RADHA GOVIND UNIVERSITY

RAMGARH, JHARKHAND

Department of Microbiology

Under Faculty of Science

Choice Based Credit System Curriculum for

Bachelor of Science in Microbiology

(Effective from Academic Session 2019-22)

RADHA GOVIND UNIVERSITY, RAMGARH, JHARKHAND

DEPARTMENT OF MICROBIOLOGY

Vision & Mission

Vision

To contribute to nation building by transforming people through quality education, creating knowledge, to make invisible world more visible and inculcate scientific temper and provide platform research.

Mission

To create an ideal department keeping students at the centre of its aspirations and endeavours while manifesting wholehearted commitment.

To encourage research by providing state of the art facility and with committed standards.

To cultivate healthy and hygienic environment, to be good citizen of future India and no to extinction of Mankind.

Competence, discipline, dedication and contribution to society.

RADHA GOVIND UNIVERSITY, RAMGARH, JHARKHAND

DEPARTMENT OF MICROBIOLOGY

PROGRAM EDUCATION OBJECTIVE (PEO)

PEO 1: Have a successful career in Microbiology and related disciplines.

PEO 2: Excel in research career in microbiology and inter-disciplinary fields and actively contribute to science and society.

PEO 3: Possess technical and professional competency to address growing demands of society and industrial needs ethically.

PEO 4: Demonstrate life-long independent and reflective skills in their career.

PEO 5: Apply research and entrepreneurial skills augmented with a rich set of communication, teamwork and leadership skills to excel in their profession.

PEO 6: Enhance analytical and quantitative skills and demonstrate an understanding of basic computational and statistical techniques in the field of microbiology.

PROGRAMME SPECIFIC OUTCOME (PSO)

The students of B.Sc. Microbiology should be able to:

PSO1: To emphasize the distribution, morphology and physiology of microorganisms and demonstrate the skills in aseptic handling of microbes including isolation, identification and maintenance.

PSO2: Demonstrate the ability to identify significant microbiological research questions, develop research protocols, and analyse research outcomes as per the scientific methods to improve the employment skills.

PSO3: Enhance analytical and quantitative skills and demonstrate an understanding of basic computational and statistical techniques in the field of microbiology.

RADHA GOVIND UNIVERSITY, RAMGARH, JHARKHAND

DEPARTMENT OF MICROBIOLOGY

PROGRAME OUTCOME (PO)

PO 1: Basic and applied knowledge: Gathers in-depth knowledge of basic and applied areas of microbiology.

PO 2: Core microbiology laboratory skills: Understands various methods of safe handling, culturing and storage of microorganisms in the laboratory.

PO 3: Critical Thinking: Develops scientific logic and approaches a problem with critical reasoning.

PO 4: Effective Communication: Develops effective communication skills through oral presentations of ongoing developments in the field and the compiling of information in the form of reports.

PO 5: Social Interaction: Elicit views of others, mediate disagreements and help reach conclusions in group settings.

PO 6: Advanced Usage of Technology: Apply advanced instrumentation tools, online resources with an understanding of the troubleshooting and limitations

PO 7: Modern Microbiology usage: Develop new technologies, protocols, resources, using modern microbiological techniques and therapeutics and apply it to solve complex human health problems and conserve biodiversity.

PO 8: Global perspective: Becomes acquainted with standard international practices and emerging technologies used to study microbes.

PO 9: Ethics: Acquires an awareness of work ethics and ethical issues in scientific research as well as plagiarism policies.

PO 10: Research related skills: Will develop ability to identify problems, give justifications for solutions by lab investigations & critical analysis by using appropriate research related biological skills.

PO 11: Environment and Sustainability: Develops a basic understanding of the microbiological principles that that have environmental implications, and gains an awareness of regulatory requirements and their compliance in biotechnology and microbiological research.

PO 12: Self-directed and Life-long Learning: Develops self-discipline, planning and organization skills, and time management skills.

COURSE STRUCTURE

Details of Courses under B.Sc. (Honours)

Course	**Credits**
I. Core Course	
Core Course Theory (14 Papers)	14 × 04 = 56
Core Course Practical (07 Papers)	07× 04 = 28
II. Elective Course(8 Papers)	
A.1. Discipline Specific Elective(04 Papers)	04 × 04 = 16
A.2. Discipline Specific Elective	
Practical/ Tutorial (04 Papers)	04 × 02 = 08
B.1. Generic Elective/ Interdisciplinary (4 Papers)	04 × 04 = 16
B.2. Generic Elective	
Practical/ Tutorial (04 Papers)	04 × 02 = 08
III. Ability Enhancement Courses	
1. Ability Enhancement Compulsory (2 Papers)	02 × 02 = 04
English Communication	
Environmental Science	
2. Ability Enhancement Elective (Skill Based) (2 Papers)	02 × 02 = 04
Constitution and Human Rights	
Life and Science	
Total Credits	**140**

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

SEMESTER	CORE COURSE (14)	AECC (2)	SEC (2)	DSE (4)	GENERIC (4)
I	**CC-1** **CC-2** **Practical**	English Communication	-	-	GE-1 Practical
II	**CC-3** **CC-4** **Practical**	Environmental Science	-	-	GE-2 Practical
III	**CC-5** **CC-6** **CC-7** **Practical**	-	SEC-1	-	GE-3 Practical
IV	**CC-8** **CC-9** **CC-10** **Practical**	-	SEC-2	-	GE-4 Practical
V	**CC-11** **CC-12** **Practical**	-	-	DSE-1 DSE-2	-
VI	**CC-13** **CC-14** **CC** **Practical**	-	-	DSE-3 DSE-4	-

SEMESTER	COURSE OPTED	COURSE NAME	CREDITS
I	Ability Enhancement Compulsory Course-I	English Communication	2
	Core Course- I	Introduction to Microbiology and Microbial Diversity	4
	Core Course- II	Bacteriology	4
	Core Course Practical- I	-	4
	Generic Elective-1	Introduction and Scope of Microbiology	2
	Generic Elective Practical-1	-	2
II	Ability Enhancement Compulsory Course-II	Environmental Science	2
	Core Course- III	Biochemistry	4
	Core Course- IV	Virology	4
	Core Course Practical- II	-	4
	Generic Elective-2	Bacteriology	2
	Generic Elective Practical-2	-	2
III	Core Course- V	Microbial Physiology and Metabolism	4

	Core Course- VI	Cell Biology	4
	Core Course- VII	Molecular Biology	4
	Core Course Practical- III	-	6
	Skill Enhancement Course- 1	Constitution of India and Human Rights	2
	Generic Elective-3	Microbial Metabolism	4
	Generic Elective Practical-3	-	2
IV	Core Course-VIII	Microbial Genetics	4
	Core Course- IX	Environmental Microbiology	4
	Core Course- X	Food and Dairy Microbiology	4
	Core Course Practical- IV	-	6
	Skill Enhancement Course- 2	Science and Life	4
	Generic Elective-4	Microbes in Environment	4
	Generic Elective Practical-4	-	2
V	Core Course-XI	Industrial Microbiology	4
	Core Course- XII	Immunology	4
	Core Course Practical- V	-	4
	Discipline Specific Elective – 1	Bioinformatics	4

	Discipline Specific Elective – 2	Microbial Biotechnology	4
	Discipline Specific Elective Practical- 1	-	4
VI	Core Course-XIII	Medical Microbiology	4
	Core Course- XIV	Recombinant DNA Technology	4
	Core Course Practical- VI	-	4
	Discipline Specific Elective – 3	Plant Pathology	4
	Discipline Specific Elective – 4	Instrumentation and Biotechniques	4
	Discipline Specific Elective Practical- 2	-	4
TOTAL CREDITS			**140**

Structure of B.Sc. Honours Microbiology under CBCS

Core Course

CC-1: Introduction to Microbiology and Microbial Diversity

CC-2: Bacteriology

CC-3: Biochemistry

CC-4: Virology

CC-5: Microbial Physiology and Metabolism

CC-6: Cell Biology

CC-7: Molecular Biology

CC-8: Microbial Genetics

CC-9: Environmental Microbiology

CC-10: Food and Dairy Microbiology

CC-11: Industrial Microbiology

CC-12: Immunology

CC-13: Medical Microbiology

CC-14: Recombinant DNA Technology

Discipline Specific Elective

DSE-1: Bioinformatics

DSE-2: Microbial Biotechnology

DSE-3: Plant Pathology

DSE-4: Instrumentation and Biotechniques

Generic Electives

GE-1: Introduction and Scope of Microbiology

GE-2: Bacteriology and Virology

GE-3: Microbial Metabolism

GE-4: Microbes in Environment

B.Sc. (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)

SEMESTER–I

CC-1: INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

Course Objectives:

The main objective of this course is to give students an insight into the world of microorganisms. The paper discusses the historical developments and major milestones leading to the development of microbiology as a separate discipline of science. The students will understand the diversity, structure, evolution and impact of microbes in our day to day life and for the sustenance of life on Earth in general.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

	COURSE OUTCOMES
CO 1	Will be acquainted with the historical account and development of microbiology as a scientific discipline.
CO 2	Will have gained knowledge on different systems of classification. They will also acquire an overview of acellular and cellular microorganisms.
CO 3	Will have acquired in-depth knowledge of the diversity, distribution, cell structure, life cycles and economic importance of algae.
CO 4	Will have gathered detailed information on the diversity, distribution, structure, life cycles and economic importance of fungi.
CO 5	Will be aware of general characteristics of protozoa and their economic importance
CO 6	Will have a broad perspective of the scope of microbiology.

THEORY

TOTAL HOURS: 60 **CREDITS:4**

Unit 1 History of Development of Microbiology

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Antonvon Leeuwenhoek, Louis Pasteur, RobertKoch, Joseph Lister, Alexander Fleming

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A. Waksman Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner

Unit 2 Diversity of Microbial World

Systems of classification

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

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

Algae

History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cellular-structure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Different types of life cycles in algae with suitable examples: Haplobiontic, Haplontic, Diplontic, Diplobiontic and Diplohaplontic life cycles. Applications of algae in agriculture, industry, environment and food.

Fungi

Historical developments in the field of Mycology including significant contributions of eminent mycologists. General characteristics of fungi including habitat, distribution, nutritional requirements,fungal cell ultra- structure, thallus organization and aggregation, fungal wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism. Economic importance of fungi with examples in agriculture, environment, Industry, medicine, food, biodeterioration and mycotoxins.

Protozoa

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

Unit 3 An overview of Scope of Microbiology

PRACTICALS

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2,3	1	-	-	-	-	-	1	1	1	2	-	2	-	2	-
CO2	1,4	1	-	-	-	-	-	3	-	-	2	-	2	1	-	-
CO3	2,4	1	-	2	1	-	1	2	2	-	3	-	3	3	-	-
CO4	2,4	1	-	2	1	-	1	2	2	-	3	-	3	3	-	-
CO5	1,2	1	-	1	-	-	-	1	1	-	2	-	2	2	2	-
CO6	1,2	1	-	2	-	-	-	3	2	-	1	-	3	-	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READING

1. Tortora GJ, Funke BR and Case CL. (2008). Microbiology: AnIntroduction.9thedition.PearsonEducation
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 L Mand Woolverton CJ. (2013). Prescott's Microbiology. 9th Edition. Mc Graw Hill International.
5. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM. T. Brown Publishers.
6. Pelczar MJ, Chan EC Sand Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.

CC-2: BACTERIOLOGY

Course Objective:

The main objective of this course is to provide in-depth knowledge of bacterial cell structure, its cultivation, growth and reproduction. Further, it gives insight into bacterial diversity and its significance. It will also give hands on training of basic and very important bacteriological techniques which will give the student a strong base in microbiology.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will gain knowledge about morphology, structure and organisation of different cell components and be able to differentiate between cell walls of Gram positive and Gram-negative bacteria, cell walls and cell membranes of archaea and eubacteria. Will also be able to explain gram and acid-fast staining reactions and effect of antibiotics and enzymes on cell wall structure
CO 2	Will get familiar with various techniques used for isolation, cultivation and preservation of different types of bacterial cultures. Will gain insight into working and importance of compound microscope.
CO 3	Will understand nutritional requirements of different types of bacteria and formulation of media for bacterial growth
CO 4	Will be able to briefly explain methods of asexual reproduction in bacteria. Will understand different phases of growth curve and be able to define generation time and growth rate
CO 5	Can define and differentiate various types of classifications. Will gain insight into techniques used in polyphasic bacterial taxonomy
CO 6	Will get acquainted with differences between archaea and eubacteria and can list their important general characteristics along with ecological significance and economic importance

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Cell organization

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), spheroplasts, 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

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

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

Unit 4 Growth and nutrition

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

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

Unit 6 Bacterial Systematics

Aim and principles of classification, systematic 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

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 suitable examples Alpha proteobacteria: General characteristics with suitable examples Beta proteobacteria: General characteristics with suitable examples Gamma proteobacteria: General characteristics with suitable examples.

Delta proteobacteria: General characteristics with suitable examples Epsilonproteobacteria: General characteristics with suitable examples Zeta proteobacteria: General characteristics with suitable examples

Gram Positive:

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

***Cyanobacteria*:** An Introduction

PRACTICAL

TOTAL HOURS: 30 **CREDITS:2**

1. Preparation of different media: synthetic media BG-11,Complex media-Nutrient agar, McConkey agar,EMB agar.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining – permanent slide only.
6. Capsule staining
7. Endospore staining.

8. Isolation of pure cultures of bacteria by streaking method.
9. Preservation of bacterial cultures by various techniques.
10. Estimation of CFU count by spread plate method / pour plate method.
11. Motility by hanging drop method.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1	2,3	3	2	2	-	-	3	2	-	-	2	-	-	3	3	-
CO2	3,4	2	3	1	-	-	2	2	1	-	3	-	-	3	2	-
CO3	1,2	-	2	2	-	-	-	1	-	-	1	-	-	3	-	-
CO4	3,5	-	1	1	-	-	1	1	-	-	2	-	-	2	2	-
CO5	2,4	-	-	2	-	-	2	2	1	-	1	-	-	1	-	2
CO6	2,3	-	-	1	-	-	1	-	2	-	1	1	-	1	-	1

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READINGS

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T. Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Microorganisms.14th edition. Parker J.Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht
6. Stanier R Y, Ingraham J L, Wheelis M L and Painter P R. (2005). General

Microbiology. 5th edition McMillan.

7. Tortora G J, Funke B R, and Case C L. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
8. Willey J M, Sherwood L M, and Woolverton C J. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
9. Cappuccino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.

G E-1: INTRODUCTION AND SCOPE OF MICROBIOLOGY

Course Objectives:

The major objective of this paper is to introduce students of other disciplines to the fascinating world of microorganisms. The paper discusses the development of microbiology as an important scientific discipline. The diversity among different groups of microorganisms and their impact on various spheres of our life and the environment will be dealt with.

Course Learning outcome:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be acquainted with the historical developments and contributions of eminent scientists which led to the development of microbiology as a scientific discipline.
CO 2	Will have learned the different systems of classification and would have acquired knowledge on the characteristics and diversity prevalent among different groups of acellular and cellular microorganisms.
CO 3	Will be able to list important human diseases and their causative agents. Will also acquire knowledge about the immune system.
CO 4	Will be conversant with microbial interactions; the impact of microorganisms on agriculture and environment will also be dealt with.
CO 5	Will have gained an insight into the types of fermentation processes, fermenters and the application of microorganisms in the mass-scale production of metabolites/biomass. Will also be able to list microorganisms used as food and food supplements and discuss the desirable and undesirable activities of microorganisms in association with foods.
CO 6	Will be aware of the physical and chemical agents of microbial control used for sterilization and disinfection.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 History of Development of Microbiology

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 the 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

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

Bright Field Microscope, Dark Field Microscope, Phase Contrast Microscope, Fluorescence Microscope, Transmission Electron Microscope, Scanning Electron Microscope.

Unit 4 Sterilization

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

Unit 5 Microbes in Human Health & Environment

Medical microbiology and immunology: List of important human diseases and their causative agents of various human systems. Definitions of immunity (active/passive), primary and secondary immune response, antigen, antibody, and their types.

Environmental microbiology: Definitions and examples of important microbial interactions

– mutualism, commensalism, parasitism. Definitions and microorganisms used as biopesticides, biofertilizers, in biodegradation, biodeterioration, and bioremediation (e.g., hydrocarbons in oil spills).

Unit 6 Industrial Microbiology

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

Unit 7 Food and Dairy Microbiology

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

PRACTICALS

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	2	-	-	2	2	-	-	-	-	-	3	1	1
CO2	2,4	3	3	1	-	-	3	3	-	-	-	-	-	-	2	-
CO3	1,5	2	2	1	-	-	1	2	-	-	-	-	-	-	1	-
CO4	2,5	-	1	-	-	-	2	-	-	-	-	3	3	3	2	-
CO5	2,4, 6	-	2	1	-	-	2	3	-	-	2	-	-	-	2	2
CO6	2,5	-	1	-	-	-	-	1	-	-	2	-	-	-	2	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READING

1. Tortora G.J., Funke B.R. and Case C.L. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
2. Madigan M.T., Martinko J.M., Dunlap P.V. and Clark D.P. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.
3. Cappuccino J. and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.
4. Wiley J.M., Sherwood L.M. and Woolverton C.J. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
5. Atlas R.M. (1997). Principles of Microbiology. 2nd edition. W.M. T. Brown Publishers.
6. Pelczar M.J., Chan E.C.S. and Krieg N.R. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier R.Y., Ingraham J.L., Wheelis M.L., and Painter P.R. (2005). General Microbiology. 5th edition. McMillan.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)

SEMESTER – II

CC-3: BIOCHEMISTRY

Course Objective:

The major objective of this paper is to help the students develop a clear understanding of the fundamental properties of different biomolecules: carbohydrates, lipids, proteins and nucleic acids and to enable students to understand the principles of thermodynamics, bioenergetics, and their applications to biological systems. The course will provide a foundation for the course on microbial physiology and metabolism and for biotechnology-based courses.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have developed an understanding of the principles of thermodynamics applied to biological systems and will be able to calculate free energy changes accompanying metabolic reactions and comment on their feasibility.
CO 2	Will be thoroughly conversant with the structures of carbohydrates and their key properties and be able to detect their presence in samples by performing chemical tests.
CO 3	Will be able to explain the properties of storage and membrane lipids. Will be acquainted with different types of lipid aggregates and their applications.
CO 4	Will be conversant with the structure and properties of amino acids, formation of polypeptides and protein folding. Will become familiar with the use of spectrophotometer and would have gained practical knowledge of biochemical techniques with proteins.
CO 5	Will be familiar with the structures of the building blocks of nucleic acids. Will become conversant with the key conventions used in nucleic acid description.
CO 6	Will have learnt the basic concepts of enzyme biochemistry including enzyme kinetics, and will become aware of different variants of enzymes found in living cells.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Bioenergetics

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

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-acetylneuraminic 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

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

Unit 4 Proteins

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. Nonprotein amino acids: Gramicidin, beta-alanine, D-alanine and D-glutamic acid. Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame. Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins. Tertiary and quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure, Quaternary structures of proteins.

Unit 5 Enzymes

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

Unit 6 Vitamins

Classification and characteristics with suitable examples, sources and importance.

PRACTICALS

TOTAL HOURS: 30 **CREDITS: 2**

1. Properties of water, Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts.
2. Numerical problems on calculations of Standard Free Energy Change and Equilibrium constant.
3. Standard Free Energy Change of coupled reactions.
4. Qualitative/Quantitative tests for carbohydrates, reducing sugars, non-reducing sugars.
5. Qualitative/Quantitative 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 Vmax, Km, Kcat values.

8. Study effect of temperature, pH and Heavy metals on enzyme activity.
9. Estimation of any one vitamin.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3	1	-	2	-	-	1	-	3	-	1	-	2	1	-	1
CO2	3,6	-	2	-	-	-	1	2	-	-	2	-	-	2	-	-
CO3	1,2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3,5	-	-	1	-	-	2	2	-	-	-	-	-	3	2	2
CO5	1,2	2	1	2	-	-	-	-	-	-	-	-	-	-	1	-
CO6	1,3	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READING

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

CC-4: VIROLOGY

Course Objective:

The major objective of this course is to acquaint students with the structure of viruses of plants, animals, and bacteria, their genome organization, and replication strategies within the host cell. The student will learn how they evolve, spread and cause disease, and prevention and control methods for the same. The course also includes description of oncogenic viruses and their role in cancers, and emerging viruses in context of threat to public health and their management.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be able to describe the nature, properties and structure of viruses and will also gain knowledge of taxonomy of different groups of viruses.
CO 2	Will be familiar with diversity and multiplication of lytic and lysogenic bacteriophages.
CO 3	Will be able to describe different ways of viral transmission, and prominent and unusual genomic features of different viruses with their significance.
CO 4	Will understand about the replication strategies, maturation and release of important plant, animal and bacterial viruses.
CO 5	Will have gained knowledge about strategies to prevent viral infections: interferons, vaccines and antiviral compounds
CO 6	Will understand the concept of oncogenesis, DNA and RNA cancer causing viruses and will learn of newly emerging viruses which have the potential to cause serious threats to public health and have become a global concern.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Nature and Properties of Viruses

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

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

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 (phiX174, Retroviridae, Vaccinia, Picorna), Assembly, maturation and release of virions.

Unit 4 Viruses and Cancer

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

Unit 5 Prevention & control of viral diseases

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

Unit 6 Applications of Virology

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

PRACTICAL

TOTAL HOURS: 30 **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 ringspot, cucumber mosaic and alpha-alpha mosaic viruses) using electron micrographs.
3. Study of the structure of important bacterial viruses (ϕX174, T4, λ) using electron micrograph.
4. Isolation and enumeration of bacteriophages (PFU) from water/sewage samples using double agar layer technique.
5. Studying isolation and propagation of animal viruses by chick embryo technique.
6. Study of cytopathic effects of viruses using photographs.
7. Perform local lesion technique for assaying plant viruses.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	2	-	-	-	-	-	1	-	-	-	-	2	3	-	-
CO2	2,3	-	-	-	-	-	-	1	-	-	-	-	-	1	-	1
CO3	2,5	-	3	-	-	-	2	-	-	-	-	-	-	-	-	-
CO4	1,2	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-
CO5	1,2	2	3	-	-	-	2	-	-	-	-	-	-	2	2	2
CO6	2,6	1	-	3	-	1	-	1	3	-	-	-	-	-	2	1

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READING

1. Dimmock, N.J., Easton, A.L., Leppard, K.N. (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 S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R., Skalka, A.M. (2004). Principles of Virology, Molecular biology, Pathogenesis and Control. 2nd edition. ASM press Washington DC.
4. Levy J.A., Conrat H.F., Owens R.A. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
5. Wagner E.K., Hewlett M.J. (2004). Basic Virology. 2nd edition. Blackwell Publishing.
6. Mathews. (2004). Plant Virology. Hull R. Academic Press, New York.
7. Nayudu M.V. (2008). Plant Viruses. Tata McGraw Hill, India.
8. Bos L. (1999) Plant viruses - A textbook of plant virology by. Backhuys Publishers.
9. Versteeg J. (1985). A Color Atlas of Virology. Wolfe Medical Publication.

GE-2: BACTERIOLOGY AND VIROLOGY

Course Objectives:

The main objective of this course is to introduce the students of other streams to basic concepts of Bacteriology and Virology including structure, multiplication and economic importance.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have gained knowledge about structure and organisation of different cell components of bacteria. Will be able to differentiate between Gram positive and Gram-negative bacteria; archaebacteria and eubacteria cell wall and cell membrane.
CO 2	Will get familiar with various media and techniques used for cultivation and maintenance of different types of bacteria. Will also gain insight into different phases of growth in batch culture and binary fission as a method of reproduction.
CO 3	Will understand the concept of different types of classification. Will learn about the morphology, ecological significance and economic importance of the various bacterial genera.
CO 4	Will understand morphology of viruses with important examples.
CO 5	Will have learnt structure and replication of different groups of viruses. Will get acquainted with the concept of lytic cycle and lysogeny.
CO 6	Will become aware of viral pathogens of plant, animal and human diseases. Will also gain knowledge about prevention and control of viral diseases.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Cell Organization

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

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

Taxonomy, nomenclature, systematics, types of classifications. Morphology, ecological significance and economic importance of the following groups: Archaea: methanogens, thermophiles and halophiles. Eubacteria: Gram negative and Gram positive. Gram negative: Non-proteobacteria – Deinococcus, Chlamydiae, Spirochetes. Alphaproteobacteria - Rickettsia, Rhizobium, Agrobacterium. Gammaproteobacteria – Escherichia, Shigella, Pseudomonas.

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

Unit 4 Introduction to Viruses

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

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

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

PRACTICAL

TOTAL HOURS:30 **CREDITS:2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,4	3	2	2	-	-	2	2	-	-	-	-	-	3	2	-
CO2	1,3, 4	3	2	3	-	-	3	3	-	-	2	-	-	3	3	-
CO3	1,2, 4	3	2	1	-	-	2	-	-	-	-	2	-	2	1	-
CO4	2,4	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO5	2,3	-	1	-	-	-	1	-	-	-	-	-	-	-	3	-
CO6	2,3, 4	-	2	-	-	-	1	1	2	-	2	-	-	-	3	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READING

1. Atlas R.M. (1997). Principles of Microbiology. 2nd edition. W.M.T. Brown Publishers.
2. Madigan M.T., Martinko J.M., Dunlap P.V. and Clark D.P. (2014). Brock Biology of Micro-organisms. 14th edition. Pearson Education, Inc.
3. Stanier R.Y., Ingraham J.L., Wheelis M.L. and Painter P.R. (2005). General Microbiology. 5th edition. McMillan.
4. Carter J. and Saunders V. (2007). Virology; principles and Applications. John Wiley and Sons.
5. Flint S.J., Enquist, L.W., Krug, R.M., Racaniello, V.R. Skalka, A.M. (2004). Principles of Virology, Molecular Biology, Pathogenesis and Control. 2nd edition. ASM Press.
6. Shors Teri (2013). Understanding Viruses 2nd edition. Jones and Bartlett Learning

Burlington USA.

7. Pelczar Jr. M.J., Chan E.C.S., and Krieg N.R. (2004). Microbiology. 5th edition. Tata McGraw Hill.
8. Tortora G.J., Funke B.R., and Case C.L. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
9. Willey J.M., Sherwood L.M., and Woolverton C.J. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
10. Dimmock, N.J., Easton, A.L., Leppard, K.N. (2007). Introduction to Modern Virology. 6th edition, Blackwell Publishing Ltd.
11. Cann A.J. (2012). Principles of Molecular Virology, Academic Press Oxford UK.

B.Sc (HONOURS) MICROBIOLOGY (CBCS STRUCTURE)

SEMESTER–III

CC-5: MICROBIAL PHYSIOLOGY AND METABOLISM

Course Objective:

The main objective of this course is to give students a comprehensive insight into various aspects of microbial physiology and metabolism. These include transport mechanisms present in microbes for the uptake of nutrients, bacterial growth and factors affecting it, and diverse metabolic pathways existing in microbes for energy production and carbon and nitrogen assimilation. The course will build the strong foundation needed by the students for further studies in the field of microbiology.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have got acquainted with the diverse physiological groups of bacteria/archaea and microbial transport systems.
CO 2	Will have an in-depth knowledge of patterns of bacterial growth, bacterial growth curve, calculation of generation time and specific growth rate, and effect of the environment on growth.
CO 3	Will understand the variety of pathways used by bacteria for energy generation and conservation during growth on glucose under aerobic and anaerobic conditions.
CO 4	Will become conversant with two important fermentation pathways in microbes.
CO 5	Will have an added knowledge on the groups and families of chemolithotrophs and phototrophs, based on their ability to extract energy from inorganic compounds and assimilate carbon from CO2.
CO 6	Will have learnt about a typical capability of prokaryotes to reduce nitrogen gas to ammonia. Will become familiar with the physiology of nitrogen fixation and assimilation of inorganic nitrogen by bacteria.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth

Definitions of growth, measurement of microbial growth, Batch culture, Continuous culture, generation time and specific growth rate, synchronous growth, diauxic growth curve.

Microbial growth in response to environment - Temperature (psychrophiles, mesophiles, thermophiles, extremophiles, thermodurics, psychrotrophs), pH (acidophiles, alkaliphiles), solute and water activity (halophiles, xerophiles, osmophilic), Oxygen (aerobic, anaerobic, microaerophilic, facultative aerobe, facultative anaerobe), barophilic.

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

Unit 2 Nutrient uptake and Transport

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

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

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

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 photosynthesizing green bacteria, purple bacteria and cyanobacteria.

Unit 6 Nitrogen Metabolism - an overview

Introduction to biological nitrogen fixation. Ammonia assimilation.

Assimilatory nitrate reduction, dissimilatory nitrate reduction, denitrification.

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO1 1	PO1 2	PSO1	PSO2	PSO3
CO1	3,4	3	3	-	-	-	-	3	1	-	-	-	3	3	2	-
CO2	2,3	2	2	-	-	-	3	-	-	-	-	2	-	2	2	-
CO3	3,5	-	2	-	-	-	-	-	-	-	2	-	2	-	3	-
CO4	1,2	-	2	-		-	3	3	-	-	3	-	-	-	1	-
CO5	2,4	-	2	-		-	-	2	-	-	-	2	1	2	-	-
CO6	2,5,6	-	2	-		-	-	2	-	-	-	2	1	2	-	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READINGS

1. Madigan M.T., and Martinko J.M. (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
2. Moat A.G., and Foster J.W. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
3. Reddy S.R., and Reddy S.M. (2005). Microbial Physiology. Scientific Publishers India.
4. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag.
5. Stanier R.Y., Ingrahm J.I., Wheelis M.L., and Painter P.R. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey J.M., Sherwood L.M., and Woolverton C.J. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

CC-6: CELL BIOLOGY

Course Objective:

The objective of this laboratory course is to provide practical skills on biochemical estimation and understanding on viral disease and diagnosis

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have gained knowledge about features of the cell wall, plasma membrane, cell transport mechanisms and cytoskeleton.
CO 2	Will be able to understand the structures and functions of the nucleus and different cell organelles. The structural organization and function roles of chromatin will be learnt.
CO 3	Will have understood the mechanisms of protein sorting, intracellular trafficking, protein export.
CO 4	Will have gathered understanding of how cells perceive and respond to various signals from within and outside.
CO 5	Will have learnt the mechanisms of cell division and the significance of cell cycle and its regulation. Will become familiar with stem cell technology and its applications
CO 6	Will understand the basics of cancer biology including diagnostic techniques and therapy.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Structure and organization of Cell

Cell Organization – Eukaryotic (Plant and animal cells) and prokaryotic. Plasma membrane: Structure and transport of small molecules. Cell Wall: Eukaryotic cell wall, Extra cellular 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

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

Unit 3 Protein Sorting and Transport

Ribosomes, Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids.

Golgi apparatus – Organization, protein glycosylation, protein sorting and export from Golgi apparatus. Lysosomes.

Unit 4 Cell Signalling

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

Unit 5 Cell Cycle, Cell Death and Cell Renewal

Eukaryotic cell cycle and its regulation, Mitosis and Meiosis. Development of cancer, causes and types. Programmed cell death. Stem cells. Embryonic stem cell, induced pleuripotent stem cells.

PRACTICAL

TOTAL HOURS: 30 **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.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	-	-	-	-	1	-	-	-	-	-	3	-	-
CO2	2,3	3	1	-	-	-	-	1	-	-	3	-	-	1	-	-
CO3	2,4	2	1	-	-	-	-	1	-	-	-	-	-	2	-	3
CO4	2,4, 5	1	-	2	-	-	-	1	-	-	2	-	-	-	2	-
CO5	2,3	-	-	-	-	-	3	1	-	-	1	-	-	2	2	-
CO6	2,6	-	-	-	-	-	3	1	-	-	2	-	-	-	2	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READING

1. Hardin J, Bertoni G and Kleinsmith L.J. (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, E.D.P. and De Robertis E.M.F. (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.

CC-7: MOLECULAR BIOLOGY

Course Objective:

The major objective of this course is to develop a clear understanding of the basicconcepts of molecular biology starting from the structure and function of DNA to its replication. The student will become familiar with the central dogma of molecular biology, and will learn about the conversion of information from DNA to RNA to proteins, by the study of transcriptional and translational processes.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be acquainted with the structure of various types of DNA and RNA as well as their organization as genetic material in various living organisms
CO 2	Will gain an in-depth knowledge of DNA replication mechanisms in prokaryotes and eukaryotes, enzymes and proteins involved in replication.
CO 3	Will have learnt the fundamental principles of transcription in prokaryotes and eukaryotes, including the RNA polymerases and general transcription factors involved. Will be able to distinguish between the process in prokaryotes versus eukaryotes.
CO 4	Will understand the concept of split genes, introns, exons, spliceosomes and alternative splicing besides learning about other processing events like polyadenylation and capping. Will become familiar with RNA interference and its significance, siRNA and miRNA.
CO 5	Will get a clear understanding of translational mechanisms in both prokaryotes and eukaryotes along with the inhibitors of protein synthesis.
CO 6	Will understand various mechanisms involved in regulation of gene expression in prokaryotes and eukaryotes at the level of transcription, post-transcriptional processes, and modifications in chromatin structure.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Structures of DNA and RNA/Genetic Material

DNA Structure: Miescher to Watson and Crick - historic perspective, DNA structure, Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves.

DNA topology - linking number, topoisomerases; Organization of DNA Prokaryotes, Viruses, Eukaryotes. RNA Structure, Organelle DNA - mitochondria and chloroplast DNA.

Unit 2 Replication of DNA (Prokaryotes and Eukaryotes)

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

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

Split genes, concept of introns and exons, RNA splicing, spliceosome machinery, concept of alternative splicing. Polyadenylation and capping, Processing of rRNA. RNA interference: siRNA, miRNA and its significance.

Unit 5 Translation (Prokaryotes and Eukaryotes)

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 eukaryotes.

Unit 6 Regulation of gene Expression in Prokaryotes and Eukaryotes

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.

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

1. Study of different types of DNA and RNA using micrographs and model/schematic representations.
2. Study of semi-conservative replication of DNA through micrographs/schematic representations.
3. Isolation of genomic DNA from *E. coli*.
4. Estimation of salmon sperm/calf thymus DNA using colorimeter (diphenylamine reagent) or UV spectrophotometer (A260 measurement).
5. Estimation of RNA using colorimeter (orcinol reagent) or UV spectrophotometer (A260 measurement).
6. Resolution and visualization of DNA by Agarose Gel Electrophoresis.
7. Resolution and visualization of proteins by Polyacrylamide Gel Electrophoresis (SDS-PAGE).

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	2,3	3	2	-	-	-	2	-	-	-	-	-	3	3	1	-
CO2	1,2, 3	2	2	2	-	-	1	-	-	-	-	-	-	2	1	-
CO3	2,4	-	1	3	-	-	2	-	-	-	2	-	-	2	2	-
CO4	2,4, 5	-	-	-	-	-	3	-	-	-	2	-	-	2	1	-
CO5	2,4	-	1	-	-	-	2	-	-	-	-	-	2	1	2	-
CO6	2,4, 6	-	1	-	-	-	2	-	-	-	-	-	2	2	2	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

SUGGESTED READINGS

1. Watson J.D., Baker T.A., Bell S.P., Gann A., Levine M. and Losick R. (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Lab. Press, Pearson Publication.
2. Becker W.M., Kleinsmith L.J., Hardin J. and Bertoni G.P. (2009) The World of the Cell, 7th edition, Pearson Benjamin Cummings Publishing, San Francisco.
3. De Robertis E.D.P. and De Robertis E.M.F. (20

GE-3: MICROBIAL METABOLISM

Course Objective:

The main objective of this paper is to make students acquainted with various aspects of microbial physiology and metabolism. These include types of microbes based on nutrition, basic transport mechanisms present in microbes for the uptake of nutrients, bacterial growth and factors affecting it and diverse metabolic pathways existing in microbes for energy production and carbon and nitrogen assimilation. An understanding of these physiological and metabolic aspects of the microbes will create interest among students for further studies in the field of microbiology.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have got acquainted with the diverse physiological groups of bacteria/archea and transport systems commonly employed by microbes.
CO 2	Will have sufficient knowledge of bacterial bacterial growth curve, calculation of generation time and effect of environmental factors on the growth.
CO 3	Will understand catabolic pathways of energy generation and conservation used by bacteria during growth on glucose under aerobic and anaerobic conditions. They will also become familiar with the concepts of aerobic respiration and fermentation in microbes.
CO 4	Will have got conversant with the groups of microbes having ability to extract energy from inorganic compounds and assimilate carbon from CO2 (chemolithotrophs).
CO 5	Will have an added knowledge on the families of phototrophic microorganisms. Students would also be aware of differences between anoxygenic and oxygenic photosynthesis.
CO 6	Will have learnt about basic concepts of assimilation of inorganic nitrogen like nitrogen gas, ammonia and nitrates by bacteria.

THEORY

TOTAL HOURS:60 **CREDITS:4**

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth

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

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

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

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 (homo fermentative and heterofermentative pathways), concept of linear and branched fermentation pathways

Unit 5 Chemolithotrophic and Phototrophic Metabolism

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

Introduction to biological nitrogen fixation Ammonia assimilation Assimilatory nitrate reduction.

PRACTICAL

TOTAL HOURS:30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	2,3, 6	3	3	-	-	-	-	-	-	-	-	-	-	3	2	-
CO2	1,3, 6	3	2	3	-	-	-	-	-	-	-	1	-	2	2	2
CO3	3,6	-	3	-	-	-	-	2	-	-	2	-	-	3	3	-
CO4		-	1	-	-	-	-	2	-	-	2	-	-	2	3	-
CO5		-	1	-	-	-	-	1	-	-	-	2	-	2	2	-
CO6		-	1	-	-	-	-	1	-	-	-	2	-	2	2	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READINGS

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

SEMESTER–IV

CC-8: MICROBIAL GENETICS

Course Objective:

The major objective of this course is to develop a clear understanding of various aspects of microbial genetics and genomes in relation to microbial survival and propagation and to enable students to better understand courses taught later such as recombinant DNA technology and other allied papers.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be acquainted with the organization of prokaryotic and eukaryotic genomes and organelle genomes in eukaryotes.
CO 2	Will get acquainted with basic and applied aspects of mutations and mutagenesis and their importance and the role of mutator genes. Will learn of the use of a microbial test in detecting the carcinogenic potential of chemicals. Will become aware of different repair mechanisms.
CO 3	Will have learnt the role of plasmids and their types in microorganisms. Will get acquainted with plasmid replication and partitioning as well as aspects related to plasmid copy number, its regulation and plasmid curing.
CO 4	Will be aware of detailed mechanisms of genetic exchange in bacteria. Will be familiarized with molecular aspects and applications of transformation, conjugation, and transduction. Will learn how to map genes using interrupted mating technique and recombination.
CO 5	Will be familiar with the lytic/lysogenic switch in phage lambda. Will be able to discuss the role of CRISPR-Cas in bacterial defense mechanisms.
CO 6	Will be acquainted with fundamentals and applied aspects of transposons, types and mechanisms of transposition. Will have learnt of various eukaryotic transposons and their uses.

THEORY

TOTAL HOURS: 60 **CREDITS:4**

Unit 1 Genome Organization and Mutations

Genome Organization: *E.coli, Saccharomyces, Tetrahymena* 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 intergenic suppression; Ames test; Mutator genes

Unit 2 Plasmids

Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids,yeast-2μplasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of Copy Number,curing of plasmids

Unit 3 Mechanisms of Genetic Exchange

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

Features of T4 genetics, Genetic basis of lytic *versus* lysogenic switch of phage lambda

Unit 5 Transposable Elements

Prokaryotic transposable elements– Insertion Sequences, composite and non-composite transposons,Replicative and Nonreplicative transposition, Mutransposon, Eukaryotic Transposable Elements-Yeast (Tyretrotransposon), Drosophila (Pelements), Maize(Ac/Ds). Uses of transposons and transposition

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

1. Preparation of Master and Replica Plates.
2. Study the effect of chemical (HNO2)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 Agarose gel electrophoresis.
6. Demonstration of Bacterial Conjugation
7. Demonstration of bacterial transformation and transduction
8. Demonstration of AMES test.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	3	-	-	-	-	2	1	-	-	-	-	3	2	2	-
CO2	1,2, 4	2	2	-	-	-	-	1	-	-	2	-	-	3	1	-
CO3	3,4	3	1	-	-	-	1	1	-	-	-	-	-	3	1	-
CO4	5,6	2	2	-	-	-	3	2	-	-	3	-	-	2	2	-
CO5	3,5, 6	2	2	-	-	-	2	2	-	-	2	-	1	1	1	3
CO6	2,4	2	-	-	-	-		1	-	-	-	-	2	1	1	-

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

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 S Petal. (2008) Molecular Biology of the Gene, 6th Ed., BenjaminCummings

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. , Cold Spring Harbour Laboratory press.

8. Maloy SR, Cronan JE and Friefelder D (2004) Microbial Genetics 2nd EDITION., Jones and Barlett Publishers.

CC-9: ENVIRONMENTAL MICROBIOLOGY

Course Objective:

The objective of this course is to understand the role of microorganisms in environmental processes and learn principles and applications of microbiology in bioremediation of pollutants and wastewater treatment.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will get acquainted with natural habitats of diverse microbial population.
CO 2	Will understand how microbes interact among themselves and with higher plants and animals with the help of various examples.
CO 3	Will become aware of the important role microorganisms play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.
CO 4	Will gain in-depth knowledge of different types of solid wastes and their management with emphasis on advantages and disadvantages of various methods used for their treatment.
CO 5	Will acquire knowledge about composition and strength of sewage and its treatment using primary, secondary and tertiary methods. Will have learnt about treatment and safety of drinking water and be conversant with different methods to test its potability.
CO 6	Will get familiar with problems of pollution and applications of clean-up technologies (bioremediation) for the pollutants such as pesticides, oil, e-waste and plastic in the ecosystem and gain insights into the importance of finding sustainable and novel methods for treating such pollutants.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Microorganisms and their Habitats

Structure and function of ecosystems, Terrestrial Environment: Soil profile and soil microflora, Aquatic Environment: Microflora of freshwater 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

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation, Microbe-Plant Interaction: Symbiotic and nonsymbiotic interactions, Microbe-animal interaction: Microbes in Ruminants,nematophagous fungi and symbiotic luminescent bacteria

Unit 3 Biogeochemical Cycling

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

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

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

Unit 6 Water Potability

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

PRACTICAL

TOTAL HOURS: 30 **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 wastewater sample.
6. Study the presence of microbial activity by detecting (qualitatively) enzymes (dehydrogenase, amylase, urease) in soil.
7. Isolation of *Rhizobium* from root nodules.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	3	1	-	-	-	-	-	-	-	-	-	-	3	1	-
CO2	2,4	3	-	-	-	-	-	2	-	-	1	-	-	3	1	-
CO3	1,2, 3	1	1	-	-	-	-	-	-	-	1	3	-	-	2	-
CO4	2,4	1	2	-	-	-	2	-	-	-	2	3	-	-	2	-
CO5	3,6	-	2	2	-	-	2	-	-	-	2	3	-	-	3	-
CO6	4,5	-	2	2	-	-	3	2	-	-	2	3	-	-	3	2

H (3) -High, M (2) - Moderate, L (1) - Low, '-' for No correlation

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, NewYork.

5. Singh A, Kuhad, RC & Ward OP (2009). Advances in Applied Bioremediation.Volume 17, Springer-Verlag, Berlin Heidelberg

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. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

CC-10: FOOD AND DAIRY MICROBIOLOGY

Course Objective:

The main objective of this paper is to acquaint students with the role of microorganisms in association with foods, highlighting both their beneficial and harmful activities and their applications in the food industry

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be aware of the possible sources of contamination of foods and the parameters affecting microbial growth in foods.
CO 2	Will gain insight into the microbial spoilage of some foods.
CO 3	Will acquire an in-depth knowledge of various physical and chemical methods used for food preservation.
CO 4	Will be acquainted with microbial production of fermented dairy and non-dairy food products. Will also be able to understand the health benefits of prebiotics, probiotics and symbiotic.
CO 5	Will be conversant with some food-borne diseases and will be able to explain methods for detection of food borne pathogens.
CO 6	Will be able to understand the concept of quality control of food.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Foods as a substrate for microorganisms

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

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

Unit 3 Principles and methods of food preservation

Principles, physical methods of food preservation: temperature (low, high, canning, drying),irradiation, hydrostatic pressure, high voltage pulse, microwave processing and aseptic packaging, chemical methods of food preservation: salt, sugar, organic acids, SO2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins

Unit 4 Fermented Foods

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

Unit 5 Food borne diseases (causative agents, foods involved, symptoms and preventive measures)

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

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.

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

1. MBRT of milk samples and their standard plate count.

2. Alkaline phosphatase test to check the efficiency of pasteurization of milk.

3. Isolation of any food borne bacteria from food products.

4. Isolation of Spoilage Microorganisms From Spoiled Vegetables/fruits.

5. Isolation of spoilage microorganisms from bread.

6. Preparation of Yogurt/Dahi.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1, 2	2	1	-	-	-	1	2	-	-	-	-	2	1	2	-
CO2	1, 2	3	1	-	-	-	-	2	-	-	-	-	3	1	2	-
CO3	2, 3	3	-	-	-	-	-	2	-	-	3	-	-	2	1	-
CO4	2, 3	1	2	-	-	-	1	2	-	-	2	-	-	1	3	-
CO5	1, 4	-	1	-	-	-	2	-	-	--	2	-	-	3	2	-
CO6	2, 5	-	1	2	-	-	-	2	-	-	-	-	2	-	-	1

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READINGS

1. Jay JM, Loessner MJ and Golden DA. (2005). Modern Food Microbiology. 7th edition, CBS Publishers and Distributors, Delhi, India.

2. Lund BM, Baird Parker AC, and Gould GW. (2000). The Microbiological Safety and Quality of Foods.Vol.1-2,ASPEN Publication, Gaithersberg, MD.

3. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

GE-4: MICROBES IN ENVIRONMENT

Course Objective:

The main objective of this paper is to enable students to gain knowledge of microbial fermentation processes and the application of microorganisms in the industrial production of biomass/metabolites of interest. They would also be acquainted with the desirable and undesirable activities of microorganisms in association with foods and their applications in the food industry.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have acquired knowledge about different types of fermentation processes feasible using both solid and liquid state substrates/media. They will also be acquainted with types of fermenters and the components of a typical fermenter.
CO 2	Will have learnt the various techniques involved in the isolation, screening, preservation, and maintenance of industrial strains. They will also be familiar with the ingredients used in a fermentation medium.
CO 3	Will have gained in-depth knowledge about the microbial production of various products and enzymes in the industry along with their downstream processing.
CO 4	Will have gathered an understanding of important parameters affecting microbial growth in foods. Spoilage of some common foods by microorganisms will also be discussed. and student will acquire knowledge of commonly occurring food borne diseases.
CO 5	Will become acquainted with different physical methods and chemicals used in food preservation. The student will also be aware of the concept of quality control of food.
CO 6	Will be conversant with the use of microorganisms in the production of fermented foods (dairy and non-dairy), and microorganisms as food supplements.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Microorganisms and their Habitats

Structure and function of ecosystems Terrestrial Environment: Soil profile and soil microflora Aquatic Environment: Microflora of freshwater and marine habitats Atmosphere: Aero micro flora 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

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

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

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

Principles and degradation of common pesticides, hydrocarbons (oil spills).

Unit 6 Water Potability

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.

PRACTICAL

TOTAL HOURS: 30 **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.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
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CO2	2,4, 5	-	-	-	-	-	3	2	-	-	1	-	-	-	1	-
CO3	1,2	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO4		-	2	-	-	-	-	-	2	-	-	-	-	3	2	-
CO5		-	-	-	-	-	2	-	2	-	-	-	-	3	1	-
CO6		-	3	-	-	-	-	-	-	-	-	-	-	3	1	-

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, AcademicPress

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.Coyne MS. (2001). Soil Microbiology: An Exploratory Approach. Delmar Thomson Learning.

7. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

SEMESTER–V

CC-11: INDUSTRIAL MICROBIOLOGY

Course Objective:

The major objective of this course is to acquaint students with the various aspects of industrial microbiology, different types of fermentation processes, fermenters designs and operations Students will become familiar with mass scale culturing of microorganisms for industrial production of various biomolecules and /metabolites of industrial interest and different recovery methods in detail. Students will also learn about immobilization of enzymes and their applications.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will understand the development and importance of industrial microbiology and will be conversant with different types of fermentation processes in liquid media as well as solid state substrates media.
CO 2	Will learn about the design, operation and uses of different types of fermenters of laboratory, pilot and industrial scale.
CO 3	Will gain insight into the techniques of isolation, screening, preservation and maintenance of industrially important microbial strains and different types of media used in fermentation processes.
CO 4	Will be acquainted with principles of techniques used for the extraction and purification of industrial products produced using microbial fermentation processes.
CO 5	Will have gained in-depth knowledge of the principles of microbial production and recovery of industrial products at large scale.
CO 6	Will have an understanding of the methods of enzyme immobilization, its advantages, drawbacks and its applications in the industry.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to industrial microbiology

Brief history and developments in industrial microbiology

Unit 2 Isolation of industrially important microbial strains and fermentation media

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 3 Types of fermentation processes, bioreactors and measurement of fermentation parameters

Types of fermentation processes- Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg.baker's yeast) and continuous fermentations

Components of a typical bioreactor, 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 4 Down-stream processing

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

Unit 5 Microbial production of industrial products (microorganisms involved, media, fermentation conditions, downstream processing and uses)

Citric acid, ethanol, penicillin, glutamic acid, VitaminB12, Enzymes (amylase, protease, lipase) Wine, beer

Unit 6 Enzyme immobilization

Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase)

PRACTICAL

TOTAL HOURS: 30 **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: Citric acid
    d. Alcohol: Ethanol
3. A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	3,4, 6	2	-	-	-	-	1	2	-	-	-	-	2	1	3	3
CO2	3,4, 5	2	-	3	-	-	2	3	-	-	3	-	3	-	3	3
CO3	2,4	2	3	3	-	-	3	3	-	-	3	-	3	3	2	-
CO4	3,5	-	2	1	-	-	2	2	-	-	1	-	-	1	2	-
CO5	2,5, 6	3	-	2	-	-	2	3	-	-	1	-	-	-	2	2
CO6	2,4, 5	-	-	1	-	-	-	-	-	-	2	-	-	-	1	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READINGS

1. Oka for N. (2007). Modern Industrial Microbiology and Biotechnology. 1st edition. Bios Scientific Publishers Limited. USA

2. Waites M.J., Morgan N.L., Rockey J.S. and Higton G. (2001). Industrial Microbiology: An Introduction.1st edition.Wiley–Blackwell

3. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition. Panima Publishing Co. New Delhi.

4. Stanbury, Whitaker A and Hall SJ. (2006). Principles of Fermentation Technology. 2nd edition, Elsevier Science Ltd.

CC-12: IMMUNOLOGY

Course Objective:

The major objective of this course is to develop a clear understanding about the host immune system and advances in the field of Immunology. The student will gain an understanding of the relationship between the immune system, pathogens and the development of immunity, and will learn how the inappropriate immune response can lead to allergy, autoimmunity and other consequences. The course will further the student's understanding of how advances in immunology have changed the face of modern medicine.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be acquainted with the emergence of immunology and how the immune system protects us from infection through various lines of defence.
CO 2	Will have gained an in-depth knowledge of characteristics and functions of the cells of the immune system and the organization of organs of the immune system.
CO 3	Can understand the characteristics that make the molecules to act as antigens. The students will also be conversant with the types, properties and functions of antibodies made against the antigens. Will be able to outline the production and use of monoclonal antibodies.
CO 4	Will understand the cell surface proteins essential for generation of acquired immune response to differentiate self and non-self molecules and the pathways for antigen processing and presentation.
CO 5	Will be acquainted with the mechanisms by which the complement system is recruited and enhances (complements) the ability of antibodies and phagocytic cells to clear microbes and damaged cells from an organism, promotes inflammation, and attacks the pathogen's cell membranes.
CO 6	Will be acquainted with the generation and the killing mechanisms of humoral and cell mediated immunity. Will be able to outline the immunodeficiency disorders like autoimmunity and hypersensitivity.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction

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, Mac Farlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa

Unit 2 Immune Cells and Organs

Structure, Functions and Properties of: Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mastcell, Dendritic cell; and Immune Organs– Bone Marrow, Thymus, Lymph Node, Spleen, GALT, MALT, CALT

Unit 3 Antigens

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

Unit4 Antibodies

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

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

Components of the Complement system; Activation pathways (Classical, Alternative and Lectin Pathways); Biological consequences of complement Activation

Unit 7 Generation of Immune Response

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

Unit 8 Immunological Disorders and Tumor Immunity

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

Unit 9 Immunological Techniques

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

PRACTICAL

TOTAL HOURS: 60 **CREDITS: 2**

1. Identification of human blood groups.
2. PerformTotal 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.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	-	-	2	-	-	-	-	-	-	1	-	3	-	-	1
CO2	1,2, 3	3	-	2	-	-	-	-	-	-	1	-	-	1	2	2
CO3	2,4	-	2	-	-	-	2	1	-	-	-	-	-	-	2	-
CO4	2,3	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
CO5	3,4	-	2	2	-	-	2	2	-	-	2	-	-	3	2	-
CO6	3,5	3	1	2	-	-	3	2	-	-	2	-	-	-	1	2

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTEDREADINGS

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. Golds by 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.

DSE-1: BIOINFORMATICS

Course Objective:

The major objective of this course is to develop a clear understanding of the various concepts in bioinformatics which encompasses molecular biology, genetics, genomics, transcriptomics, proteomics, and their applications in research and development. This will enable students to take up interdisciplinary subjects later.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be acquainted with bioinformatics and its relation with molecular biology, genetics and genomics, various modes of data transfer and simultaneously learning the advantages of encrypted data transfer, gained an in-depth knowledge of primary, secondary and composite databases, organization of diverse types of biological databases.
CO 2	Will have learnt the concept and significance of sequence alignment, comparative assessment of global and local sequence alignment, softwares used for pairwise and multiple sequence comparisons and their applications, phylogeny, types of phylogenetic trees.
CO 3	Will understand the details of domains, motifs and folds, homology modelling for protein structure prediction, proteomics, computer aided drug designing and discovery
CO 4	Student will have gathered understanding of diversity of viral, prokaryotic, eukaryotic genomes and their organization, sequencing strategies and also the knowledge of current techniques in genomics and transcriptomics namely NGS Sequencing, Microarray, along with current concepts in gene organization, challenges in gene prediction, primer designing.
CO 5	Students will also be familiar with the file formats of sequence file formats.
CO 6	This allows students to apply the acquired knowledge in retrieving and analyzing biological information on the web.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to Computer Fundamentals

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

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

Local and Global Sequence alignment, pair wise and multiple sequence alignment. Scoring analignment, scoring matrices, PAM & BLOSUM series of matrices

Types of phylogenetic trees, Different approaches of phylogenetic tree construction- UPGMA, Neighbour joining, Maximum Parsomony,Maximum likelihood

Unit 4 Genome organization and analysis

Diversity of Genomes: Viral, prokaryotic & eukaryotic genomes

Genome, transcriptome, proteome, 2-D gelelectrophoresis, Maldi Toff spectroscopy Major features of completed genomes: *E.coli, S.cerevisiae, Arabidopsis,* Human

Unit 5 Protein Structure Predictions

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

PRACTICAL

TOTAL HOURS: 60 **CREDITS: 2**

1. Introduction to different operating systems- UNIX, LINUX and Windows
2. Introduction to bioinformatics databases (anythree): NCBI/ PDB/ DDBJ, Uniprot, PDB
3. Sequence retrieval using BLAST
4. Sequence alignment & phylogenetic analysis using clustal W & 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 Swiss model. Molecular visualization using jmol, Protein structure model evaluation (PROCHECK).
7. Prediction of different features of a functional gene.

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1,2	3	-	1	-	-	2	-	3	-	3	-	2	-	3	2
CO2	2,3, 6	-	-	2	-	-	2	-	-	-	1	-	2	-	2	3
CO3	3,4	2	-	2	-	-	3	-	-	-	1	-	-	-	1	3
CO4	2,3, 6	2	-	2	-	-	2	3	-	-	3	-	2	-	1	2
CO5	1,2	-	-	2	-	-	2	-	-	-	2	-	-	-	-	1
CO6	2,4	-	-	2	-	-	2	-	-	-	1	-	-	-	1	2

H-High, M- Moderate, L- Low, '-' for No correlation

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

DSE-2: MICROBIAL BIOTECHNOLOGY

Course Objective:

This paper is aimed at providing a clear understanding of the role of microorganisms in the advent of biotechnology, both traditional as well as modern. The student will become aware of the benefits and concerns of using microbe-based procedures/tools such as biosensors, biopesticides, bioplastics, bioleaching as well as genetically modified organisms. Non-traditional vaccines and the promise they hold will be discussed.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will get an overview of the possibility of using microbes in a number of technologies and fields for the direct/indirect benefit of mankind and the environment.
CO 2	Will get familiarized with how manipulated producer microbes and/or procedures may yield products of medical/therapeutic value, hence contributing to human longevity.
CO 3	Will learn how microorganisms are the mightiest candidates in fighting environmental pollution and minimizing xenobiotics, thereby elevating human living conditions. Biosensors and whole cell/enzyme immobilization would be appealing illustrations to the students as some of the strategies towards this goal.
CO 4	Will delve deep into the role of microorganisms in maintaining environmental homeostasis, combating pollution, eliminating xenobiotics and inexpensive energy production from waste natural lignocellulosics.
CO 5	Will become familiar with the contribution of specific microorganisms in traditional agriculture practices, and will become acquainted with GM crops, RNA interference and edible vaccines.
CO 6	Will obtain information on IPR, its main components, national institutes related to the same, and the know-how of start-ups and the importance of innovative research.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Microbial Biotechnology and its Applications

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

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

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

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

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

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

Unit 7 Intellectual Property Rights

Patents, Copyrights, Trademarks

PRACTICAL

TOTAL HOURS: 60 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	-	2	-	-	-	3	2	-	-	2	-	-	3	2	-
CO2	1,2	2	-	2	-	-	2	-	-	-	2	-	3	1	1	-
CO3	2,3, 4	-	1	3	-	-	-	-	1	-	3	3	-	2	2	-
CO4	2,6	1	-	2	-	-	1	1	-	-	2	3	-	2	2	-
CO5	3,5, 6	3	2	2	-	-	1	1	-	-	1	-	-	3	-	-
CO6	2,4	-	-	-	-	-	-	-	-	-	3	-	3	-	-	3

H-High, M- Moderate, L- Low, '-' for No correlation

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.

SEMESTER–VI

CC-13: MEDICAL MICROBIOLOGY

Course Objective:

The main objective of this course is to provide in-depth knowledge of plant diseases, the causes, symptoms, and the biochemical and genetical aspects of host-pathogen interactions. The student will become conversant with various means by which plants can defend themselves and plant diseases can be controlled or prevented.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be introduced to the concept and importance of plant diseases. Will also get acquainted with contributions of various plant pathologists.
CO 2	Will gain in-depth knowledge of stages in the development of a disease which will form the base for further course material.
CO 3	Will learn about types of diseases based on life cycles of hosts and pathogens, factors controlling them and how to forecast diseases in an Indian context.
CO 4	Will understand how microbes attack plants using enzymes, toxins, growth regulators, etc. thereby affecting their physiological processes. Will also get conversant with the genetics of plant diseases and how plants defend themselves.
CO 5	Will gain insight into how these diseases can be prevented and/or cured with various cultural methods, regulatory, physical, chemical and biological means.
CO 6	Will acquire knowledge about causes, symptoms, epidemiology, and control of fungal and bacterial diseases.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Normal microflora of the human body and host pathogen interaction

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

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

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*, *Treponemapallidum,Clostridium difficie*

Unit 4 Viral diseases

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

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

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

Unit 7 Antimicrobial agents: General characteristics and mode of action

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

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	2	-	-	-	1	-	-	2	3	3	3	-	-
CO2	1,2, 3	2	2	-	-	-	-	-	-	-	2	-	-	2	-	-
CO3	2,3	2	2	-	-	-	-	2	-	2	1	-	-	2	2	-
CO4	4,5	-	1	-	-	-	2	-	-	-	2	2	-	-	2	-
CO5	2,6	-	1	-	-	2	2	2	-	-	2	-	-	-	-	-
CO6	1,2, 4	-	1	-	-	-	-	-	2	-	1	3	-	1	-	-

H-High, M- Moderate, L- Low, '-' for No correlation

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. Mc Graw 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. Mc Graw Hill Higher Education.

5. Madigan MT, Martinko JM, Dunlap PV and Clark DP. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.

CC-14: RECOMBINANT DNA TECHNOLOGY

Course Objective:

The main objective of this paper is to ensure that the student develops a clear comprehension of the concepts of recombinant DNA technology. The student will get acquainted with the tools and techniques used such as the enzymes, vectors, and cloning methods that can be used, and the applications of cloning such as creation of DNA libraries and recombinant products.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will get an overview of developments and contributions of scientists in the field of genetic engineering.
CO 2	Will get familiarized with basic cloning tools such as enzymes used to manipulate DNA, and cloning vectors.
CO 3	Will have learnt various gene delivery methods and basic essential techniques of DNA, RNA and protein analysis.
CO 4	Will gather in-depth knowledge of DNA amplification and sequencing methods.
CO 5	Will become conversant with construction and screening of genomic and cDNA libraries.
CO 6	Will become aware of the applied aspects of all major techniques being used for the benefit of humankind in the areas of agriculture and pharmaceuticals. Students will design a strategy outlining all the steps of developing a novel recombinant.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction to Genetic Engineering

Milestones in genetic engineering and biotechnology

Unit 2 Molecular Cloning-Tools and Strategies

Cloning Tools; Restriction modification systems: TypesI, II and III. Modeofaction, nomenclature, applications of Type II restriction enzymes in genetic engineering

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

Cloning Vectors: Definition and Properties Plasmid vectors: pBR and pUC series Bacteriophage lambda and M13 based vectors Cosmids, BACs, YACs

Use of linkers and adaptors

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

Unit 3 Methods in Molecular Cloning

Transformation of DNA: Chemical method, Electroporation,

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

DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern-and Northern-blotting techniques, dotblot, DNA microarray analysis, SDS-PAGE and Westernblotting.

Unit 4 DNA Amplification and DNA sequencing

PCR: Basics of PCR, RT-PCR, Real-Time PCR, Sanger's method of DNA Sequencing: traditional and automated sequencing Primer walking and shot gun sequencing

Unit 5 Construction and Screening of Genomic and cDNA libraries

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

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

PRACTICAL

TOTAL HOURS: 30 **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. Amplification of DNA by PCR
9. Demonstration of Southern blotting

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	3	-	3	-	-	3	3	-	-	3	-	-	-	3	-
CO2	1,2, 3	-	-	1	-	-	1	1	-	-	3	-	-	-	2	-
CO3	1,3	2	2	-	-	-	2	1	-	-	-	-	3	2	2	3
CO4	1,2	3	1	1	-	-	-	2	-	-	1	-	-	1	1	-

CO5	2,3	-	-	2	-	-	2	2	-	-	-	-	-	1	1	-
CO6	2,5	-	1	-	-	-	3	1	-	-	2	3	-	-	-	2

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READING

1. Brown TA. (2010). Gene Cloning and DNA Analysis. 6th edition. Blackwell Publishing, Oxford, U.K.

2. Clark D P 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.

5. Wiley JM, Sherwood LM and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. Mc Graw 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.

DSE-3: PLANT PATHOLOGY

Course Objective:

The main objective of this course is to provide in-depth knowledge of plant diseases, the causes, symptoms, and the biochemical and genetic aspects of host-pathogen interactions. The student will become conversant with various means by which plants can defend themselves and plant diseases can be controlled or prevented.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will be introduced to the concept and importance of plant diseases. Will also get acquainted with contributions of various plant pathologists.
CO 2	Will gain in-depth knowledge of stages in the development of a disease which will form the base for further course material.
CO 3	Will learn about types of diseases based on life cycles of hosts and pathogens, factors controlling them and how to forecast diseases in an Indian context.
CO 4	Will understand how microbes attack plants using enzymes, toxins, growth regulators, etc. thereby affecting their physiological processes. Will also get conversant with the genetics of plant diseases and how plants defend themselves.
CO 5	Will gain insight into how these diseases can be prevented and/or cured with various cultural methods, regulatory, physical, chemical and biological means.
CO 6	Will acquire knowledge about causes, symptoms, epidemiology, and control of fungal and bacterial diseases.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Introduction and History of plant pathology

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

Unit 2 Stages in development of a disease

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

Unit 3 Plant disease epidemiology

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

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 ® gene and a virulence (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

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

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

A. Important diseases caused by fungi White rust of crucifers-Albugo Candida, Downy mildew of onion- *Peronospora destructor* Late blight of potato - *Phytophthora infestans* Powdery mildew of wheat - *Erysiphe graminis* Ergotofrye-*Clavicepspurpurea,* Black stem rust of wheat- *Puccinia graminis tritici,* Loose Smut of Wheat- *Ustilago nuda,* Wilt of tomato- *Fusarium oxysporum* f.sp. *lycopersici,* Red rot of sugarcane- *Colletotrichum falcatum,* Early blight of potato- *Alternaria solani*

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

C. Important diseases caused by phytoplasmas: Asteryellow, citrus stubborn

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

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

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2	3	2	2	-	-	-	1	-	-	2	3	3	3	-	-
CO2	1,2, 3	2	2	-	-	-	-	-	-	-	2	-	-	2	-	-
CO3	2,3	2	2	-	-	-	-	2	-	2	1	-	-	2	2	-
CO4	4,5	-	1	-	-	-	2	-	-	-	2	2	-	-	2	-
CO5	2,6	-	1	-	-	2	2	2	-	-	2	-	-	-	-	-
CO6	1,2, 4	-	1	-	-	-	-	-	2	-	1	3	-	1	-	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READINGS

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

DSE-4: INSTRUMENTATION AND BIOTECHNIQUES

Course Objective:

The major objective of this paper is to develop understanding of the key concepts of basic as well as some advanced experimental techniques used across biological sciences, with a focus on principle and design of the instruments. This will enable the students to connect between theoretical concepts of these techniques and their immense biological applications in diverse fields.

Course Learning Outcomes:

After successful completion of this course, students will be able to:

CO	COURSE OUTCOMES
CO 1	Will have identified the principle components of a light microscope, fluorescence microscope, phase contrast microscope, confocal and electron microscope, simultaneously learning about their principles and practical applications in visualizing, identifying and measuring cell, its components and biomolecules.
CO 2	Will have gained an in-depth knowledge of principles and applications of paper chromatography, thin layer chromatography, gel filtration chromatography, ion- exchange chromatography, affinity chromatography, GC, HPLC.
CO 3	Will have learnt basic concepts of various techniques used to resolve and analyze nucleic acids and proteins - agarose gel electrophoresis, native polyacrylamide gel electrophoresis, SDS polyacrylamide gel electrophoresis, isoelectric focusing, 2D gel electrophoresis, zymogram preparation.
CO 4	Will comprehend details of working principle and outline of UV-visible spectrophotometer as well as be able to understand absorption spectra of biomolecules, and will be able to interpret UV visible and fluorescence spectroscopy outputs.
CO 5	Will have clear fundamentals of centrifugation, RCF, sedimentation coefficient, different types of rotors used, principle and working of differential and density gradient centrifugation, preparative and analytical scales of centrifuge, and the specific uses of ultracentrifuge.
CO 6	Will be introduced to the concepts of advanced techniques like flow cytometry, circular dichroism, surface plasmon resonance and mass spectrometry.

THEORY

TOTAL HOURS: 60 **CREDITS: 4**

Unit 1 Microscopy

Bright field and dark field microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Confocal Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

Unit 2 Chromatography

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

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

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

Unit 5 Centrifugation

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

PRACTICAL

TOTAL HOURS: 30 **CREDITS: 2**

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

Mapping of Course Outcomes onto Program Outcomes and Program Specific Outcomes

CO	BL	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	1,2, 3	3	3	2	-	-	3	3	1	-	3	-	3	1	1	-
CO2	2,3, 4	2	2	2	-	-	2	3	-	-	2	-	3	-	1	-
CO3	1,2, 6	2	1	2	-	-	3	1	1	-	2	-	3	-	1	-
CO4	2,3	2	1	2	-	-	1	2	-	-	2	-	3	-	1	-
CO5	1,3	2	1	2	-	-	1	1	-	-	2	-	3	-	1	-
CO6	3,5	2	1	2	-	-	1	2	-	-	2	-	3	-	1	-

H-High, M- Moderate, L- Low, '-' for No correlation

SUGGESTED READINGS

1. Wilson K and Walker J. (2010). Principles and Techniques of Biochemistry and Molecular Biology. 7thEd., Cambridge University Press.

2. Nelson DL and Cox MM. (2008). Lehninger Principles of Biochemistry, 5thEd., W.H .Freeman and Company.

3. Willey MJ, Sherwood LM & Woolverton CJ. (2013). Prescott, Harley and Klein's Microbiology. 9thEd., Mc Graw Hill.

4. Karp G. (2010) Cell and Molecular Biology: Concepts and Experiments. 6th edition. John Wiley & Sons. Inc.

5. De Robert is ED Pand 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 Mc Graw Hill.