swissmodel. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK).
7. Prediction of different features of a functional gene.

SUGGESTED READING

1. Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House.
2. Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications.
3. Lesk M.A.(2008) Introduction to Bioinformatics . Oxford Publication, 3rd International Student Edition.

4. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication.
5. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell.
6. Ghosh, Z. and Mallick, V. (2008) Bioinformatics- Principles and Applications. Oxford University Press.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-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 (K.C.Mehta, Mundkur, Dastur and Sadasivan).

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 (histological-cork 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*.

Late blight of potato - *Phytophthora infestans*.

Ergot of rye - *Claviceps purpurea*.

Black stem rust of wheat - *Puccinia graminis tritici*.

Red rot of sugarcane - *Colletotrichum falcatum*.

B. Important diseases caused by phytopathogenic bacteria: Angular leaf spot of cotton and crown gall.

DSE-2: 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 plantmaterial - *Albugo, Puccinia, Ustilago, Fusarium, Colletotrichum.*
3. Study of following diseases through photographs: bacterial leaf blight of rice, Angular leaf spot of cotton, crown galls, bacterial cankers of citrus, Aster yellow, citrus stubborn, Papaya ring spot, tomato yellow leaf curl, banana bunchy top, rice tungro disease, Potato spindle tuber, coconut cadang cadang disease.

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. BlackwellScience, Oxford.
3. Mehrotra RS. (1994). Plant Pathology. Tata McGraw-Hill Limited.
4. Rangaswami G. (2005). Diseases of Crop Plants in India. 4th edition. Prentice Hallof India Pvt. Ltd., New Delhi.
5. Singh RS. (1998). Plant Diseases Management. 7th edition. Oxford & IBH, NewDelhi.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-3: INHERITANCE BIOLOGY (THEORY)
SEMESTER –V

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 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 5 Recombination **No. of Hours: 3**

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

Unit 6 Extra-Chromosomal Inheritance **No. of Hours: 9**

Introduction and 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*.
Epigenetics.

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-3: INHERITANCE BIOLOGY (PRACTICAL)
SEMESTER –V

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 *Chironomus / 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-4: BIOMATHEMATICS AND BIOSTATISTICS

(THEORY)

SEMESTER –V

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 **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-4: BIOMATHEMATICS AND BIOSTATISTICS

(PRACTICAL)

SEMESTER –V

TOTAL HOURS: 60 **CREDITS: 2**

- Word Problems based on Differential Equations
- Mean, Median, Mode from grouped and ungrouped Data set
- Standard Deviation and Coefficient of Variation
- Skewness and Kurtosis
- Curve fitting
- Correlation
- Regression
- Finding area under the curve using normal probability
- Testing of Hypothesis- Normal Distribution, t-test and Chi-Square-test
- 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-5: MICROBIAL BIOTECHNOLOGY (THEORY)
SEMESTER –VI

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 6 Intellectual Property Rights **No. of Hours: 4**

Patents, Copyrights, Trademarks.

DSE-5: MICROBIAL BIOTECHNOLOGY (PRACTICAL)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 2**

1. Study yeast cell immobilization in calcium alginate gels.
2. Study enzyme immobilization by calcium 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.
6. Hydrolysis of Starch/Polysaccharide/Lignocellulosic residue.
7. Biotransformation of steroid and its detection by a suitable method (TLC).
8. Demonstration of production of a recombinant product.

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-6: ADVANCES IN MICROBIOLOGY (THEORY)
SEMESTER –VI

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 , CRISPR/CAS system.

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 and quenching 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-6: ADVANCES IN MICROBIOLOGY (PRACTICAL)
SEMESTER –VI

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) Brock'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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-7: INSTRUMENTATION AND BIOTECHNIQUES (THEORY)
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 4**

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

Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast 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, ion-exchange 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-7: Instrumentation and Biotechniques (PRACTICAL)
SEMESTER –VI

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. To demonstrate column packing in any form of column chromatography.
5. Separation of protein mixtures by Polyacrylamide Gel Electrophoresis (PAGE).
6. Determination of λ_{max} for an unknown sample and calculation of extinction coefficient.
7. Separation of components of a given mixture using a laboratory scale centrifuge.
8. 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. 9th Ed., 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-8: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (IPR)
(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-6: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (IPR) (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 (IBSC).
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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
DSE-9: Project Work
SEMESTER –VI

TOTAL HOURS: 60 **CREDITS: 4**

Note:
1. Number of students who will be offered project work will vary from college to college depending upon the infrastructural facilities and may vary each year.

2. The college shall announce regarding the number of seats for project work well in advance and may select the students for the same based on merit.

3. Project work will involve experimental work and the student will have to do this in the time after their regular theory and practical classes.

4. The final evaluation of the project work will be through a committee involving internal and external examiners.

5. Guidelines provided by University of Delhi for executing and evaluation of project work will be final.
6. Students will be asked their choice for Project work at the end of IV semester and all formalities of topic and mentor selection will be completed by this time.

7. Project work will be offered in lieu of any one Discipline Specific Elective and will be evaluated for 6 credits.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-1: INTRODUCTION AND SCOPE OF MICROBIOLOGY (THEORY)
SEMESTER –I

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 3 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 4 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 5 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: INTRODUCTION AND SCOPE OF MICROBIOLOGY (PRACTICALS)
SEMESTER –I

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*, *Penicillium*, *Aspergillus* 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.BrownPublishers.

6. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGrawHill Book Company.

7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). GeneralMicrobiology. 5th edition. McMillan.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-2: BACTERIOLOGY AND VIROLOGY (THEORY)
SEMESTER – II

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, Chlamydia,* 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-2: BACTERIOLOGY AND VIROLOGY (PRACTICAL)
SEMESTER – II

TOTAL HOURS: 60 **CREDITS: 2**

1. Preparation of different media: Nutrient agar, Nutrient broth.
2. To perform simple staining of the bacterial smear
3. To perform Gram's staining.
4. To perform spore staining.
5. Isolation of pure cultures of bacteria by streaking method.

6.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 Contro*l*.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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-3: MICROBIAL 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, 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-3: MICROBIAL METABOLISM (PRACTICAL)
SEMESTER –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. Demonstration of alcoholic fermentation.
6. 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.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-4: MICROBIAL GENETICS AND MOLECULAR BIOLOGY (THEORY)
SEMESTER – III

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Structures of DNA and RNA / Genetic Material **No. of Hours:10**
DNA structure, Salient features of double helix, Types of DNA, denaturation and renaturation, topoisomerases; Organization of DNA Prokaryotes,Viruses, Eukaryotes. RNA Structure.

Unit 2 Replication of DNA **No. of Hours: 6**
Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replication.
Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends.

Unit 3 Transcription **No. of Hours: 6**
Transcription: Definition, promoter - concept and strength of promoter. Transcriptional Machinery and Mechanism of transcription.

Unit 5 Translation **No. of Hours: 6**
Genetic code, Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides.

Unit 6 Regulation of gene Expression **No. of Hours: 5**
Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons.

Unit 7 Mutations **No. of Hours: 9**
Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Uses of mutations, DNA repair mechanisms.

Unit 8 Mechanisms of Genetic Exchange **No. of Hours: 10**
Transformation - Discovery, mechanism of natural competence.
Conjugation - Discovery, mechanism, Hfr and F' strains.
Transduction - Generalized transduction, specialized transduction.

Unit 9 Plasmids and Transposable Elements **No. of Hours: 8**
Property and function of plasmids, Types of plasmids. Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Uses of transposons and transposition.

GE-4: MICROBIAL GENETICS AND 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. Estimation of salmon sperm / calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A_{260} measurement).
4. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
5. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).
6. Study the effect of chemical (HNO_2) and physical (UV) mutagens on bacterial cells.

7. Study survival curve of bacteria after exposure to ultraviolet (UV) light.
8. Demonstration of Bacterial Transformation and calculation of transformation efficiency.

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.
8. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings.
9. Maloy SR, Cronan JE and Friefelder D(2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers.
10. Russell PJ. (2009). *i* Genetics- A Molecular Approach. 3rd Ed, Benjamin Cummings.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-5: INDUSTRIAL AND FOOD MICROBIOLOGY (THEORY)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to Industrial microbiology **No. of Hours: 10**
Brief history and developments in industrial microbiology.
Types of fermentation processes - solid state, liquid state, batch, fed-batch and continuous.
Types of fermenters – laboratory, pilot-scale and production fermenters.
Components of a typical continuously stirred tank bioreactor.

Unit 2 Isolation of industrial strains and fermentation medium **No. of Hours: 8**
Primary and secondary screening.
Preservation and maintenance of industrial strains.
Ingredients used in fermentation medium - molasses, corn steep liquor, whey &yeast extract.

Unit 3 Microbial fermentation processes **No. of Hours: 12**
Downstream processing - filtration, centrifugation, cell disruption, solvent extraction.
Microbial production of industrial products - citric acid, ethanol and penicillin.
Industrial production and uses of the enzymes - amylases, proteases, lipases and cellulases.

Unit 4 Food as a substrate for microbial growth **No. of Hours: 9**
Intrinsic and extrinsic parameters that affect microbial growth in food.
Microbial spoilage of food - milk, egg, bread and canned foods.

Unit 5 Principles and methods of food preservation and food sanitation **No. of Hours: 9**
Physical methods - high temperature, low temperature, irradiation, aseptic packaging.
Chemical methods - salt, sugar, benzoates, citric acid, ethylene oxide, nitrate and nitrite.
Food sanitation and control – HACCP.

Unit 6 Dairy products, probiotics and Food-borne Diseases **No. of Hours: 12**
Fermented dairy products - yogurt, acidophilus milk, kefir, dahi and cheese.
Probiotics definition, examples and benefits.
Food intoxication by *Clostridium botulinum* and *Staphylococcus aureus*.
Food infection by *Salmonella* and *E.coli*.

GE-5: INDUSTRIAL AND FOOD MICROBIOLOGY (PRACTICAL)
SEMESTER – IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Microbial fermentation for the production and estimation of amylase.
2. Microbial fermentation for the production and estimation of citric acid.
3. Microbial fermentation for the production and estimation of ethanol.
4. Determination of the microbiological quality of milk sample by MBRT.
5. Isolation of fungi from spoilt bread/fruits/vegetables.
6. Preparation of yogurt.

SUGGESTED READING

1. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd Edition. Panima Publishing Company, New Delhi.
2. Patel AH. (1996). Industrial Microbiology .1st Edition. MacMillan India Limited Publishing Company Ltd. New Delhi, India.

3. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An introduction.9th Edition. Pearson Education.
4. Willey JM, Sherwood LM AND Woolverton CJ (2013), Prescott, Harley and Klein's Microbiology.9thEdition. McGraw Hill Higher education.
5. Casida LE. (1991). Industrial Microbiology. 1st edition. Wiley Eastern Limited.
6. Stanbury PF, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.
7. Adams MR and Moss MO. (1995). Food Microbiology. 4th edition, New Age International (P) Limited Publishers, New Delhi, India.
8. Banwart JM. (1987). Basic Food Microbiology. 1st edition. CBS Publishers and Distributors, Delhi, India.
9. Frazier WC and Westhoff DC. (1992). Food Microbiology. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India.
10. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-6: MICROBES IN ENVIRONMENT (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.
Other elemental cycles: Iron and manganese.

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, hydrocarbons (oil spills).

Unit 7 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 faecal coliforms (b) Membrane filter technique and (c) Presence/absence tests.

GE-6: MICROBES IN ENVIRONMENT (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 (dehydrogenase, amylase, urease) 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-7: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (THEORY)
SEMESTER – 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 7 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 8 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 9 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-7: MEDICAL MICROBIOLOGY AND IMMUNOLOGY (PRACTICAL)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Identify pathogenic 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 pathogenic 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
GE-8: GENETIC ENGINEERING AND BIOTECHNOLOGY (THEORY)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to genetic engineering **No. of Hours: 16**

Milestones in genetic engineering and biotechnology.

Restriction modification systems: Mode of action, 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: Use of linkers and adaptors.

Transformation of DNA: Chemical method, Electroporation.

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

Unit 2 Vectors **No. of Hours: 16**

Cloning Vectors: Definition and Properties.

Plasmid vectors: pBR and pUC series.

Bacteriophage lambda and M13 based vectors.

Cosmids, BACs, YACs.

Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

Unit 3 DNA Amplification and DNA sequencing **No. of Hours: 10**

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

Genomic and cDNA libraries: Preparation and uses, Genome sequencing.

Sanger's method of DNA Sequencing: traditional and automated sequencing.

Unit 4 Application of Genetic Engineering and Biotechnology **No. of Hours: 14**

Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery.

Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, flavo savo tomato, Gene therapy, recombinant vaccine, protein engineering.

Unit 5 Intellectual Property Rights **No. of Hours: 4**

Patents, Copyrights, Trademarks.

GE-8: GENETIC ENGINEERING AND BIOTECHNOLOGY (PRACTICAL)
SEMESTER –IV

TOTAL HOURS: 60 **CREDITS: 2**

1. Isolation of Plasmid DNA from *E.coli*.
2. Digestion of DNA using restriction enzymes and analysis by agarose gel electrophoresis.
3. Ligation of DNA fragments.
4. Interpretation of sequencing gel electropherograms.
5. Designing of primers for DNA amplification.
6. Amplification of DNA by PCR.
7. 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 Pasternik 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. (2013). Prescott, Harley and Klein's Microbiology. 8th edition, 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.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-1: MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES
SEMESTER – III/IV

TOTAL HOURS: 30 **CREDITS: 2**

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

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, geldiffusion, 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-2: MICROBIAL DIAGNOSIS IN HEALTH CLINICS
SEMESTER – III/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, clinical samples for diagnosis of infectious disease.

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 3Microscopic examination and culture methods. **No of Hours: 5**

Examination of sample by staining - Gram stain, Ziehl-Neelson staining for tuberculosis, Giemsa-stained 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-3: BIOFERTILIZERS AND BIOPESTICIDES
SEMESTER – III/IV

TOTAL HOURS: 30 **CREDITS: 2**

Unit 1Biofertilizers **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 N2 fixers **No of Hours: 4**

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

Unit 3 Phosphate and silicate solubilizers **No of Hours: 4**

Phosphate and silicate 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. Introduction to mycoinsecticides.

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-4: FOOD FERMENTATION TECHNIQUES
SEMESTER – III/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**

Pickles, 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-5: MANAGEMENT OF HUMAN MICROBIAL DISEASES
SEMESTER – III/IV

TOTAL HOURS: 30 **CREDITS: 2**

Unit 1 Introduction to Human Microbial Diseases **No of Hours: 8**

Definition and concept of health, disease, Infection and Pathogen.
Types of human microbial diseases and their transmission, causative agents and symptoms of human microbial diseases: Respiratory microbial diseases, gastrointestinal microbial diseases, nervous system diseases, skin diseases, eye diseases, urinary tract diseases, sexually transmitted diseases, mosquito borne disease, Microbial mediated cancers and Nosocomial infections.
Recent outbreaks of human microbial diseases (SARS/ Swine flu/Ebola) – causes, spread and control.

Unit 2 Diagnosis of Human Microbial diseases **No of Hours: 8**

Various serological and molecular methods for diagnosis of microbial diseases.
Detection by diagnostic kits based on ELISA, Immunofluorescence, Agglutination tests, PCR, DNA probes (illustrate each with one example).

Unit 3 Therapeutics of Microbial diseases **No of Hours: 8**

Treatment using antibiotics: Mechanism of action of antibiotics belonging to different classes: beta lactam antibiotics (penicillin, cephalosporins), quinolones, polypeptides and aminoglycosides**.** Judicious use of antibiotics, importance of completing antibiotic regimen, Concept of DOTS, emergence of antibiotic resistance, current issues of MDR/XDR microbial strains.
Treatment using antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine. Concept of HAART.

Unit 4 Prevention of Microbial Diseases **No of Hours: 6**

General preventive measures, Importance of personal hygiene, environmental sanitation and methods to prevent the spread of infectious agents transmitted by direct contact, food, water and insect vectors.
Vaccines: Importance, types, vaccines available against microbial diseases, vaccination schedule (compulsory and preventive) in the Indian context.

Suggested Readings

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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-6: MICROBIOLOGICAL ANALYSIS OF AIR AND WATER
SEMESTER – III/IV

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 test(MPN test), 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 Water-A 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.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)
SE-7: FUNDAMENTALS OF BIOINFORMATICS
SEMESTER –V

TOTAL HOURS: 30 **CREDITS: 2**

Unit 1 Introduction to Bioinformatics **No. of Hours: 6**

Bioinformatics – Definition and Applications

Information Flow in Biology, DNA Structure, RNA Structure, Protein Structure, Genomes (Prokaryotic and Eukaryotic), Genome sequencing

Unit 2 Biological Databases **No. of Hours: 10**

RDBMS, Biological databases - nucleic acid, genome, protein sequence and structure, gene expression databases, Database of metabolic pathways

Mode of data storage - File formats - FASTA, Genbank and Uniprot,

Data submission & retrieval from NCBI, EMBL, Uniprot, PDB

Unit 2 Sequence Alignments, Phylogeny and Phylogenetic trees **No. of Hours: 8**

Local and Global Sequence alignment, pairwise and multiple sequence alignment. Molecular Phylogeny, Softwares for phylogeny

Unit 3 Protein Structure Predictions **No. of Hours: 6**

Hierarchy of protein structure - primary, secondary and tertiary structures, modelling (Homology)

Structural Classes, Motifs, Folds and Domains

Protein structure and rational drug design

SUGGESTED READING

1. Saxena Sanjay (2003) A First Course in Computers, Vikas Publishing House
2. Pradeep and Sinha Preeti (2007) Foundations of Computing, 4th ed., BPB Publications
3. Lesk M.A. (2008) Introduction to Bioinformatics . Oxford Publication, 3rd International Student Edition
4. Rastogi S.C., Mendiratta N. and Rastogi P. (2007) Bioinformatics: methods and applications, genomics, proteomics and drug discovery, 2nd ed. Prentice Hall India Publication
5. Primrose and Twyman (2003) Principles of Genome Analysis & Genomics. Blackwell
6. Ghosh, Z. and Mallick, V. (2008) Bioinformatics- Principles and Applications. Oxford University Press.