DAV UNIVERSITY, JALANDHAR
DEPARTMENT OF MICROBIOLOGY

Course Scheme & Syllabus
For
M.Sc. (Hons.) Microbiology
(Programme ID 40)
1st to 4th Semester
Examinations 2018–2019 Session Onwards

Course Scheme and Syllabus Applicable to Admissions in 2018-2019

Total minimum credits required for M.Sc. (Hons.) Microbiology are 96

Scheme of Courses (Program ID 40)
Master of Microbiology

Semester 1

S. No	Course Code	Course Title	Type	L	T	P	Cr
1	MIC531	General Microbiology	Core	4	0	0	4
2	MIC533	Microbial Diversity	Core	4	0	0	4
3	BCH501	Bioanalytical Techniques	Core	4	0	0	4
4	BCH529	Biological Macromolecules	Core	4	0	0	4
5	MIC532	General Microbiology Laboratory	Core	0	0	3	2
6	MIC534	Microbial Diversity Laboratory	Core	0	0	3	2
7	BCH503	Bioanalytical Techniques Laboratory	Core	0	0	3	2
8	BCH530	Biological Macromolecules Laboratory	Core	0	0	3	2
Total							24

L: Lectures T: Tutorial P: Practical Cr: Credits

Scheme of Courses
Master of Microbiology

Semester 2

S. No	Course Code	Course Title	Type	L	T	P	Cr
1	MIC541	Microbial Genetics	Core	4	0	0	4
2	MIC545	Soil and Environmental Microbiology	Core	4	0	0	4
3	MIC550	Microbial Physiology and Metabolism	Core	4	0	0	4
4	MIC542	Microbial Genetics Laboratory	Core	0	0	3	2
5	MIC546	Soil and Environmental Microbiology Laboratory	Core	0	0	3	2
6	MIC540	Research Methodology and Aptitude	Core	4	0	0	4
	Departmental Elective I						6
Total							26
Departmental Elective Courses (Choose one theory and corresponding laboratory course)							
1	MIC543	Clinical Microbiology	Elective	4	1	0	4
	MIC544	Clinical Microbiology Laboratory	Elective	0	0	3	2
2	MIC547	Advances in Microbiology	Elective	4	1	0	4
	MIC548	Advances in Microbiology Laboratory	Elective	0	0	3	2

L: Lectures T: Tutorial P: Practical Cr: Credits

Scheme of Courses
Master of Microbiology

Semester 3

S.No	Course Code	Course Title	Type	L	T	P	Cr
1	MIC641	Industrial Microbiology	Core	4	0	0	4
2	MIC637	Food Microbiology	Core	4	0	0	4
3	MIC642	Industrial Microbiology Laboratory	Core	0	0	3	2
4	MIC638	Food Microbiology Laboratory	Core	0	0	3	2
5	MIC701	Project Part I	Core	0	0	0	2
6	MIC630	Seminar I	Core	0	0	0	2
7	Departmental Elective II						6
8	Open Elective I						4
Total							26
Departmental Elective Courses (Choose one theory and corresponding laboratory course)							
1	MIC631	Immunology	Elective	4	0	0	4
	MIC632	Immunology Laboratory	Elective	0	0	3	2
2	MIC635	Eukaryotic Microbiology	Elective	4	0	0	4
	MIC636	Eukaryotic Microbiology Laboratory	Elective	0	0	3	2
Open Elective I							
1	BTY511	Molecular Biology	Elective	4	1	0	4

***Project Part I: Project Synopsis/ Seminar/ Poster Presentation**

L: Lectures T: Tutorial P: Practical Cr: Credits

Scheme of Courses
Master of Microbiology

Semester 4

S.No	Course Code	Course Title	Type	L	T	P	Cr
1	BTY521	Recombinant DNA Technology	Core	4	0	0	4
2	BTY522	Recombinant DNA Technology Laboratory	Core	0	0	3	2
3	MIC640	Seminar II	Core	0	0	0	2
4	Open Elective II						4
Departmental Elective Course (Choose Project Work or Course of equivalent credits)*							
5	MIC702	Project Part II	Elective	0	0	0	8
Total							20
Open Elective II							
1	BTY681	Virology		4	0	0	4

***Project Work/ Review/ Course of equivalent credits**

L: Lectures T: Tutorial P: Practical Cr: Credits

Course Title: GENERAL MICROBIOLOGY

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC531

Course Objective: The objective of this course is to introduce the students to the various aspects of microbiology encompassing the types and structural organization of microbes, bacterial nutritional requirements, reproduction and growth as well as methods for their control.

Course Content:

Unit A: (15 hours)

History of microbiology. Spontaneous generation *vs.* biogenesis. Germ theory of disease. Discovery of anaerobic life form. Discovery of first antibiotic penicillin. Development of key techniques for isolation and pure culture of microorganisms. History of soil microbiology and enrichment culture techniques. History of medical microbiology and immunology.

Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three domain classification system. Difference between three kingdoms.

General characteristics of 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.

Unit B: (15 hours)

Bacterial Cellular organization: Cell size, shape and arrangement, outer membrane, lipopolysaccharide, cell wall, inner membrane, capsule, flagella, endoflagella, fimbriae and pili, cytoplasm, ribosomes, mesosomes. Endospores. Effect of antibiotics and enzymes on the cell wall. Sphaeroplasts and protoplasts.

Basics of microscopy and observation of microbes. Light microscopy: bright field microscopy, dark field microscopy, phase contrast microscopy, fluorescence microscopy, transmission electron microscopy, scanning electron microscopy.

Unit C: (15 hours)

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 involving heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation to control microbes. Chemical methods involving antiseptics, disinfectants, sanitizers, sterilizers and antibiotics to control microbes.

Unit D: (15 hours)

Asexual methods of reproduction, logarithmic growth of bacterial populations, phases of growth, calculation of generation time and specific growth rate. Diauxic growth. Maintenance of population in exponential phase, synchronous growth, continuous culture, fed batch culture and measurement of growth.

Catabolism vs. anabolism. Energy currency and reducing power of a living cell. Fermentation vs. aerobic and anaerobic respiration.

Bacterial cell division and genes involved in the process.

SUGGESTED READINGS

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

Course Title: GENERAL MICROBIOLOGY LABORATORY

Course Code: MIC532

L	T	P	Credit	Marks
0	0	3	2	50

Experiments:

1. Microbiology Good Laboratory Practices and Biosafety.
2. Study the principle and applications of important instruments (biological safety cabinets, autoclave, incubator, hot air oven, light microscope, pH meter, spectrophotometer) used in the microbiology laboratory
3. Preparation of general purpose 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. Use of compound light microscope
9. Motility by hanging drop method
10. Simple staining
11. Negative staining
12. Study of different shapes of microorganisms under microscope.
13. Isolation of pure cultures of bacteria by streaking method
14. Preservation of bacterial cultures by various techniques
15. Gram's staining
16. Acid fast staining
17. Endospore staining
18. Spread plate technique
19. Pour plate technique
20. Estimation of CFU count by spread plate method/pour plate method.

Course Title: MICROBIAL GENETICS

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC541

Course Objective: This course will provide an insight into various aspects of microbial genetics like microbial genetic organization, DNA replication, mutation and repair, control of genetic expression and methods of genetic variations.

Course Content:

Unit A: (15 hours)

History of DNA structure, from Miescher to Watson and Crick, Building blocks of nucleic acids. Salient features of DNA double helix. Types of DNA.
Types of genetic material. Nucleous, nucleoid
Denaturation and renaturation.
Bidirectional and unidirectional replication. Conservative, Dispersive and semi- conservative and semi- discontinuous replication. Mechanism of DNA replication: Enzymes and proteins involved in DNA replication. DNA polymerases, DNA ligase, primase. Various models of DNA replication including rolling circle and Θ (theta) mode of replication.

Unit B: (15 hours)

DNA repair (Mismatch repair, excision repair, recombination, SOS repair.)
Genotype and phenotype. Understanding of events involved in gene expression (transcription, translation, posttranslational events)
Mutation, variation and evolution. Types of mutation. Mechanism of mutation (spontaneous mutation, chemical mutagen, UV irradiation)
Isolation and identification of mutants (mutation and selection, replica plating, penicillin enrichment, molecular methods)
Phenotype restoration (reversion, suppression)

Unit C: (15 hours)

Gene organization. Transcriptional control (terminators, attenuators, anti-terminators, induction and repression). Translational control. Codon usage, Plasmids, Plasmid replication and stability, Plasmid incompatibility

Unit D: (15 hours)

Gene transfer: Transformation, Conjugation (F plasmid), Transduction (general and specialized) Insertion sequence, Transposons, Mechanism of transposition, strain development, Generation of variation, Overproduction of primary metabolite, Overproduction of secondary metabolite. Genetic methods for investigating bacteria (complementation, cross feeding, reporter genes)

SUGGESTED READINGS

1. Klug WS, Cummings MR, Spencer, C, Palladino, M. *Concepts of Genetics*, 10th Ed., Benjamin Cummings. 2011. Print
2. Krebs J, Goldstein E, Kilpatrick S. *Lewin's Essential Genes*, 3rd Ed., Jones and Bartlett Learning. 2013. Print
3. Pierce BA. *Genetics: A Conceptual Approach*, 4th Ed., Macmillan Higher Education Learning. 2011. Print

4. Watson JD, Baker TA, Bell SP et al. *Molecular Biology of the Gene*, 6th Ed., Benjamin Cummings. 2008. Print
5. Gardner EJ, Simmons MJ, Snustad DP. *Principles of Genetics*. 8th Ed. Wiley-India. 2008. Print
6. Russell PJ. *i Genetics- A Molecular Approach*. 3rd Ed, Benjamin Cummings. 2009. Print
7. Sambrook J and Russell DW. *Molecular Cloning: A Laboratory Manual*. 4th Edition, Cold Spring Harbour Laboratory press. 2001. Print
8. Maloy SR, Cronan JE and Friefelder D. *Microbial Genetics.* 2nd Ed., Jones and Barlett Publishers. 2004. Print

Course Title: Microbial Genetics Laboratory

L	T	P	Credit	Marks
0	0	3	2	50

Course Code: MIC542

Experiments:

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. Isolation of plasmid DNA from *E. coli*
5. Resolution and visualization of DNA by Agarose Gel Electrophoresis
6. Estimation of salmon DNA using UV spectrophotometer (A260 measurement)
7. Preparation of competent cells by chemical method
8. Preparation of competent cells for electroporation
9. Transformation of *Escherichia coli*
10. Transduction of *Escherichia coli* by P1 phage
11. Conjugation mating in *Escherichia coli*
12. PCR amplification of gene from *Escherichia coli* genomic DNA
13. Restriction digestion of DNA
14. Ligation of DNA fragments
15. Blue-white selection cloning of DNA
16. Isolation of DNA from fungal biomass

Course Title: RESEARCH METHODOLOGY AND APTITUDE

Course Code: MIC540

L	T	P	Credit	Marks
4	0	0	4	100

Course Objective: This course will help the students to develop an understanding about the fundamentals of research, using various tools for conduction of literature survey and data analysis, methods of data presentation, statistical analysis of data interpretation etc.

Course Content:

Unit A: (10 hours)

System of measurement and scaling. Units for length, area, volume, weight, concentration, temperature and time. Metric system. Imperial system. SI units. Conversion between units. Unit name, symbol and prefixes. Indian and western numbering system.

Atomic weight. Molecular weight. Equivalent weight. Avogadro number. Normality. Molarity. Molality. Understanding of pH scale.

Preparation of solution of known concentration. Stock and working solution. Dilution of solution.

Unit B: (10 hours)

Word processing tools: Introduction to word processing applications. Page layout. Common features, Using font, paragraph, italics, superscript, subscript. Numbering. Inserting symbol, image and table.

Spreadsheet tools: Introduction to spreadsheet applications. Common features, Using formulas and functions. Data sorting. Use of mathematical and statistical formula. Generating charts / graph.

Presentation tools: Introduction to presentation applications. Common features and functions. Customizing page layout and design. Inserting image and table. Preparing and customizing line diagrams. Showing presentation.

Unit C: (10 hours)

Safe web browsing and use of general web search engines. Use of specialized search engines for life sciences. Databases of scientific literature. Searching relevant research and review articles. Citing scientific information resources. Measure of impact of scientific literature. Introduction to biological data bases and their use. Search, collect, process and present the sequence and structure of biologically important macromolecules. Introduction to bioinformatics tools and their scope of use. Using standalone and server based bioinformatics tools.

Unit D: (15 hours)

Meaning, motivation and objectives of research. Types of research. Theoretical vs. experimental and quantitative vs. qualitative approach in research. Significance of research.

Outline of a research process: Identification of problem, Learning the background, Developing a working hypothesis, Designing the research strategy, Arranging sample/materials required, Performing the experiment and data collection, Data analysis and hypothesis testing, Interpretation and report writing. Criteria of good research and its reporting/presentation.

Unit E: (**15 hours)**

Correlation and Regression, Student's t-test, One Way Analysis of Variance, Two Way Analysis of Variance, Basic principles and significance of research design; Randomized Block Designs (RBD), completely randomized designs (CRD); Latin square design and Factorial design

SUGGESTED READINGS

1. Kothari, C.R.Research Methodology–Methods and Techniques. 2nd revised ed. New Delhi: New Age International (P) Ltd. Publishers, 2007. Print.

2. McKillup, S. Statistics Explained. An Introductory Guide for Life Scientists. Cambridge,
UK: Cambridge University Press, 2006. Print.

3. Selvin, S. Biostatistics–How it Works. First Impression. New Delhi: Pearson Education Inc., 2007. Print.

4. Agarwal, B.L. Basic Statistics. New Delhi: New Age International, 2006. Print.

Course Title: CLINICAL MICROBIOLOGY

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC543

Course Objective: The objective of this course is to help the students to comprehend role of microbes in disease development, epidemiology of microbial diseases, various techniques used in diagnosis of microbial diseases and various antimicrobial agents and their modes of action.

Course Content:

Unit A: (15 hours)

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.

Unit B: (15 hours)

Immune system. Types of immunity. Mediators of immunity.

Collection, transport and culturing of clinical samples, principles of laboratory diagnosis of infectious diseases. Staining and microscopy. Isolation and identification of causal organism. Selective and differential medium. Growth media specific to isolate or differentiate various pathogenic bacteria. Immunologic tests like ELISA, Immunofluorescence, Agglutination based tests, Complement fixation and western blotting. Nucleic acid analysis based tests like PCR, restriction digestion, northern and southern hybridization.

Unit C: (15 hours)

Control of microbes. Disinfection, pasteurization and sterilization. Physical and chemical agents to control microbes. Mechanism of action of different agents used to control microbes. Kinetics of microbial killing.

Epidemiology of infectious disease. Epidemic, endemic and pandemic with example.

Communicable diseases and modes of transmission.

Strategies to control epidemics.

Unit D: (15 hours)

History of antibacterial agents. Minimal inhibitory concentration. Bactericidal and bacteriostatic. Laboratory tests for checking antimicrobial activity. Trends in antibiotic and antiviral discovery.

Source and spectrum of antibacterial agents.

Cell wall biosynthesis inhibitor. Protein synthesis inhibitor. Nucleic acid synthesis inhibitors. Membrane active agents.

Antiviral agents. Inhibitors of uncoating, penetration and neuraminidase. DNA polymerase, RNA polymerase and reverse transcriptase inhibitor. Viral protease inhibitor.

Prophylactic and curative treatment.

Susceptibility and resistance to antimicrobials. Intrinsic and acquired resistance.

Mechanisms of resistance development.

Strategies to avoid development and spread of resistance.

Vaccines: their types and future trends

SUGGESTED READINGS

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

Course Title: CLINICAL MICROBIOLOGY LABORATORY

Course Code: MIC544

L	T	P	Credit	Marks
0	0	3	2	50

Experiments:

1. Preparation of general purpose medium.
2. Preparation of selective medium.
3. Preparation of differential medium.
4. Use of important selective and differential media for identification of pathogenic bacteria: EMB Agar, McConkey agar, Mannitol salt agar, Deoxycholate citrate agar, TCBS
5. Identify pathogenic bacteria (any three of *E. coli*, *Salmonella, Pseudomonas, Staphylococcus*, *Bacillus*) on the basis of cultural, morphological and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
6. Test of motility on agar plate and under microscope
7. Test of hemolysis. α, β hemolysis.
8. Siderophore production detection by chromo azurol sulfate agar
9. Study of bacterial flora of skin and mouth by swab method
10. Perform antibacterial sensitivity by Kirby-Bauer method

Course Title: IMMUNOLOGY

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC631

Course Objective: The students will get an insight into various aspects of immune system like its components, immune cells and their receptors, genetic organization of immune cells, cytokines, antigen-antibody interactions and immune system disorders. This course will also provide information regarding application of immunology in diagnostics and vaccination.

Course Content:

Unit A: (15 hours)

History of immunology.
Three fundamental concepts in immunology: Specificity, discrimination of self from non-self and memory
Structure, Functions and origin of Immune Cells – Stem cell, T cell, B cell, NK cell, Macrophage, Neutrophil, Eosinophil, Basophil, Mast cell, Dendritic cell and Immune Organs like Bone marrow, Thymus, Lymph Node, Spleen.
Characteristics of an antigen (Foreignness, Molecular size and Heterogeneity); Haptens; Epitopes, Adjuvants, Structure, Types and Functions of antibodies.
Principles of Precipitation, Agglutination, Immunodiffusion, Immunoelectrophoresis, ELISA.
Classification of immune system: innate and adaptive components and humoral and cell mediated

Unit B: (15 hours)

Immune cell receptors: Detailed structure and development of B cell (Ig) and T cell (TcR) receptors.
Structure of CD4, CD8, MHC-I, MHC-II molecules, cellular adhesion molecules (ICAM, VCAM, MadCAM, selectins, integrins); Pattern Recognition Receptors (PRRs) and Toll-like receptors (TLR).
Markers of suppressor / regulatory T cells - CD4+ CD25+

Unit C: (15 hours)

Genetic organization: Organization of the genes for B and T cell receptors.
Genetic organization of MHC-I and MHC-II complex, Peptide loading and expression of MHC-I and MHC-II molecules.
Molecular mechanisms responsible for generating diversity of antibodies and T cell receptors.
Hybridoma technology and monoclonal antibodies.
Complement system. Classical, lectin and alternative pathway for complement activation.

Unit D: (15 hours)

Major cytokines and their role in immune system: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, IL-10, IL-12, IL-17, TGFβ.
Tolerance and autoimmunity and their mechanism; Mechanisms of autoimmunity;
Autoimmune components of diabetes mellitus (DM), multiple sclerosis (MS), experimental autoimmune encephalitis (EAE); Infections leading to autoimmune diseases.
Hypersensitivity and allergy. Comparative study of Type I-V hypersensitivities with examples.
Vaccines and their modes of production

SUGGESTED READINGS

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

Course Title: IMMUNOLOGY LABORATORY

L	T	P	Credit	Marks
0	0	3	2	50

Course Code: MIC632

Experiments:

1. Identification of human blood groups.
2. To separate serum from the blood sample (demonstration).
3. To perform Total Leukocyte Count of the given blood sample.
4. To perform Differential Leukocyte Count of the given blood sample.
5. To perform immunodiffusion by Ouchterlony method.
6. Agglutination of bacteria
7. Separation of IgG by ammonium sulfate precipitation of blood serum.
8. Reduction of IgG with mercaptoethanol to four chain.
9. SDS-PAGE electrophoresis of immunologic effector proteins.
10. Papain digestion of IgG
11. Pepsin digestion of IgG
12. Immunoelectrophoresis
13. Western Blotting
14. ELISA

Course Title: MICROBIAL DIVERSITY

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC533

Course Objective: The aim of this course is to expose the students to vast microbial diversity with emphasis on the classification of bacteria and archea, as well as general characteristics and applications of algae, fungi and protozoa.

Course Content:

Unit A: Microbial Evolution, Taxonomy, and Diversity (15 hours)
Microbial Evolution, Introduction to Microbial Classification, and Taxonomy, Taxonomic Ranks, Techniques for Determining Microbial Taxonomy and Phylogeny, Assessing Microbial Phylogeny, The Major Divisions of Life, Binomial Nomenclature, Whittaker's five kingdom and Carl Woese's three domain classification systems and their utility. Difference between prokaryotic and eukaryotic microorganisms, Introduction to Bergey's Manual of Systematic Bacteriology

Unit B: The Archaea (5 hours)
Introduction to the Archaea, Phylum Crenarchaeota, Phylum Euryarchaeota, Archaeal Phylogeny, Methanotrophic Archaea

Unit C: *Bacteria:* The Deinococci and Nonproteobacteria Gram Negatives- (15 hours)
Aquificae and *Thermotogae* , *Deinococcus-Thermus* , Photosynthetic Bacteria, The Mechanism of Gliding Motility, Phylum *Planctomycetes*, Phylum *Chlamydiae* , Phylum *Spirochaetes* , Phylum *Bacteroidetes*
***Bacteria:* The *Proteobacteria*-** Class *Alphaproteobacteria*, Class *Betaproteobacteria*, Class *Gammaproteobacteria*, Class *Deltaproteobacteria*, Class *Epsilonproteobacteria*
The Low G +C Gram Positives-General Introduction, Class *Mollicutes* (The Mycoplasmas), Peptidoglycan and Endospore Structure, Class *Clostridia*, Class *Bacilli*
***Bacteria:* The High G+C Gram Positives-**General Properties of the Actinomycetes, *Actinomycineae, Micrococcineae, Corynebacterineae, Micromonosporineae, Propionibacterineae*

Unit D: Algae (10 hours)
History of phycology with emphasis on contributions of Indian scientists; General characteristics of algae including occurrence, thallus organization, algae cell ultrastructure, pigments, flagella, eyespot food reserves and vegetative, asexual and sexual reproduction. Applications of Algae in agriculture, industry, environment and food.

Unit E: Fungi and Protozoa (15 hours)
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, eterothallism and parasexual mechanism. Economic Importance of Fungi with Examples in Agriculture, environment, Industry, medicine, food, biodeterioration, mycotoxins
Protozoa-General characteristics with special reference to *Amoeba, Paramecium and Giardia*

SUGGESTED READINGS

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

Course Title: MICROBIAL DIVERSITY LABORATORY

Course Code: MIC534

L	T	P	Credit	Marks
0	0	3	2	100

Experiments:

1. Preparation of different media: synthetic media, Complex media-nutrient agar, McConkey agar, EMB agar, PVK agar etc.
2. Simple staining
3. Negative staining
4. Gram's staining
5. Acid fast staining-permanent slide only.
6. Capsule staining
7. Spore staining.
8. Isolation of pure cultures of bacteria by streaking method.
9. 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.
12. Isolation and growth of fungi by using potato dextrose agar/ Malt extract agar
13. Biochemical characterization of a bacterial culture

Course Title: SOIL AND ENVIRONMENTAL MICROBIOLOGY

Course Code: MIC545

L	T	P	Credit	Marks
4	0	0	4	100

Course Objective: This course will help the students to understand the significance of microbes in soil with special emphasis on biogeochemical cycling of nutrients and their environmental applications like bioremediation, waste treatment etc.

Course Content:

Unit A: Soil Habitat (10 hours)

Soil biota, Soil microbial ecology, Types of organisms in different soils, Soil microbial biomass, Microbiology and biochemistry of root-soil interface; phyllosphere, Biofertilizers, soil enzyme activities and their importance. Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Unit B: Biogeochemical Cycling (15 hours)

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 C: Microbial Bioremediation (12 hours)

Biochemical composition and biodegradation of soil organic matter and crop residues. Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures: Biotic factors in soil development. Genetic engineering of microbes for enhanced pesticide degradation Mechanisms of pesticide degradation by microbes. organic (hydrocarbons, oil spills) and inorganic (metals) matter, biosurfactants, Phytoremediation

Unit D: Microbial Interactions (8 hours)

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 E: Waste Management (10 hours)

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, Gaseous treatment

Unit F: Water Potability (5 hours)

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

SUGGESTED READINGS

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

Course Title: SOIL AND ENVIRONMENTAL MICROBIOLOGY LABORATORY

Course Code: MIC546

L	T	P	Credit	Marks
0	0	3	2	100

Experiments:

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.
8. Isolation of plant growth promoting rhizobacteria i.e. P-solubilizing bacteria.

Course Code: MIC547

L	T	P	Credit
4	0	0	4

Course Title: ADVANCES IN MICROBIOLOGY

Course Objective: The aim of this course is to provide an exposure to the students about some recent developments in the field of microbiology with special emphasis on genomics, metagenomics, systems biology and synthetic biology.

Course Content:

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

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

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

Brief history and development of metagenomics, Understanding bacterial diversity using metagenomics approach, Prospecting genes of biotechnological importance using metagenomics

Basic knowledge of viral metagenome, metatranscriptomics, metaproteomics and metabolomics.

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

Epiphytic fitness and its mechanism in plant pathogens, Hypersensitive response (HR) to plant pathogens and its mechanism, Type three secretion systems (TTSS) of plant and animal pathogens,

Biofilms: types of microorganisms, molecular aspects and significance in environment, health care, virulence and antimicrobial resistance

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

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

SUGGESTED READINGS

1. Fraser CM, Read TD and Nelson KE. *Microbial Genomes*. Humana Press. 2004. Print
2. Miller RV and Day MJ. *Microbial Evolution- Gene establishment, survival and exchange*. ASM Press. 2004. Print
3. Bull AT. *Microbial Diversity and Bioprospecting.* ASM Press. 2004. Print
4. Sangdun C. *Introduction to Systems Biology*. Humana Press. 2007. Print
5. Klipp E, Liebermeister W. *Systems Biology – A Textbook.*Wiley –VCH Verlag. 2009. Print
6. Caetano-Anolles G. *Evolutionary Genomics and Systems Biology*. John Wiley and Sons. 2010. Print
7. Madigan MT, Martink JM, Dunlap PV and Clark DP. *Brock's Biology of Microorganisms*. 14th edition, Pearson-Bejamin Cummings. 2014. Print
8. Wilson BA, Salyers AA Whitt DD and Winkler ME. *Bacterial Pathogenesis- A molecular Approach.* 3rd edition, ASM Press. 2011. Print

Course Code: MIC548

L	T	P	Credit
0	0	3	2

Course Title: ADVANCES IN MICROBIOLOGY LABORATORY

Experiments:

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

Course Title: FOOD MICROBIOLOGY

Course Code: MIC637

L	T	P	Credit	Marks
4	0	0	4	100

Course Objective: This course will help the students to appreciate the significance of microbes in the food industry including the negative aspects like food spoilage, food infection, intoxication and the positive aspects like food fermentation. The students will also learn about various approaches of food preservation.

Course Content:

Unit A: Foods as a substrate for microorganisms and Microbial spoilage of various foods **No. of Hours: 15**

Intrinsic and extrinsic factors that affect growth and survival of microbes in foods, natural flora and source of contamination of foods in general. Principles, Spoilage of vegetables, fruits, Cereals, sugar products, meat, eggs, milk and butter, bread, canned Foods. Detection of spoilage and characterization.

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

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

Unit C: Fermented foods **No. of Hours: 15**

Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss, kefir, dahi and cheese, other fermented foods: bread, dosa, sauerkraut, soy sauce and tampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market. Mushrooms: nutritive values of mushrooms, Edible and poisonous Mushrooms.

Unit D: Food intoxications and Food infections **No. of Hours: 15**

Bacterial and nonbacterial food intoxication/infections–with examples of *Clostridium, Bacillus, Escherichia, Salmonella, Shigella, Staphylococcus, Vibrio, Yersinia*, Nematodes, protozoa, algae, fungi and viruses. Foodborne outbreaks laboratory testing procedures, Food control agencies and its regulations, HACCP, Indices of food sanitary quality and sanitizers, Plant sanitation –Employee's health standards –waste treatment –disposal –quality control, Cultural and rapid detection methods of food borne pathogens in foods

SUGGESTED READINGS

1. Adams MR and Moss MO. *Food Microbiology*. 4th edition, New Age International (P) Limited Publishers, New Delhi, India. 1995. Print
2. Banwart JM. *Basic Food Microbiology*. 1st edition. CBS Publishers and Distributors, Delhi, India. 1987. Print
3. Davidson PM and Brannen AL. *Antimicrobials in Foods*. Marcel Dekker, New York. 1993. Print
4. Dillion VM and Board RG. *Natural Antimicrobial Systems and Food Preservation*. CAB International, Wallingford, Oxon. 1996. Print
5. Frazier WC and Westhoff DC. *Food Microbiology*. 3rd edition. Tata McGraw-Hill Publishing Company Ltd, New Delhi, India. 1992. Print

6. Gould GW. *New Methods of Food Preservation*. Blackie Academic and Professional, London. 1995. Print
7. Jay JM, Loessner MJ and Golden DA. *Modern Food Microbiology*. 7th edition, CBS Publishers and Distributors, Delhi, India. 2005. Print
8. Lund BM, Baird Parker AC, and Gould GW. *The Microbiological Safety and Quality of Foods*. Vol. 1-2, ASPEN Publication, Gaithersberg, MD. 2000. Print
9. Tortora GJ, Funke BR, and Case CL. *Microbiology: An Introduction*. 9th edition. Pearson Education. 2008. Print

Course Title: FOOD MICROBIOLOGY LABORATORY

Course Code: MIC638

L	T	P	Credit	Marks
0	0	3	2	50

Experiments:

1. Alkaline phosphatase test to check the efficiency of pasteurization of milk.
2. Determination of quality of a milk sample by methylene blue reduction test.
3. Determination of number of bacteria in milk by standard plate count.
4. Isolation of any pathogenic bacteria from food products.
5. Isolation of spoilage microorganisms from spoiled vegetables/fruits.
6. Isolation of spoilage microorganisms from bread.
7. Preparation of Yogurt/Dahi etc.
8. Production of sauerkraut by microorganisms.

Course Title: INDUSTRIAL MICROBIOLOGY

Course Code: MIC641

L	T	P	Credit	Marks
4	0	0	4	100

Course Objective: The objective of this course is to provide knowledge to the students about the fundamentals of industrial microbiology and fermentation technology like isolation of industrially important microbes, types of fermenters, downstream processing and microbial production of industrial products etc.

Course Content:

Unit A: Introduction to industrial microbiology and fermentation processes

No. of Hours: 15

Brief history and developments in industrial microbiology, Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations, Design of laboratory bioreactor; Types of Bioreactor: Stirred tank reactor, Airlift reactor, Packed bed reactor, Fluidized bed reactors, Scale-up principles.

Unit B: Isolation of industrially important microbial strains and fermentation media

No. of Hours: 15

Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Microbial substrate- Media formulation, Crude and synthetic media; molasses, corn steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates, Optimization of media, Optimization of media using statistical designs.

Unit C: Down-stream processing **No. of Hours: 10**

Instrumentation control, physical and chemical environment sensors, Downstream processing: Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying, Fermentation economics.

Unit D: Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses) **No. of Hours: 15**

Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12, Enzymes (amylase, protease, lipase), Wine, beer, Single cell proteins, Biopesticides, Biofertilizers, Microbial transformation, Production of metabolites of non-microbial origin eg. Insulin, Interlukin, Hormones etc. using rDNA technology.

Unit E: Enzyme immobilization **No. of Hours: 5**

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

SUGGESTED READINGS

1. Stanbury P. F., A. Whitaker, S. J. Hall. Principles of Fermentation Technology Publisher: Butterworth-Heinemann.
2. Prescott and Dunn's Industrial Microbiology.Publisher: Gerald Reed: Books.
3. Shuler M.L. and F. Kargi: Bioprocess Engineering Basic Concepts by Publisher Prentice Hall.

4. Vogel H.C., C.L. Todaro, C.C. Todaro: Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment by Publisher: Noyes Data Corporation/ Noyes Publications.
5. W. Crueger and A.Crueger: Biotechnology. A Textbook of Industrial Microbiology, Publisher : Sinauer Associates.

Course Title: INDUSTRIAL MICROBIOLOGY LABORATORY

Course Code: MIC642

L	T	P	Credit	Marks
0	0	3	2	50

Experiments:

1. Study different parts of fermenter
2. Microbial fermentations for the production and estimation (qualitative and quantitative) of:
(a) Enzymes: Amylase, Protease and Cellulase
(b) Amino acid: Glutamic acid
(c) Organic acid: Citric acid
(d) Alcohol: Ethanol
3. Isolation of antibiotic-producing microorganisms from soil.
4. Study enzyme immobilization by sodium alginate method.
5. Production of wine from grapes/apple etc.
5. A visit to any educational institute/industry to see an industrial fermenter, and other downstream processing operations.

Course Title: EUKARYOTIC MICROBIOLOGY

L	T	P	Credit	Marks
4	0	0	4	100

Course Code: MIC635

Course Objective: The course is designed to help the students to comprehend the diversity of eukaryotic microbes like fungi, algae, protists with emphasis on their structural organization, reproduction and life-cycle.

Course Content:

Unit A: Eucaryotic Cell Structure and Function (20 hours)
An Overview of Eucaryotic Cell Structure, The Plasma Membrane and Membrane Structure, The Cytoplasmic Matrix, Microfilaments, Intermediate Filaments, and Microtubules Disease Getting Around, Organelles of the Biosynthetic-Secretory and Endocytic Pathways, Eucaryotic Ribosomes, Mitochondria, Chloroplasts, The Origin of the Eucaryotic Cell, The Nucleus and Cell Division, External Cell Coverings, Cilia and Flagella, Comparison of Procaryotic and Eucaryotic Cells

Unit B: Fungi (15 hours)
Physiology of growing hypha, spores, classification. The structure and composition of fungal cell, The growth and form of fungal cell, The growth sof population and colonies. The effect of environment on growth, Vegetative multihyphal system, Prevention of fungal growth. Role of spores in mycology and in the life of the organism. General characteristics of the fungal divisions i.e. Myxomycota, Oomycota, Chytridiomycota, Zygomycota, Ascomycota, Plectomycetes, Basidiomycota, Heterobasidiomycota, Urediniomycetes, Ustilaginomycetes etc.

Unit C: Algae (15 hours)
Basic characteristics of algae, structure of the algal cell, Nutrition, Classification, Algal fossil records. Toxic algae, Chemical defence mechanism of algae, applications of algae. The prokaryotic algae- cyanobacteria, Morphology, protoplasmic structure, pigments, heterocysts-nitrogen fixation, asexual reproduction, symbiosis, ecology of cyanobacteria, cyanotoxins, cyanophages, General characteristics of the algal divisions i.e. Glaucophyta, Rhodophyta, Euglenophyta, symbiotic dianoflagellates, Cryptophyta, Heterokontophyta, Prymnesiophyta etc.

Unit D: The Protists (10 hours)
Distribution, Nutrition, Morphology, Encystment and Excystment, Reproduction, Protist classification with special reference to *Amoeba, Paramecium and Giardia*

SUGGESTED READINGS

1. Tortora GJ, Funke BR and Case CL. *Microbiology: An Introduction*. 9th edition. Pearson Education. 2008. Print
2. Madigan MT, Martinko JM, Dunlap PV and Clark DP. *Brock Biology of Microorganisms*. 14th edition. Pearson International Edition. 2014. Print
3. Cappucino J and Sherman N. *Microbiology: A Laboratory Manual*. 9th edition. Pearson Education Limited. 2010. Print
4.Wiley JM, Sherwood LM and Woolverton CJ. *Prescott's Microbiology*. 9th Edition. McGraw Hill International. 2013. Print
5. Atlas RM. *Principles of Microbiology*. 2nd edition. WM.T.Brown Publishers. 1997. Print

6. Pelczar MJ, Chan ECS and Krieg NR. *Microbiology*. 5th edition. McGraw Hill Book Company. 1993. Print
7. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. *General Microbiology*. 5th edition. McMillan. 2005. Print

Course Title: EUKARYOTIC MICROBIOLOGY LABORATORY

Course Code: MIC636

L	T	P	Credit	Marks
0	0	3	2	50

Experiments:

1. Preparation of potato dextrose and malt extract agar medium.
2. Isolation of fungi from rotten bread and vegetables.
3. Gram stain slides of *Candida albicans* and *Cryptococcus neoformans*.
4. Looking at cotton blue stained *Rhizopus, Aspergillus, Penicillium, Fusarium*.
5. Looking at spores of *Rhizopus, Aspergillus, Penicillium, Fusarium*
6. Study of *Spirogyra, Nostoc, Anabena, Spirulina, Sargassum, Chara, Chlamydomonas,* and *volvox* using temporary Mounts.
7. Study of the following protozoans using permanent mounts/photographs: *Amoeba, Entamoeba, Paramecium* and *Plasmodium*

Course Title: MOLECULAR BIOLOGY

L	T	P	Credits	Marks
4	0	0	4	100

Course Code: BTY511

Course Objective: A comprehensive knowledge of molecular aspects of biological function at the molecular level, particular emphasis on the structure and regulation of genes, as well as, the structure and synthesis of proteins and applications of these concepts in human medicine and health, agriculture, study evolution and other areas.

Course Content:

Unit I (**14 hours)**

Introduction to molecular biology, basic techniques in molecular biology. DNA and its various forms, super coiling of DNA, DNA melting, repetitive sequences, cot and rot curves, C value paradox, DNA protein interaction, DNA super coiling. Prokaryotic & eukaryotic DNA replication, enzymes and accessory proteins involved in DNA replication, replication origin & replication fork, fidelity of replication, extra chromosomal replicons, DNA damage and repair mechanisms, gene amplification, mobile genetic elements, homologous and site specific recombination.

Unit II **(14 hours)**

Prokaryotic and eukaryotic transcription, RNA polymerase, transcription factors, regulatory elements, transcriptional activator, repressor & mechanism of transcription regulation, post-transcriptional processing of mRNA, rRNA & tRNA.

Unit III **(12 hours)**

Protein synthesis and processing: Ribosome structure, genetic code, prokaryotic & eukaryotic translation, the translation machinery, mechanism and regulation of translation & translation proof-reading, translational inhibitors, Post- translational modification of proteins and intracellular protein targeting, import into nucleus, mitochondria and peroxisome.

Unit IV **(10 hours)**

Control of gene expression at transcription and translation level (regulating the expression of phages, viruses, prokaryotic and eukaryotic genes, role of chromatin in gene expression and gene silencing).

Unit V **(10 hours)**

Regulation of cell cycle, cancer and apoptosis. Signal transduction and its molecular basis, molecular mechanism of plant hormone action mitochondrial control of fertility, structure, organization and regulation of nuclear gene concerning storage proteins and starch synthesis.

Reference Books:

1. Molecular cell biology (2008). Harvey F. Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher (W.H.Freeman).
2. Genes IX (2008). Benjamin Lewin (Jones and Bartlett Publishers).
3. Molecular cloning: A laboratory manual (2000). J. Sambrook, E.F. Fritish and T. Maniatis (Cold Spring Harbor Laboratory Press,New York).
4. Molecular Biology of the Gene. J D Watson (7th edn) 2017. Pearson Publn.

Course Title: MOLECULAR BIOLOGY LABORATORY

L	T	P	Credits	Marks
0	0	3	2	50

Course Code: BTY512

Experiments:

1. Isolation of genomic DNA from bacteria.
2. Isolation of genomic DNA from plant.
3. Isolation of total RNA from tissue.
4. Demonstration of DNA protein interaction.
5. Quantitation of nucleic acids and proteins.
6. Gel electrophoresis:
    - Nucleic acid
    - Protein

Course Title: RECOMBINANT DNA TECHNOLOGY

L	T	P	Credits	Marks
4	0	0	4	100

Course Code: BTY521

Course Objective: The basic objective of the paper is to present the principles of gene manipulation and its associated technologies. How developments in gene manipulation have revolutionized medicine, agriculture and health.

Course Content:

Unit I **(10 hours)**

Introduction and scope of Recombinant DNA Technology. DNA modifying enzymes- Terminal deoxynucleotidyl transferase, Polynucleotide kinase, Alkaline phosphatase, Nucleases, Methylases, Ligases- *E. coli* and T4 DNA ligases, Linker, Adaptor, Homopolymer tailing, Restriction Endonucleases.

Unit II **(14 hours)**

Isolation and Purification of nucleic acid: Basic techniques and considerations criteria of purity, isolation and purification of phage DNA plasmid, chromosomal DNA, RNA and mRNA. Cloning and expression vector: Characteristics of cloning and expression vectors; plasmid, phage and cosmid vectors, multipurpose cloning vectors, shuttle vectors; bacterial, yeast, plant and mammalian expression vectors.

Unit III **(10 hours)**

Cloning and expression hosts: Characteristics of cloning and expression host, bacterial, yeast, plant and mammalian host systems for cloning and expression of genes.DNA Cloning Strategies: Preparation of genomic and cDNA libraries, criteria for selection of cloning vectors - plasmid, bacteriophage and cosmid. transformation and transfection, electroporation, screening of gene library and selection of clone.

Unit IV **(15 hours)**

Nucleic acid Blotting and Hybridization: Southern and northern blotting and hybridization techniques, radioactive and non-radioactive labeling of probe, western blotting. Expression of cloned genes :Expression of cloned genes in *E. coli*, *Bacillus subtilis*, s*treptomyces*, yeast and mammalian cells, detection and analysis of proteins expression from cloned genes. Protein-Protein interactions-Phage display (*in vivo*, *in vitro* and *in planta*, Yeast two hybrid system, Yeast three hybrid system. Bicomplementation and Florescence Resonance Energy Transfer (FRET).

Unit V **(11 hours)**

Polymerase chain reaction and site directed mutagenesis: Principle and application of polymerase chain reaction, Real Time PCR, random mutagenesis, site-directed mutagenesis and protein engineering. Impact of rDNA on human genetics: Mapping & cloning of human disease genes, DNA based diagnosis, gene targetting, human genome project history and scope. Applications of r-DNA technology in industry, agriculture and forensic science.

Reference Books:

1. Gene cloning and DNA analysis – An Introduction (2006). 5th edition, T.A. Brown, Blackwell publisher.
2. Genetic Engineering. An Introduction to gene analysis and exploitation in eukaryotes (1998). S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford.

3. Molecular Cloning : A Laboratory Manual (2000). J. sambrook, E.F. Fritsch and T.Maniatis, Cold Spring Harbor Laboratory Press, New York.
4. Molecular Biotechnology-Principles and Applications of Recombinant DNA (2003). 3rd edition, Bernard R Glick and Jack J pasternak. ASM press, Washington.
5. Principles of Genetic Engineering (2009). Mousumi Debnath, pointer publisher, Jaipur.
6. Principles of gene manipulation and Genomics (2006). 7th edition, S.B Primose and R.M Twyman, Blackwell publishing.

Course Title: RECOMBINANT DNA TECHNOLOGY LABORATORY

Course Code: BTY522

L	T	P	Credits	Marks
0	0	3	2	50

Experiments:

1. Preparation and purification of pUC plasmid.
2. Preparation and purification of genomic DNA
3. Restriction digestion of plasmid and genomic DNA and gel electrophoresis.
4. Gene cloning
5. Bacterial transformation
6. Southern blotting and hybridization with non-radioactive probes.
7. Amplification of DNA with PCR Temperature cycler.

Course Title: VIROLOGY

L	T	P	Credits	Marks
4	1	0	4	100

Course Code: BTY681

Course Objective: This course deal with the classical as well as modern concept of virology plant as well as animal virology, as biological concept arising from the virology. Role of plant and animal viruses in agriculture and human health.

Course Content:

Unit I **(15 hours)**

History and development of virology, taxonomy of viruses (earlier classification systems) and viroids, significance of virology and latest ICTV classification of viruses. Origin and evolution of viruses. Principles of biosafety, containment facilities, maintenance and handling of laboratory animals and plants.

Unit II **(10 hours)**

Propagation, purification, characterization, identification and genomics of viruses. Methods of virus diagnosis, detection, assays and comparison of their sensitivities. Structure of viruses and methods employed in structural and functional genomics of the viruses.

Unit III **(15 hours)**

Symptoms of plant virus diseases, transmission of plant viruses, viral and viroid diseases and their control: General discussion on symptoms caused by viruses and viroids in diseased economically important trees and agricultural crops, and their control. Microbial viruses: Diversity, classification, characteristics and applications of bacteriophages, and general account on algal, fungal and protozoan viruses. Virus-like agents: Prions, satellite DNAs and RNAs, satellite viruses; defective interfering particles and virophages.

Unit IV **(10 hours)**

Virus replication Strategies: Principal events involved in replication: Adsorption, penetration, uncoating nucleic acid and protein synthesis, intracellular trafficking, assembly, maturation and release, viral-host interaction, Host response to viral infection.

Unit V **(10 hours)**

Anti-viral strategies: prevention and control of viral diseases. Introduction to recent trends in management and control of viral diseases. Introduction to applications of plant and animals viruses.

Reference Books:

1. Principles of Virology: Molecular Biology, Pathogenesis and Control of Animal Viruses (2003). Flint, S.J., Enquist, L.W., Racaniello, V.R. and Skalka, A.M. 2nd Edition, ASM Press, Washington, DC. Print.
2. Introduction to Modern Virology (2007). Dimmock, N., Easton, A. and Leppard, K. 6th Edition. Wiley-Blackwell. Print.
3. Basic Virology (2007). Wanger, E.K., Hewiett, M., Bloom, D. and Camerini, D. 3rd edition, Wiley-Blackwell. Print.
4. Principles of Molecular Virology (2011). Cann, A.J. 5th Edition. Elsevier Academic Press. Print.
5. Plant Virology (2013). Hull, R. 5th Edition. Academic Press. Print.
6. Principles of Molecular Virology (2001). Alan J. Cann, 3rd edition, Elsevier Academic Press.
7. Plant Virology (2002). Roger Hull, 4th edition, Academic press.

Course Title: BIOANALYTICAL TECHNIQUES

L	T	P	Credits	Marks
4	1	0	4	100

Course Code: BCH501

Course Objective: The course introduces students all the major bioanalytical techniques relevant to students of biochemistry. It covers the theoretical aspects of various techniques, along with their instrumentation and applications.

Course Content:

Unit A **(20 hours)**

Spectroscopy – Concepts of spectroscopy, Visible and UV spectroscopy, Laws of photometry. Beer-Lambert's law, Principles and applications of colorimetry, Fluorescence Spectroscopy.

Chromatography – Principles of partition chromatography, paper, thin layer, ion exchange and affinity chromatography, gel permeation chromatography, HPLC and FPLC

Unit B **(20 hours)**

Centrifugation – Principles of centrifugation, concepts of RCF, different types of instruments and rotors, preparative, differential and density gradient centrifugation, analytical ultra-centrifugation, determination of molecular weights and other applications, subcellular fractionation.

Mass Spectrometry – Principle of MS, ionization modes, equipment, MS of proteins/peptides, interface of MS with other methods – MS/MS, LC/MS, and GC/MS, peptide mapping, post-translation modification analysis of proteins, protein sequencing by MS.

Unit C **(10 hours)**

Electrophoretic techniques – Principles of electrophoretic separation. Continuous, zonal and capillary electrophoresis, different types of electrophoresis including paper, cellulose, acetate/nitrate and gel. Electroporation, pulse field gel electrophoresis.

Immunochemical techniques – Making antibodies, Immunoassay formats, Immunomicroscopy, Lateral flow devices, Epitope mapping, Immunoblotting, Fluorescent activated cell sorting (FACS), Cell and tissue staining techniques, Immunocapture, polymerase chain reaction (PCR) Immunoaffinity chromatography (IAC), Antibody-based biosensors, Therapeutic antibodies

Unit D **(10 hours)**

Bioinformatics – Overview, Sequence databases – DNA, protein, genome, EST and SNP databases, BLAST programs, ClustalW, Tertiary protein structure databases, PDB, Rasmol, Pymol and Swiss-PDB viewer, Homology modeling.

Recommended books:

1. Physical Biochemistry – Principles and Applications – 2nd Edition – David Sheehan, Wiley-Blackwell (2009).
2. Analytical Biochemistry – 3rd Edition – David Holme and Hazel Peck, Pearson Education Ltd. (1998)

Course Title: BIOANALYTICAL TECHNIQUES LABORATORY

Course Code: BCH503

L	T	P	Credits	Marks
0	0	3	2	50

Experiments:

1. Titration of a weak acid using a pH meter, preparation of buffers
2. Verification of Beer-Lambert's law and determination of absorption coefficients
3. Paper chromatography – Separation of amino acids and carbohydrates in a mixture
4. Thin layer chromatography of fatty acids
5. Column chromatography – Separation of a mixture of proteins and salt using Sephadex column
6. Electrophoresis

Course Title: MICROBIAL PHYSIOLOGY AND METABOLISM

L	T	P	Credits	Marks
4	0	0	4	100

Course Code: MIC550

Course Objectives:
This course will allow the students to understand various types of microbial metabolic activity including unique features of bacterial biosynthesis and differentiation.

Unit 1 **(10 hours)**
Microbial physiology: Definitions of growth, measurement of microbial growth, generation time, growth rate, synchronous growth, diauxic growth, classification of microbes with respect to carbon, energy and electron source
Basic aspects of Bioenergetics: Principles of thermodynamic reaction, Electron carriers, entropy, enthalpy

Unit 2
Chemolithotrophic and Phototrophic Metabolism **(10 hours)**
aerobic and anaerobic chemolithotrophy, Hydrogen oxidation, sulphur oxidation, methanogenesis
Photolithotrophy- Oxygenic and anoxygenic photosynthetic bacteria and their mechanism, photosynthetic pigments, Photosynthetic electron transport system, Photophosphorylation, Dark reaction and C3, C4 pathways,

Unit 3
Metabolism of Carbon **(15 hours)**
Embden Mayer Hoff Pathway, Enter Doudroff Pathway, Hexose Monophosphate Pathway, Krebs Cycle, Oxidative phosphorylation, Reverse TCA cycle - Gluconeogenesis,

Unit-4 Respiration and fermentation **(10 hours)**
Anaerobic respiration, with special reference to dissimilatory nitrate reduction
Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation

Unit 5 **(5 hours)**
Nitrogen metabolism: Assimilation of nitrogen, Dinitrogen, Nitrate nitrogen and ammonia assimilation, General reactions of amino acids, Stickland reaction

Unit 6 **(5 hours)**
Synthesis of cell wall and endospore: Synthesis of peptidoglycan, Bacillus endospore formation, Activation of bacterial endospores, Germination of bacterial endospores, Outgrowth of bacterial endospores

Unit 7 **(5 hours)**
Bacterial motility: Structure, arrangement and function of bacterial flagella, Synthesis of bacterial flagella, bacterial motility, Bacterial chemotaxis

SUGGESTED READINGS

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

Course Title: Biological Macromolecules
Paper Code: BCH529

L	T	P	Credits	Marks
4	0	0	4	100

Course Objective:

The course is intended for master's course students. This course is a broad survey of all the major concepts of biochemistry with emphasis on all the important categories of biomolecules and their biochemistry.

Unit A **(10 hours)**

Introduction

Structure of atoms, molecules and chemical bonds, Cellular and chemical foundations of life. Water as a biological solvent.The concept of pH, pKa, dissociation and ionization of acids and bases, Physiological buffers and their buffering mechanism, Henderson-Hasselbalch equation.

Carbohydrates

Structure of monosaccharides.Stereoisomerism and optical isomerism of sugars. Reactions of aldehyde and ketone groups. Ring structure and anomeric forms, mutarotation. Reactions of sugars due to hydroxyl groups. Important derivatives of monosaccharides, disaccharides and trisaccharides (structure, function and occurrence of important ones). Structure, occurrence and biological importance of monosaccharides, oligosaccharides and polysaccharides - cellulose, chitin, agar, algenic acids, pectins, proteoglycans, sialic acids, blood group polysaccharides, glycogen and starch. Bacterial cell wall polysaccharides.Glycoproteins.

Unit B **(20 hours)**

Proteins
Definition, importance and functions, amino acids as building blocks of proteins, essential amino acids, non-protein amino acids, structure of peptide bond, organizational levels of protein structure, relationship between primary and higher order structures, supramolecular assemblies of proteins, solubility, denaturation, functional diversity and species specificity of proteins, protein classification, chemical synthesis of polypeptides, Conformation of proteins: Ramachandran Plot, Secondary, tertiary and quaternary structure; domains; motif and folds. Stabilizing interactions: Vander waals, electrostatic, hydrogen bonding, Hydrophobic interactions. Stability of protein structure.

Unit C **(20 hours)**

Porphyrins:
Nucleus and classification of porphyrins, important metallo porphyrins occurring in nature, chemical nature and physiological significance of bile pigment.

Lipids
Definition, importance and functions, classification of lipids, fatty acids and essential fatty acids, general structure and functions of major lipid subclasses, acylglycerols, phosphoglycerides, sphingolipids, terpenes, steroids, eicosanoids.

Vitamins and Minerals
Definition, chemistry and functions of water and fat soluble vitamins, major trace minerals, their bound forms and functions.

Unit D **(10 hours)**

Nucleic acids
Structure and functions of different nitrogeneous bases, nucleosides, nucleotides and different types of nucleic acids (DNA, RNA). DNA with unusual structures, DNA denaturation and renaturation.

Overview of metabolite pathways: glycolysis, citric acid cycle, pentose phosphate pathway, oxidation of fatty acids, oxidative phosphorylation and photophosphorylation.

Books Recommended

1. Nelson DL and Cox MM. (2013) Lehninger Principles of Biochemistry, 6thEdition. Macmillan Worth Publishers, New Delhi.

2. Berg JM, Tymoczko JL, Gatto GJ and Stryer L (2015) Biochemistry, 8th Edition, WH Freeman &Co., New York.

3. Bender DA, Botham KM, Kennelly PJ, Rodwell VW and Weil PA (2015) Harper's Illustrated Biochemistry, 30th Edition, McGraw- Hill Medical Canada.

4. Voet D, Voet JG and Pratt CW (2015). Fundamentals of Biochemistry, 4th Edition. John Wiley & Sons. New York.

Course Title: Biological Macromolecules Laboratory

Paper Code: BCH530

L	T	P	Credit	Marks
0	0	0	2	50

Experiments:

1. Quantitative estimation of blood glucose by Folin-Wu/Anthrone/DNSO - Toluidine/Enzymatic method.

2. Estimation of proteins by Biuret method

3. Quantitative estimation of cholesterol in the blood

4. Estimation of alkaline and acid phosphatases

5. Estimation of blood glucose.

6. Estimation of cholesterol

7. Sugar Fermentation in Microorganisms.

8. Estimation of Glucose 6-Phosphate.

9. Estimation of Urea.

10. Estimation of Uric acid.

11. Estimation of Creatinine.

Course Title: SEMINAR I

L	T	P	Credit	Marks
0	0	0	2	50

Course Code: MIC630

Seminar Objective:
During the course students will come to know about the general understanding of the most common problems, recent advances in microbiology research. Each student shall be allotted a topic by the instructor. Student will have to understand the topic, collect literature and prepare the presentation. Through this the students will develop habit of reading newer topics, will become inquisitive and develop confidence of presentation and discussion before audience.

The students shall submit a project report on the allotted topic, which shall be evaluated by the concerned internal faculty. He/She then would present a seminar on the concerned topic. The students will be encouraged to explore all available literature as well as the internet to prepare the seminar report and present the same using informative slides made using Power Point or projectors.

Seminar Contents:
Students will present their work on a selected topic with the following headings:

- Title
- Objectives
- Review of Literature
- Materials and Methods
- Results
- Conclusion/recommendations

Examination Scheme:

Literature study/ Preparation/ Presentation	30
Question answer session	20
Total	50

Course Title: SEMINAR II

L	T	P	Credit	Marks
0	0	0	2	50

Course Code: MIC640

Seminar Objective:
During the course students will come to know about the general understanding of the most common problems, recent advances in microbiology research. Each student shall be allotted a topic by the instructor. Student will have to understand the topic, collect literature and prepare the presentation. Through this the students will develop habit of reading newer topics, will become inquisitive and develop confidence of presentation and discussion before audience.

The students shall submit a project report on the allotted topic, which shall be evaluated by the concerned internal faculty. He/She then would present a seminar on the concerned topic. The students will be encouraged to explore all available literature as well as the internet to prepare the seminar report and present the same using informative slides made using Power Point or projectors.

Seminar Contents:
Students will present their work on a selected topic with the following headings:

- Title
- Objectives
- Review of Literature
- Materials and Methods
- Results
- Conclusion/recommendations

Examination Scheme:

Literature study/ Preparation/ Presentation	30
Question answer session	20
Total	50

Course Title: PROJECT PART – I

L	T	P	Credit	Marks
0	0	0	2	50

Course Code: MIC701

Guidelines for Project Synopsis:

Research experience is as close to a professional problem-solving activity as anything in the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty guide. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-art instrumentation. Research is genuine exploration of the unknown that leads to new knowledge which often warrants publication.

As a preparatory of project work student/s need to formulate a legible research problem and go through literature search to propose ways to address the problem. A short account of this work need to be presented by the students in written format to the advisors. A verbal presentation aided with media tools should follow the submission of written synopsis.

Course Title: PROJECT PART – II

L	T	P	Credit	Marks
0	0	0	8	200

Course Code: MIC702

Guidelines for Project:

Research is genuine exploration of the unknown that leads to new knowledge which often warrants publication. But whether or not the results of research project are publishable, the project should be communicated in the form of a research report written by the student.

Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be criticized by the faculty guide and corrected by the student at each stage.

The file is the principal means by which the work carried out will be assessed and therefore great care should be taken in its preparation.

In general, the File should be comprehensive and include:

- A short account of the activities that were undertaken as part of the project
- A statement about the extent to which the project has achieved its stated goals.
- Assessment about the outcomes of the experimentation processes engaged in as part of the project;
- Any activities planned but not yet completed as part of the project, or as future initiative directly resulting from the project;
- Any problems that have arisen that may be useful to document for future reference.

Report Layout

The report should contain the following components:

Title or Cover Page

The title page should contain the following information: Project Title; Student' name; Course; Year; Supervisor' name

Acknowledgements (optional)

Acknowledgement to any advisory or financial assistance received in the course of work may be given

Abstract

A good abstract should be straight to the point; not too descriptive but fully informative. First paragraph should state what was accomplished with regard to the objectives. The abstract does not have to be an entire summary of the project, but rather a concise summary of the scope and results of the project

Table of Contents

Title and subtitles are to correspond exactly with those in the text

Introduction

Here brief introduction to the problem that is the central to the project and an outline of the structure of the rest of the report should be provided. The introduction should aim to catch the imagination of the reader, so excessive details should be avoided.

Materials and Methods

This section should aim at experimental designs, materials used. Methodology should be mentioned in details including modification if any.

Results and Discussion

Present results, discuss and compare these with those from other workers etc. In writing these section, emphasis should be given on what has been performed and was achieved in the course of the work, rather than discuss in detail what is readily available in the text books. Avoid abrupt changes in the contents from section to section and maintain a lucid flow throughout the thesis. An opening and closing paragraph in every chapter should be included in a smooth flow.

Note that in writing the various sections, all figures and tables should as far as possible be next to the associated text, in the same orientation as the main text, numbered, and given appropriate titles or captions. All major equations should also be numbered and unless it is really necessary never write in "point" form.

Conclusion

A conclusion should be the final section in which the outcome of the work is mentioned briefly.

Future Prospects

Appendices

The appendix contains material which is of interest to the reader but not an integral part of the thesis and any problem that have arisen that may be useful to document for future reference.

References

This should include papers and books referred to in the body of the report.