Level 6.0	Curriculum Matrix M.Sc. Microbiology						
Semester I					**Marks Distribution**		
Subject Type	**Subject Code**	**Name of Subject**	**Hours/ week**	**Credit (L+T+P)**	**External**	**Internal**	**Total**
Discipline Specific Core Course (DSCC)	MSC DSC - 101	General Microbiology	3	3	70	30	100
	MSC DSC - 102	Cell and Molecular Biology	3	3	70	30	100
	MSC DSC - 103	Biochemistry	3	3	70	30	100
	MSC DSC - 104	Bio-Instrumentation	3	3	70	30	100
Laboratory	MSC DSC - 105	Lab Course I	2	1	35	15	50
	MSC DSC - 106	Lab Course II	2	1	35	15	50
Discipline Specific Elective Course (DSEC)	MSC DSE - 101 / MSC DSE - 102	Agriculture Microbiology **OR** Plant Pathology	4	4	70	30	100
Research Work	RM – 02	Research & Publication Ethics	4	4	70	30	100
		Total	**24**	**22**	**490**	**210**	**700**

Level 6.0	Curriculum Matrix M.Sc. Microbiology						
Semester II					**Marks Distribution**		
Subject Type	**Subject Code**	**Name of Subject**	**Hours/ week**	**Credit (L+T+P)**	**External**	**Internal**	**Total**
Discipline Specific Core Course (DSCC)	MSC DSC - 201	Microbial Physiology and Metabolism	3	3	70	30	100
	MSC DSC - 202	Bacteriology Mycology & Virology	3	3	70	30	100
	MSC DSC - 203	Immunology	3	3	70	30	100
	MSC DSC - 204	Microbial Technology	3	3	70	30	100
Laboratory	MSC DSC - 205	Lab Course III	2	1	35	15	50
	MSC DSC - 206	Lab Course IV	2	1	35	15	50
Discipline Specific Elective Course (DSEC)	MSC DSE - 201 / MSC DSE - 202	Vaccine & Antibiotics **OR** Microbial Nanotechnology	4	4	70	30	100

OJT/Internship/Project	INT – 01	Internship-I	4	4	70	30	100
		Total	**24**	**22**	**490**	**210**	**700**

Level 6.5	**Curriculum Matrix M.Sc. Microbiology**						
Semester III					**Marks Distribution**		
Subject Type	**Subject Code**	**Name of Subject**	**Hours/ week**	**Credit (L+T+P)**	**External**	**Internal**	**Total**
Discipline Specific Core Course (DSCC)	MSC DSC - 301	Medical Microbiology	3	3	70	30	100
	MSC DSC - 302	Microbial Genetics	3	3	70	30	100
Laboratory	MSC DSC - 303	Lab Course V	2	1	35	15	50
	MSC DSC - 304	Lab Course VI	2	1	35	15	50
Discipline Specific Elective Course (DSEC)-I	MSC DSE - 301 MSC DSE - 302	General Parasitology **OR** General Pathology	4	4	70	30	100
Discipline Specific Elective Course (DSEC)-II	MSC DSE - 303 MSC DSE - 304	Environmental Microbiology **OR** Industrial Microbiology	4	4	70	30	100
RP		Research Project and Proposal Writing	6	6	105	45	100
		Total	**24**	**22**	**455**	**195**	**650**

Level 6.5	**Curriculum Matrix M.Sc. Microbiology**						
Semester IV					**Marks Distribution**		
Subject Type	**Subject Code**	**Name of Subject**	**Hours/ week**	**Credit (L+T+P)**	**External**	**Internal**	**Total**

Dissertation		Dissertation Work and Thesis Writing		18	385	165	550
		Dissertation Seminar		2	35	15	50
		Viva- Voce		2	35	15	50
		Total		**22**	**455**	**195**	**650**

SEMESTER I
GENERAL MICROBIOLOGY

Credit 3
Total Marks: 100 (70+30)

Course Objectives:

1. To provide students with a foundational understanding of microbiology, including its history, scope, and differences between prokaryotic and eukaryotic organisms.
2. To develop knowledge of microbiological methods such as sterilization, pure culture techniques, microbial nutrition, and media preparation for isolation and maintenance of microorganisms.
3. To explain the principles of bacterial classification, microbial growth patterns, and structural details of unique groups like Rickettsiae, Mycoplasma, and Chlamydiae.
4. To introduce students to the morphology, reproduction, and classification of viruses, algae, fungi, and actinomycetes, along with their ecological and economic significance.
5. To familiarize learners with microbial ecology, symbiotic associations, nitrogen fixation, and various physical and chemical methods for microbial control, including antibiotics and resistance mechanisms.

Course Outcome:

Skills that students obtain after completion of the course:

1. **Explain** the historical development, scope, and fundamental differences between prokaryotic and eukaryotic microorganisms.
2. **Demonstrate** laboratory techniques for sterilization, culture preparation, microbial isolation, and preservation methods with an emphasis on aseptic practices.
3. **Analyze** bacterial classification systems, growth kinetics, and the influence of environmental and nutritional factors on microbial growth.
4. **Compare and contrast** structural and reproductive features of viruses, fungi, algae, and actinomycetes, and evaluate their economic and ecological roles.

5. **Apply** knowledge of microbial ecology and antimicrobial agents to understand microbial interactions, symbiosis, and mechanisms of microbial control and resistance.

Module I

Introduction to Microbiology: Historical background, Major Landmarks and Scope, Difference between Prokaryotic and Eukaryotic organisms.

Methods of Microbiology: Sterilization techniques, Pure culture techniques, Preservation and Maintenance of Microbial cultures, Principle of Microbial Nutrition, Perpetration of culture media, Enrichment culture, Different techniques for Isolation of Microbes.

Module II

Classification of Bacteria: Basic principle and techniques used in bacterial classification, Phylogenetic and numerical taxonomy. Bergey's manual and its importance, A brief account of Bacterial Classification. Ultra structure of Bacteria, A brief account of Rickettsiae, Mycoplasma and Chlamydiae.

Microbial Growth: The definition of growth, bacterial generation time, specific growth rate and yield measurement, Monoauxic, Diauxic and synchronized growth curve. Factors affecting microbial growth. Culture collection and maintenance of culture. Sporulation in bacteria.

Module III

Viruses: General characteristics, Morphology, Reproduction, Classification and structure of plant, animaland bacterial viruses. Cultivation of viruses, A brief account of TMV, Adenoviruses, Herpes, Retrovirus, HIV, Viroids and Prions

Module IV

Actinomycete: Distribution of actinomycetes, General characteristics, Economic importance.

Algae: Distribution of algae, Biochemical classification, Thallus organization, Reproduction, Products of algae and their Importance.

Fungi: General Characteristics, Classification, Vegetative body, Reproduction, Nutritional groups and Habitat relationships, Economic importance of fungi.

Module V

Microbial Ecology: Microbial flora of soil, Interaction among soil microorganisms. Nitrogen fixation (a brief account), Symbiotic association-types, functions and establishment of symbiosis.

Control of Microorganism by physical and chemical agents: Antimicrobial agents, Sulfa drugs, Antibiotics (penicillin and cephalosporin), Broad Spectrum antibiotics, antibiotics from prokaryotes. Anti fungal antibiotics, Mode of action, resistance of antibiotics.

SUGGESTED READINGS:

- General Microbiology-Roger. Y. Stainer, et al. 1986; Macmillan Press Ltd., Hampshire.

- Microbiology-An introduction: Gerald. J. Tortora, Berdell R.Funke,
- Christine.L.Case,Vth edition, 1995: The Benjamin/Cummings Publishing Co.Inc., USA.
- Microbiology: Essentials and Applications: Larry McKane, Judy Kandel, 2nd edition;1996; McGrawHill Inc.
- Microbiology- Prescott, Harley, Klein, 4th edition, 1999; McGraw Hill Inc.
- Microbiology: Brock and Madigan
- Microbiology: Pelczar, Chan and Krieg
- Microbiology: Powar and Daginawala
- General Microbiology: R. Y. Ingraham
- Microbiology: Katherine Black

CELL AND MOLECULAR BIOLOGY

Credit 3
Total Marks: 100 (70+30)

Course Objectives:

1. Introduce the fundamental principles of cell theory, organization, and the structural/functional aspects of prokaryotic and eukaryotic cells.
2. Develop an understanding of molecular mechanisms involved in DNA replication, repair, recombination, and transposition.
3. Explain the processes of transcription and post-transcriptional modifications in both prokaryotic and eukaryotic systems.
4. Provide in-depth knowledge of translation, ribosome structure, and protein biosynthesis.
5. Explore the genetic code and the molecular mechanisms regulating gene expression, including operon models and regulatory pathways.

Course Outcome:

Skills that students obtain after completion of the course:

1. Compare and contrast the structural organization and cell cycle regulation of prokaryotic and eukaryotic cells.
2. Analyze the enzymatic machinery and mechanisms underlying DNA replication, repair, recombination, and transposition.
3. Demonstrate understanding of transcriptional mechanisms and evaluate post-transcriptional modifications and RNA processing.
4. Illustrate the process of protein biosynthesis, including ribosome function, tRNA involvement, and translation in prokaryotes/eukaryotes.
5. Interpret the genetic code and explain regulatory mechanisms controlling gene expression with reference to operon and advanced models.

Module I

Cell Theory. Cell organization and functions: Structure of prokaryotic cells (bacteria, fungi, virus, cyanobacteria, mycoplasma etc.). General organization of eukaryotic cells; The cell cycle and its regulation; Cell division: Mitosis and Meiosis.

Module II

DNA REPLICATION: Enzymes and accessory protein involved in DNA replication. DNA replication in prokaryotes and eukaryotes. Repair of DNA;
Recombination and Transposition of DNA.

Module III

TRANSCRIPTION: In Prokaryotes and Eukaryotes; Mechanism of transcription.

Enzymology of transcription. Post-transcriptional modifications; Transcription in eukaryotes, RNA editing.

Module IV

TRANSLATION: In Prokaryotes and Eukaryotes; t-RNA and its function; Ribosome: Types and composition. Protein biosynthesis.

Module V

GENETIC CODE: Salient features of genetic code.

REGULATION OF GENE EXPRESSION: Basic elements in the control of gene expression, structural andregulatory genes, mechanism of activation of gene expression, operon model.

SUGGESTED READINGS:

- Molecular Biology of Cell, Alberts, B et. al
- Molecular Cell Biology, Darnell, Lodish, Baltimore, Scientific American Books Inc.1994.
- Molecular Biology LabFax, I.A.Brown (Ed), Bios Scientific Publishers Ltd., Oxford, 1991.
- Cell & Molecular Biology : Gerald Karp
- Cell Biology : C.B. Powar
- Essential Cell Biology : An introduction: Bruce, Alberts, Dennis
- The Cell: A Molecular Approach: Geoffrey M. Cooper
- Cell & Molecular Biology: SC Rastogi
- Molecular Cell Biology: Lodish
- Benjamin Lewin (1999) Genes VII, Oxford University Press, Oxford.
- Weaver R. F. (1999) Molecular biology, WCB McGraw-Hill Companies, Inc, New York.
- Brown T A (1995) Essential molecular biology, Vol. I, A practical approach, IRL press, Oxford.

BIOCHEMISTRY

Credit 3
Total Marks: 100 (70+30)

Course Objectives:

1. **To understand the chemical properties, structure, and biological importance of biomolecules** such as carbohydrates, lipids, proteins, nucleic acids, and enzymes.
2. **To explore the stereochemistry and structural organization of biomolecules**, including configuration, conformation, and interactions among various molecular forms.
3. **To examine the biochemical significance and functional diversity** of macromolecules like polysaccharides, lipids, proteins, and nucleic acids in living systems.
4. **To develop knowledge of enzyme kinetics and mechanisms**, including enzyme-substrate interaction, catalysis, inhibition, and regulation.
5. **To integrate structural and functional aspects of biomolecules** to understand their role in metabolism, energy regulation, and cellular organization.

Course Outcome:
Skills that students obtain after completion of the course:

1. **Describe** the structure, classification, and biological roles of carbohydrates, lipids, amino acids, nucleic acids, and enzymes.
2. **Interpret** stereochemical representations, ring structures, and conformational changes in sugars, amino acids, and nucleotides.
3. **Explain** the relationship between the structure and function of biomolecules such as polysaccharides, proteins, and nucleic acids.
4. **Analyze** enzyme kinetics, catalytic mechanisms, and various modes of enzyme inhibition and regulation.
5. **Apply** theoretical knowledge to explain molecular interactions and biochemical processes essential for life, such as energy metabolism and molecular recognition.

Module I

Carbohydrates: Chemical Properties, Classification and Biological Importance**.**

Stereochemistry: Stereochemistry of Sugars, Ring Structure (Aldose & Ketose) and Anomeric forms,Mutarotation.

Mono and Oligosccharides: Structure and Biochemical Roles of Mono and Oligosccharides.

Polysaccharides: Structure and Biochemical Roles of Homo and Heteropolysaccharides, Proteoglycans, Peptidoglycan, Glycosaminoglycans, Glycoconjugates, Glycoproteins.

Module II

Lipids: Classification, Fatty acids, Properties of Fatty acids, Triglycerides, Phospholipids and Sphingolipids; Biological Significance of Lipids.

Membrane Lipid: Lipid Bilayers, Formation of Lipid Bilayers, Membrane Fluidity, Fluid Mosaic Model.

Module III

Amino acids: Physical and Chemical Properties, Titration of amino acids, Separation and Identification of

amino acids,

Peptide bond: Primary structure, Determination of amino acid sequencing, Ramachandran plot, Secondary structure of α-helix, β-strand, β-sheet, turns and loops. Tertiary structure, Quaternary Structure, Globular and Fibrous Protein, Protein Sequencing.

Membrane Protein: Integral, Lipid-linked and Peripheral Membrane Proteins.

Module IV

Purine and Pyrimidine Bases: Structure and Types, Composition of DNA and RNA, Phosphodiester bond, Nucleosides and Nucleotides.

Nucleic Acid: Watson - Crick Model of Double helix, Chargaff's rule. Different forms of DNA structure (A, B & Z), RNA, Primary, Secondary and Tertiary of RNA, Denaturation and Annealing of DNA, Cot Value and Super coiling of DNA. Protein-Nucleic Acid Interaction

Nucleic Acid Sequencing: By Restriction Endonucleases, By Chain Terminator Method.

Module V

Enzymes: Classification and Nomenclature, Co-enzyme, Cofactor and Prosthetic group, Turnover of Enzymes, Enzyme-substrate Interaction. Activation energy, Catalytic mechanism of Enzymes.

Enzyme Kinetics: Michaelis-Menten equation, Double reciprocal plot, Activator, Inhibitors, Inhibition reactions (Competitive, Uncompetitive and Non-competitive) and their kinetics. Allosteric and FeedbackInhibition.

SUGGESTED READINGS:

1. Biochemistry: J M Berg, J L Tymoczko and L Stryer.
2. Principles of Biochemistry: David L. Nelson, Albert L. Lehninger, Michael M. Cox.
3. Biochemistry: D Voet, J Voet and C W Pratt.
4. Biochemistry: U Satyanarayana and U Chakrapani.
5. Textbook of Biochemistry: Edward S West.
6. Harper's Illustrated Biochemistry: Robert K Murray, Daryl K Garner and Peter A Mayes
7. The Enzyme: Dixon and Webb.
8. Text Book of Biochemistry with Clinical Correlations: Thomas M Devlin
9. Medical Biochemistry: N Mallikarjuna Rao
10. Introduction to Enzyme and Coenzyme Chemistry: Tim Bugg

BIO-INSTRUMENTATION

Credit: 3
Total Marks: 100 (70+30)

Course Objectives:

1. To introduce students to the fundamental principles and instrumentation of centrifugation and microscopy, and their applications in biological research.
2. To provide an understanding of radioisotope techniques, radioactive decay, methods of detection, and safety measures along with applications of mass spectrometry in biological sciences.
3. To develop knowledge of spectrophotometric principles, UV–Visible, IR, atomic, and NMR spectroscopy techniques for structural and functional analysis of biomolecules.
4. To familiarize students with different chromatographic techniques, their principles, instrumentation, and applications for separation and purification of biomolecules.
5. To impart theoretical and practical insights into electrophoretic techniques for the separation, identification, and characterization of proteins, nucleic acids, and other macromolecules.

Course Outcome:
Skills that students obtain after completion of the course:

1. Demonstrate knowledge of centrifugation and microscopy principles and apply them in biological sample preparation and analysis.
2. Explain the principles of radioactivity, radioisotope safety, and evaluate the applications of radioisotopes and mass spectrometry in biological research.
3. Apply spectrophotometric laws and interpret data obtained from UV, IR, atomic, and NMR spectroscopy for molecular analysis.
4. Analyze biomolecules using various chromatographic methods and determine their suitability for specific biological applications.
5. Utilize electrophoretic methods for the separation, identification, and characterization of proteins, nucleic acids, and other macromolecules.

MODULE I

Centrifugation techniques: Basic Principles of Sedimentation.
Centrifuge and Rotor: Types, Instrumentation and Applications.
Microscopy: Principles of Microscopy; Types: Bright field, Dark field, Phase contrast, Confocal and Fluorescent, Electron Microscopes (SEM andTEM).

MODULE II

Radioisotopes Techniques: Radioactive decay. Detection and different methods of measurement of radioactivity.Use of radioactive isotopes in biology; Safety aspects.
Mass Spectrometry: Principles, Techniques and Applications;Mass spectrometer, MALDI-TOF.

MODULE III

Spectrophotometric Techniques: - Basic principles; Lambert Beer's Law, Absorbance, Transmittance and Extinction Coefficient.
UV, Visible and Infrared Spectroscopy: Theory, Instrumentation and Applications;

Atomic Spectroscopy and Nuclear Magnetic Resonance (NMR) Spectroscopy: Theory, Instrumentationand Application

MODULE IV

Chromatography Techniques: Basic Principles, Instrumentation and Applications;
Plane Chromatography: Paper and Thin Layer Chromatography (TLC).

Column chromatography: Adsorption, Partition, Gel filtration, Ion exchange, Affinity chromatography,High Performance Liquid chromatography (HPLC).

MODULE V

Electrophoretic Techniques: Theory, Instrumentation and Applications;
Types: Paper, Gel electrophoresis, Isoelectric Focusing, Pulse Field Gel Electrophoresis, Immuno-electrophoresis, Electroblotting techniques.

SUGGESTED READINGS:

1. Biophysical Chemistry Principles and Techniques: Upadhyay, Upadhyay and Nath.
2. Biotechniques Theory and Practice: S V S Rana; Rastogi Publications.
3. Principles and Techniques of Biochemistry and Molecular Biology: K Wilson and J Walkar.
4. Physical Biochemistry Principles and Application: D Sheehan; Wiley
5. Physical Biochemistry and Molecular Biology: Freifelder D.
6. Principles of instrumental analysis: Skoog and West.
7. Biochemical Techniques: Theory and Practice-Robyt and White.
8. Principles and Techniques of Practical Biochemistry: Williams and Wilson.

LAB COURSE I

Credit 1
Total Marks: 50 (35+15)

Course Objectives:

1. **To introduce students to basic microbiological laboratory techniques**, including handling, washing, and sterilization of glassware and instruments.
2. **To familiarize learners with media composition, preparation, and culture methods** for the growth and maintenance of microorganisms.
3. **To develop practical skills in microbial isolation, inoculation, and enumeration** from various environmental samples such as air, water, soil, and sewage.
4. **To impart knowledge of microbial staining and observation techniques**, including Gram staining, acid-fast staining, and motility detection.
5. **To understand the factors affecting microbial growth and reproduction**, including environmental conditions like pH, temperature, light, and nutrient sources.

Course Outcome:
Skills that students obtain after completion of the course:

1. **Demonstrate proficiency in basic microbiological techniques** such as sterilization, aseptic transfer, and culture maintenance.
2. **Prepare and utilize various types of culture media and slants/plates** for growing and identifying microorganisms.
3. **Isolate, enumerate, and characterize microorganisms** from different environmental samples using standard inoculation methods.
4. **Perform staining and microscopic analysis** to differentiate microbial types and study bacterial motility.
5. **Analyze microbial growth patterns and evaluate the effect of environmental parameters** (pH, temperature, light, nutrients) on microbial proliferation.

PRACTICALS:

1. Introduction to microbiological techniques, washing of glasswares & sterilization.
2. Different media composition and preparation used in Microbiology
3. Preparation of Slants and Plate Culture.
4. Different inoculation techniques.
5. Isolation and enumeration of microbes from air, water, soil and sewage.
6. Maintenance of pure culture.
7. Staining of microbes: Gram staining, Acid-fast staining, Cotton blue staining.
8. Hanging drop technique for motility of bacteria.
9. Study of Mitosis and Meiosis.
10. Effect of pH, temperature, light and nutrient source on the growth of microorganisms.
11. Bacterial growth curve by measuring the turbidity.

LAB COURSE II

Credit 1
Total Marks: 50 (35+15)

Course Objectives:

1. **To develop an understanding of biochemical estimation techniques** for quantifying sugars, proteins, amino acids, and nucleic acids using colorimetric and spectrophotometric methods.
2. **To impart practical knowledge of analytical methods** such as Anthrone, Folin-Wu, Biuret, Lowry's, DPA, and Orcinol for accurate biochemical analysis.
3. **To introduce students to enzyme kinetics** by determining the optimum pH and temperature for enzymatic activity (e.g., Peroxidase).
4. **To train students in chromatographic techniques** like paper and gel chromatography for the separation and identification of biomolecules.
5. **To enhance laboratory skills** through verification of fundamental principles like Lambert-Beer's Law and the estimation of physico-chemical properties of oils (Iodine number, Acid value).

Course Outcome:
Skills that students obtain after completion of the course:

1. **Perform quantitative estimation of biomolecules** such as sugars, proteins, amino acids, and nucleic acids using standard biochemical methods.
2. **Analyze and interpret biochemical data** obtained from colorimetric and spectrophotometric assays.
3. **Evaluate enzyme activity and stability parameters** by determining the effects of pH and temperature on enzyme kinetics.
4. **Apply chromatographic techniques** for separation, identification, and purification of biomolecules.
5. **Demonstrate practical proficiency** in biochemical laboratory techniques and understand their relevance in research and industrial applications.

PRACTICALS:

1. Estimation of sugar by Anthrone reagent.
2. Estimation of sugar by Folin-Wu method.
3. Estimation of Amino acids by Ninhydrin method.
4. Estimation of Total protein by Biuret and Lowry's method.
5. Quantitative estimation of Iodine number and Acid value of oil.
6. Estimation of DNA by DPA method.
7. Estimation of RNA by Orcinol method.
8. Determination of Optimum pH and Temperature of enzyme Peroxidase extracted fromgerminating seeds.
9. Paper chromatography of Amino acids.
10. Verification of Lambert Beer's Law.
11. Gel chromatography for separation of a mixture of molecules.

AGRICULTURE MICROBIOLOGY

Credit 4
Total Marks: 100 (70+30)

Course Objectives:

1. To introduce the role of microorganisms in soil fertility, plant health, and nutrient cycling.
2. To explore microbial interactions in the rhizosphere and phyllosphere.
3. To study the role of microbes in biocontrol, biofertilizers, and sustainable agriculture.
4. To impart hands-on skills in isolating and characterizing agriculturally important microbes.
5. To understand the applications of microbial biotechnology in agriculture.

Course Outcome:

Skills that students obtain after completion of the course:

1. Explain the diversity and functions of soil and plant-associated microorganisms.
2. Describe the biochemical cycles (C, N, P, S) and the role of microbes in nutrient transformation.
3. Identify the mechanisms of plant-microbe interactions, including symbiosis and antagonism.
4. Evaluate the role of microbial inoculants such as biofertilizers and biopesticides in agriculture.
5. Demonstrate awareness of the application of microbial genomics, metagenomics, and biotechnology in precision agriculture.

MODULE I: Soil Microbiology

- Soil as a habitat for microorganisms
- Microbial groups in soil (bacteria, fungi, actinomycetes, protozoa)
- Rhizosphere and phyllosphere interactions
- Biogeochemical cycling (C, N, P, S cycles)

MODULE II: Microbial Interactions

- Symbiotic nitrogen fixation: Rhizobium, Frankia, Cyanobacteria
- Mycorrhizae and their role in plant nutrition
- Plant growth-promoting rhizobacteria (PGPR)
- Pathogen-antagonist interactions

MODULE III: Biofertilizers and Biopesticides

- Types and classification of biofertilizers
- Mass production and quality control of biofertilizers
- Biopesticides: Microbial insecticides and fungicides
- Registration and commercialization

MODULE IV: Composting and Organic Farming

- Microbial composting processes (Vermicomposting, Green composting)
- Degradation of agricultural waste
- Role of microbes in organic farming

- Microbial consortia and formulation

MODULE V: Agricultural Microbial Biotechnology

- Genetic engineering in rhizobia, PGPR
- Metagenomics in soil microbial ecology

- Genetically modified microbes for agriculture
- Bioremediation of contaminated soils

SUGGESTED READINGS:

1. **Subba Rao, N.S.** – *Soil Microbiology*
2. **Dube, H.C.** – *A Textbook of Fungi, Bacteria and Viruses*
3. **Alexander, M.** – *Introduction to Soil Microbiology*
4. **Bhattacharyya, P. & Tandon, H.L.S.** – *Biofertilizers in Agriculture*
5. **Gaur, A.C.** – *Biofertilizers and Organic Farming*
6. **Willey, Sherwood, Woolverton** – *Prescott's Microbiology*
7. **Reddy, S. M.** – *Biofertilizers*
8. **Mitra, A.** – *Bioinoculants: A Step Toward Sustainable Agriculture*

PLANT PATHOLOGY

Credit 4
Total Marks: 100 (70+30)

Course Objectives:

1. Understand the types, causes, and classification of plant diseases.
2. Identify the symptoms and causal agents (fungi, bacteria, viruses, nematodes).
3. Explain disease cycles and host-pathogen interactions.
4. Apply molecular techniques for diagnosis and control of plant diseases.
5. Evaluate integrated disease management strategies in agriculture.

Course Outcomes:

Skills that students obtain after completion of the course:

Explain the scope of plant pathology, disease classification, Koch's postulates, and disease symptoms/signs.
Identify major plant pathogens (fungi, bacteria, viruses, viroids, phytoplasma, nematodes) and their life cycles.
Analyze mechanisms of infection, pathogen factors (enzymes, toxins, effectors), and host defense responses.
Apply epidemiological concepts and forecasting models to understand disease development.
Evaluate disease management strategies, including cultural, chemical, biological methods, IDM, and resistant varieties.

MODULE I: Introduction to Plant Pathology

- Definition, history and scope.
- Classification of plant diseases.
- Koch's postulates.
- Symptoms and signs of diseases.

MODULE II: Disease Causative Agents

- Fungi, Bacteria, Viruses, Viroids, Phytoplasma, Nematodes.
- Pathogen identification and life cycles.

MODULE III: Mechanisms of Disease Development

- Infection, colonization and dissemination.
- Pathogen enzymes, toxins, and effectors.
- Host defenses: structural and biochemical.

MODULE IV: Epidemiology and Disease Forecasting

- Disease triangle and tetrahedron concepts.
- Factors influencing epidemics.
- Forecasting models and their applications.

MODULE V: Disease Management

- Cultural, chemical, biological control methods.
- Integrated Disease Management (IDM).
- Use of resistant varieties.
- Role of molecular biology and biotechnology in disease resistance.

SUGGESTED READINGS:

1. Aggrawal Ashok and Mehrotra R S. 2002. Plant Pathology. Tata Mcgraw Hill, 2nd edition. Mumbai.
2. Agrios George N. 2005. Plant Pathology, Academic Press, 5th Edition.UK.
3. Robert B. 2008. Plant Pathology: Techniques and Protocols (Methods in Molecular Biology), Humana Press.USA.
4. Gail L. Schumann and Cleora J.D' Arcy 2009.Essential Plant Pathology, 2nd Edition. American Phytopathological Society.USA.
5. Sharma P.2006. Plant Pathology, Alpha Science International Ltd. New Delhi.

RESEARCH & PUBLICATION ETHICS

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. Understand the philosophy and fundamentals of research ethics.
2. Apply ethical principles in scientific research and publication.
3. Identify unethical practices and avoid research misconduct.
4. Evaluate the credibility of journals and publishers.
5. Interpret research metrics and databases to assess publication quality.

Course Outcomes:

Skills that students obtain after completion of the course:

1. Explain the concept of ethics and philosophy in research.
2. Describe different forms of research and publication misconduct.
3. Recognize predatory journals and unethical publication practices.
4. Utilize tools for plagiarism detection and ethical publication.
5. Analyze impact metrics and databases to improve research dissemination.

MODULE I: Philosophy and Ethics

- Introduction to philosophy: definition, nature, and scope, concept, branches
- Ethics: definition, moral philosophy, nature of moral judgments and reactions

MODULE II: Scientific Conduct

- Ethics in conducting research
- Research misconduct: fabrication, falsification, plagiarism
- Conflict of interest
- Guidelines for ethical research

MODULE III: Publication Ethics

- Publication ethics: definition, importance
- Best practices/standards setting initiatives and guidelines (COPE, WAME, etc.)
- Publication misconduct: types, identification, and prevention
- Predatory publishers and journals

MODULE IV: Publication Misconduct

- Identification of publication misconduct
- Complaints and appeals
- Role of authorship and contribution
- Investigation tools (e.g., Turnitin, iThenticate)

MODULE V: Databases and Research Metrics

- Databases: Indexing databases (Scopus, Web of Science, etc.)
- Research metrics: Impact Factor, h-index, i10 index, altmetrics
- Citation databases and research visibility

SUGGESTED READINGS:

- ***Macrina, F. L.*** *(2014). Scientific Integrity: Text and Cases in Responsible Conduct of Research. ASM Press.*
- ***Resnik, D. B.*** *(2020). The Ethics of Science: An Introduction. Routledge.*
- ***Steneck, N. H.*** *(2007). ORI Introduction to the Responsible Conduct of Research. U.S. Department of Health and Human Services.*
- ***ICMR Guidelines*** *– Ethical Guidelines for Biomedical Research on Human Participants, ICMR, New Delhi.*
- ***COPE (Committee on Publication Ethics)*** *website: https://publicationethics.org/*
- ***Shamoo, A. E., & Resnik, D. B.*** *(2009). Responsible Conduct of Research. Oxford University Press.*
- *UGC E-Content on Research and Publication Ethics (Available on Swayam and UGC portals)*

SEMESTER II

MICROBIAL PHYSIOLOGY & METABOLISM

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. To understand the principles of microbial growth, factors influencing growth, and quantitative measurement methods used to study microbial populations.
2. To explore the diversity of microbial energy-yielding processes including photosynthesis, chemolithotrophy, and electron transport mechanisms.
3. To study aerobic and anaerobic pathways of carbohydrate metabolism, including respiration and fermentation, and their ecological significance.
4. To examine lipid and nucleotide metabolism, emphasizing biosynthetic and degradation pathways in microorganisms.
5. To comprehend the biosynthesis, regulation, and degradation of proteins and amino acids, highlighting metabolic integration and enzymatic control.

Course Outcome:
Skills that students obtain after completion of the course:

1. Students will be able to describe microbial growth kinetics, environmental influences, and mechanisms of nutrient uptake and transport.
2. Students will explain photosynthetic and chemolithotrophic pathways, including mechanisms of ATP generation and CO_2 fixation.
3. Students will analyze carbohydrate metabolism through aerobic and anaerobic pathways, recognizing energy conservation and redox balance in microbes.
4. Students will demonstrate understanding of lipid and nucleotide metabolic pathways and their role in microbial physiology.
5. Students will evaluate protein and amino acid metabolism, including biosynthesis, regulation, and degradation processes, in various microbial systems.

Module I

Microbial growth: mathematical expression of growth, growth measurement, efficient growth curve, synchronous growth and continuous culture, effect of environmental factors on microbial growth, nutrients diffusion, active transport, group translocation, solutes, temperature, oxygen relations.

Module II

Photosynthetic microorganisms, brief account of photosynthetic pigments, Oxygenic and anoxygenic photosynthesis, cyclic and non-cyclic photophosphorylation, fixation of CO_2 - Calvin cycle -C3 & C4 pathway. Chemolithotrophy: sulphur, iron, hydrogen, nitrogen oxidations; Methanogenesis - luminescence. Electron transport- photoautotrophic generation of ATP, reverse TCA, carbohydrate anabolism. Bioluminiscence, quorum sensing, signal transduction pathways.

Module III

Aerobic respiration, EMP, ED and HMP pathway. TCA cycle- amphibolic reactions. Glyoxalate cycle. Mechanisms of substrate – level and oxidative phosphorylation. Respiratory electron transport in mitochondria and bacteria. Anaerobic respirations: Introduction, sulphate, nitrate, carbonate respirations and their ecological significance.

ETC in some anaerobic bacteria. Catalase, SOD, Pasteur Effect. Fermentation of carbohydrates- homo

and heterolactic fermentations.

Module IV

Lipid metabolism – Biosynthesis of glycerols, phospholipids and glycolipids. Oxidation of saturated and unsaturated fatty acids. Microbial metabolism of aromatic and aliphatic hydrocarbons (camphor, 2,4–D and toulene), Nucleotide metabolism – Biosynthesis of purine and pyrimidine nucleotides-salvage and *de novo* pathways.

Module V

Protein metabolism – Assimilation of inorganic nitrogen and sulphur. Biosynthetic pathways of amino acids and their regulation with emphasis on tryptophane and histidine. Porphyrine biosynthesis; catabolism of aminoacids (transaminaton, deamination). Degradation of proteins- proteases, exo & endo peptidases.

Suggested Readings:

- Microbial Physiology and Metabolism: D.R. Caldwell.
- Microbiology: Lansing M. Prescott, John P. Harley and Donald A. Klein
- Microbiology-Essentials and applications: Larry McKane and Judy Kandel.
- Microbial Physiology: A.G. Moat and J.W. Foster.
- Microbiology: M.J. Pelczar (Jr), E.C.S. Chan and N.R. Kreig.
- Fundamental principles of Bacteriology: A. J. Salle.
- The Physiology and Biochemistry of Prokaryotes: D. White.
- Microbial Physiology: S. Ram Reddy and S. M. Reddy.
- Biochemistry: Donald Voet and Judith G. Voet.
- Biochemistry : Lubert Stryer.
- Biochemistry: G Zubay.
- Principles of Biochemistry: Lehninger, Nelson & Cox
- Harper's Review of Biochemistry: Martin, Mayer & Rodwell
- Outlines of Biochemistry: Conn, Stumpf, Bruening & Doi.

BACTERIOLOGY, MYCOLOGY & VIROLOGY

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. To impart in-depth knowledge of Bacteriology, Mycology and Virology
2. To train the students to pursue further education.
3. To be familiar with microbiological tools.
4. To increase expertise of the course.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Bacteriology, Mycology and Virology and key principles of it.
2. Awareness of the major issue at the forefront of the discipline.
3. Good quantitative skills such as the ability to accurately and reproducibly prepare reagents for experiments.
4. Ability to dissect a problem in to its key features.

Module I

Systematic study of bacteria; morphological, physiological, biochemical and serological studies; Genetic characterization, identification & classification chart; Habitat, structure, reproduction & classification of bacteria; Enterobacteriaceae and related organisms, their morphological & physiological characters, genetic interrelationship, taxonomic sub-division & their importance in human health.

Module II

Myxobacteria, cytophage group, filamentous & gliding chaemoheterotrophs & filamentous sulphur oxidizing bacteria. Gram positive spore forming bacteria; unicelluar endospore formers- *Bacillus*, *Clostridia*. Miscellaneous bacteria; lactic acid bacteria, *Micrococci*, *Corynebacteria*, *Mycobacteria*.

Module III

Fungal diversity-major taxonomic group, structure, reproduction, life cycle and significance of the following representatives: Gymnomycota: general account – cellular slime moulds (Dictyostelium), plasmodial slime moulds (Myxomycetes). Mastigomycota - Coelomomyces, Phytophthora, Plasmodiophora. Amastigomycota, Zygomyocotina - *Mucor*, *Blakeclea*, *Entomophthora*. Ascomycotina - *Emericeilla*, *Chaetomium*, *Neurospora*, *Claviceps*. Basidiomycotina - *Puccinia*, *Melamspora*, *Ustilago*, *Polyporus*, *Lycoperdon*, *Ganoderma*. Deutromycotina - *Fusarium*, *Cercospora*, *Curvularia*, *Beauveria*, *Microsporum*, *Phoma*.

Module IV

Fungi and biotechnology: production of alcoholic beverages, antibiotics, organic acids, ergot alkaloids; the cultivation of fungi for food - mushrooms, myco protein and mycofoods; Role of fungi in agriculture

and forestry - mycorrhizae and their application, mycopesticides, mycotoxins, conservation of fungal germplasm.

Module V

General virology: Methods for isolation, identification, characterization and cultivation of viruses: Methodology for isolation, adsorption, One-step growth and burst size of virus. Determination of titre value, isolation of phage resistant strain, cultivation and maintenance of plant, animal and bacterial/ cyanobacterial viruses. Identification of viruses by physical, chemical and serological techniques. Prevention, treatment and control of viral diseases. Viral vaccines including DNA vaccines and interferons. Plant viruses: Some common viral diseases of plants (TMV, CMV, leaf curl of papaya). Animal viruses: Brief account of Adeno, Herpes, Hepatitis and HIV. Prevention, treatment and control of viral diseases.

Suggested Readings:

- General Microbiology-Roger. Y. Stainer, et al. 1986; Macmillan Press Ltd., Hampshire.
- Microbiology-An introduction: Gerald. J. Tortora, Berdell R. Funke,
- Christine.L.Case, Vth edition, 1995: The Benjamin/Cummings Publishing Co. Inc., USA.
- Microbiology: Essentials and Applications: Larry McKane, Judy Kandel, 2nd edition; 1996; McGraw HillInc.
- Microbiology- Prescott, Harley, Klein, 4th edition, 1999; McGraw Hill Inc.
- Microbiology: Brock and Madigan
- Microbiology: Pelczar, Chan and Krieg
- Microbiology: Powar and Daginawala
- General Microbiology: R. Y. Ingraham
- Microbiology: Katherine Black
- Fundamental Principles of Bacteriology: A J Salle, Tata McGraw-Hill.
- Introductory Mycology: C J Alexopolus, C W Mins, M M Blackwell, 4th Edition.
- An Introduction to Fungi: H C Dubey, 4th Edition.
- Textbook of Virology: Vinod Singh.
- Introduction to Modern Virology: N J Dimmnock.

IMMUNOLOGY

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. To impart through knowledge of Immunology.
2. To train the students to pursue further education.
3. To be familiar with Immunological tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Immunology and key principles of it.
2. Awareness of the major issues at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.

MODULE I

Introduction; Cells of the Immune system; Innate and Acquired immunity; Organs and cells involved in immune system and Primary and Secondary immune response; Nature of antigens; Chemical and molecular basis of antigenecity; superantigen, Immunogenicity; Epitopes, Haptens, Adjuvant, Freund's adjuvants and its significance. Immune Responses; Theory of Clonal selection.

MODULE II

B-lymphocytes, their subpopulation and activation; Structure and function of Immunoglobulin; Antigenicdeterminants on immunoglobulin; Antigen-Antibody interactions; Antibody affinity, avidity; Agglutination; Precipitation; Idiotypic antibodies; Theories of antibody formation, hybridoma technology for monoclonal antibodies and designer monoclonal antibodies. Multiple mylomas and structural basisof antibody diversity; Antibody engineering; Generation of antibody diversity; Major Histocompatibility Complex.

MODULE III

Biology of T lymphocyte; Classification of T lymphocytes; Structure of T Cell Receptor (TCR); TCR diversity and genetics, Antigen processing and presentation; Cytokines; Cell mediated cytotoxicity: mechanism of T cell and NK cell mediated lysis; Hypersensitivity. Non-specific immune mechanism: Surface defenses, Tissue defenses, Opsonization, Inflamatory reaction, and Hormone balance. Tissue metabolites with bactericidal properties (lysozyme, nuclein, histone, protamine, basic peptides of tissues – leukins, phagocytins, lecterins, haemocompounds).

MODULE IV

Expressions and Regulation of Immune Response: Antigen processing and presentation, Generation of humoral and cell mediated immune response, Activation of B and T lymphocytes, Cytokines and their role in immune regulation, T cell regulation, MHC restriction, Immunological tolerance. Cell mediated cytotoxicity: Mechanism of T cells and NK mediated lysis, antibody dependent cell mediated cytotoxicity, and macrophage mediated cytotoxicity. Complement system, Regulation of complement activation. Transplantation immunology: MHC, Types of

grafts, Grafts rejection, GVH reactions, Mechanism of graft rejection and prevention of graft rejection.

MODULE V

Immunity and Immunoassays Defense against bacteria, viruses, fungi and parasites including Immunodiagnostics and immunotherapy. Immuno-assays: SRID, ELISA, ELISA-PCR, RIA, Western Blotting, FACS, Immunofluorescence, Flow cytometry, Immunodiffusion and Immunoelectrophoresis; Hemagglutination; Immunofluroscens and their application.

SUGGESTED READINGS:

- Immunology: Kubey
- Immunology: A short Course; Eli Benjamin, Richard Coico
- Fundamentals of Immunology: William Paul
- Essentials of Immunology (6th Edition): Ivan Riot- Blackwell Scientific Publications, Oxford, 1988.
- Antibodies- A laboratory Manual: Harlow and David Lane (1988), Old Spring harbor Laboratory.
- Immunology: Roitt, Brostoff and Male
- Immunology: C.A. Janeway and Paul Travers.
- Immunology: Weir, D.M. 1992.
- Immunological techniques: I. R. Tizard, Immunology, An Introduction, 1995, 4th edition –Saunder's.

MICROBIAL TECHNOLOGY

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. Understand microbial diversity and its technological applications.
2. Learn large-scale microbial cultivation, strain improvement, and metabolic engineering.
3. Explore the role of microbes in the development of industrial products and environmental sustainability.
4. Apply modern tools like bioreactors, omics technologies, and bioprocess modeling.
5. Gain hands-on experience with microbial product development and quality control.

Course Outcomes:

1. Explain the fundamentals of microbial biotechnology and its scope.
2. Design and operate fermentation systems for product optimization.
3. Apply strain improvement techniques and metabolic engineering principles.
4. Demonstrate knowledge of biosafety, IPR, and quality assurance in microbial industries.
5. Evaluate industrial case studies in biofuels, pharmaceuticals, agriculture, and food sectors.

Module I: Microbial Diversity and Screening

- Extremophiles, halophiles, thermophiles, acidophiles
- Screening of industrially important microbes
- Preservation and maintenance of microbial cultures
- Strain development: mutagenesis and recombinant DNA approaches

Module II: Fermentation and Bioprocess Technology

- Types of fermentation: submerged, solid-state, continuous
- Bioreactors: design, instrumentation, aeration, agitation
- Upstream and downstream processing
- Process scale-up and optimization

Module III: Microbial Products and Applications

- Production of:

  - Antibiotics (e.g., streptomycin, rifamycin)
  - Organic acids (e.g., citric acid, acetic acid)
  - Alcohols and solvents (e.g., ethanol, butanol)
  - Enzymes (e.g., proteases, cellulases)
- Microbial biosurfactants, pigments, and bioplastics

Module IV: Environmental and Agricultural Microbial Technologies

- Bioremediation and biodegradation (oil spills, plastics, heavy metals)
- Biofertilizers (Rhizobium, Azolla, phosphate solubilizers)
- Biopesticides and PGPR
- Composting and vermicomposting

Module V: Medical, Food, and Industrial Microbiology Applications

- Microbial diagnostics, vaccines, and therapeutic proteins
- Microbial enzymes in food and pharma
- Probiotics and nutraceuticals
- Biosafety, bioethics, and regulatory aspects (GMP, GLP, FDA)

SUGGESTED READINGS:

Title	Author(s)	Publisher
Industrial Microbiology	L.E. Casida	Wiley Eastern
Microbial Biotechnology	Glazer & Nikaido	Cambridge University Press
Bioprocess Engineering	Shuler & Kargi	Prentice Hall
Principles of Fermentation Technology	Stanbury, Whitaker & Hall	Pergamon Press
Environmental Microbiology	Maier, Pepper, Gerba	Academic Press
Agricultural Microbiology	Subba Rao	Oxford & IBH

LAB COURSE III

Credit 1

Total Marks: 50 (35+15)

Course Objectives:

1. To impart practical knowledge and hands-on experience
2. To train the students to pursue further education.
3. Become familiar with tools.
4. Gain experience with standard molecular tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Good quantitative skills such as the ability to accurately and reproducibly prepare reagents forexperiments.
2. Ability to dissect a problem in to its key features.
3. Ability to design experiments and understand the limitations of the experimental approach

1. Determination of growth curve and generation time.
2. Estimation of microbial enzymes-amylase, invertase, protease, celllulase, lipase,catalase and phosphatase.
3. Iodine number of fatty acids.
4. Determination of K_m and V_{max}.
5. Polyacrylamide gel electrophoresis of proteins.
6. Estimation of protein by Lowry's method.
7. Effect of different concentrations of heavy metal on bacterial growth.
8. To isolate, identify and enumerate *E. coli* and other coliforms from sewage water byusing specific agar media.
9. To determine the MPN of portable and drinking water.
10. To determine the standard growth curve of *E. coli* by spectrophotometric method.
11. To isolate and identify various phyto-pathogenic fungi from infected plants foliage.
12. To measure fungal growth on solid agar media by radial method.
13. To measure the fermentation efficiency of *Saccharomyces cerevisiae* in different carbon sources.
14. To isolate bacteriophages from different water sources and perform DALT.

LAB COURSE IV

Credit 1

Total Marks: 50 (35+15)

Course Objectives:

1. To impart practical knowledge and hands-on experience
2. To train the students to pursue further education.
3. Become familiar with tools.
4. Gain experience with standard molecular tools.

Course Outcome:

Skills that students obtain after completion of the course:

2. Good quantitative skills such as the ability to accurately and reproducibly prepare reagents for experiments.
3. Ability to dissect a problem in to its key features.
4. Ability to design experiments and understand the limitations of the experimental approach

1. Precipitation reaction: antigen-antibody interaction.
2. Agglutination reaction.
3. Radial Immunodiffusion.
4. ELISA.
5. Purification of IgG from the serum by ammonium sulphate, acetone precipitation and dialysis.
6. Estimation of acid and alkaline phosphate from serum.
7. Analysis of urine sample.
8. Antibiotic sensitivity test of blood and urine culture.
9. VDRL test.
10. HBs-AG test.
11. Estimation of Hemoglobin.
12. To isolate and identify potential industrially important microorganisms (such as *Bacillus*, *Streptomyces*, and *Aspergillus* species) from soil samples using serial dilution and selective media techniques.
13. To produce and assay industrially significant enzymes (such as amylase, cellulase, or protease) from selected microbial cultures and evaluate their activity quantitatively using standard biochemical methods.
14. To carry out small-scale fermentation using yeast (*Saccharomyces cerevisiae*) and bacteria (*Lactobacillus* spp.) for the production of ethanol and lactic acid, and to monitor fermentation parameters such as pH, biomass, and product yield.
15. To produce antibiotics from soil-derived actinomycetes (e.g., *Streptomyces* spp.) and assess their antimicrobial activity using bioassay methods (agar well diffusion or paper disc assay) against test bacterial strains.
16. To prepare biofertilizers using beneficial microorganisms (e.g., *Rhizobium*, *Azotobacter*, or *Azospirillum*) and to test their efficacy by seed germination studies and nitrogen fixation potential.
17. To demonstrate the ability of selected microorganisms to degrade hydrocarbons (oil) or pesticide residues in contaminated soil or water and to assess the degradation efficiency through qualitative and quantitative analysis.

VACCINES & ANTIBIOTICS

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To impart basic knowledge of Vaccines and Antibiotics.
2. To be familiar with different tools of Vaccines and Antibiotics
3. To train the students to pursue further education.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Vaccines and Antibiotics and key principles of it.
2. Awareness of the major issues at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.
4. Ability to design experiments and understand the limitations of the experimental approach.

Module I

Vaccines: History and Nature; Types of Vaccines with examples: Simple and Mixed Vaccines, Univalent and Polyvalent Vaccines, Inactivated vaccine, Attenuated Vaccine, Live Vector Vaccine, Recombinant Vaccines, Subunit Vaccines, Conjugate Vaccines, Peptide Vaccines, DNA Vaccines, Cell Culture Vaccine.

Module II

Preparation, Standardization and Storage of Vaccines; Multivaccine System; Principles of vaccination, passive and active immunization, immunization programs and role of WHO in immunization programs.

Module III

Hybridoma Technology: Theory; Monoclonal antibodies, Production and applications; Monoclonal Antibodies as Vaccines.

Module IV

Historical background of Antibiotics; Classification of antibiotics: On the basis of Source, Mode of Action and Chemical structure with examples; Antibiotic resistance; Toxicity of antibiotics.

Module V

Broad Spectrum antibiotics: General Structure and Mode of action of Streptomycin, Penicillin, Tetracycline, Chloramphenicol, Quinolone, Sulfonamide, Fusidic acids; Applications of antibiotics.

Suggested Readings:

1. An instruction to industrial Microbiology by Dr. P. K. Sivakumaar, Dr. M. M. Joe, Dr. K. Sukesh.
2. Biotechnology, by Mohan P. Arora.
3. Medical Microbiology and Immunology by Warren Levinson and Ernest Jawetz.
4. Biotechnology by Wufl Crueger and Anneliese Crueger.
5. Microbiology: Principles and Explorations by Jacquelyn G. Black.
6. Microbiology by Prescott, Harley and Klein.
7. Medicinal Chemistry by Ashutosh Kar.

MICROBIAL NANOTECHNOLOGY

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To introduce the concept of nanotechnology in relation to microbes.
2. To explore microbial synthesis of nanoparticles and their applications.
3. To understand characterization techniques and biosafety issues related to nanomaterials

Course Outcomes:

Skills that students obtain after completion of the course:

1. Understand core concepts and principles of microbial nanotechnology
2. Describe mechanisms of nanoparticle synthesis by microorganisms
3. Analyze and interpret nanomaterial characterization data
4. Apply knowledge to design microbial nano-systems for real-world applications
5. Evaluate biosafety, environmental impact, and ethical issues of nanomaterials

MODULE I: Introduction to Nanotechnology

- Definition, scope, and historical background
- Types of nanomaterials: carbon-based, metal-based, polymers, composites
- Properties of nanoparticles: optical, electrical, catalytic, magnetic
- Applications in agriculture, medicine, environment, and industry

MODULE II: Microbial Synthesis of Nanoparticles

- Mechanisms of nanoparticle synthesis by bacteria, fungi, actinomycetes, algae
- Intracellular vs extracellular synthesis
- Factors influencing microbial nanoparticle synthesis (pH, temperature, substrate, etc.)

MODULE III: Characterization of Nanomaterials

- Techniques: UV-Vis spectroscopy, FTIR, XRD, TEM, SEM, AFM, DLS, Zeta potential
- Interpretation and significance of data
- Surface functionalization and stability

MODULE IV: Applications in Microbiology and Biotechnology

- Antimicrobial and antiviral nanomaterials
- Nanobiosensors and diagnostics
- Nano-based drug delivery systems
- Environmental remediation using microbial nanomaterials

MODULE V: Biosafety, Toxicity, and Regulatory Issues

- Ecotoxicology and biocompatibility
- Risk assessment and ethical concerns
- Guidelines from regulatory agencies (e.g., EPA, FDA, CPCB)

SUGGESTED READINGS:

1. **Khan, I., Saeed, K., & Khan, I. (2019).** Nanoparticles: Properties, applications and toxicities. *Arabian Journal of Chemistry.*
2. **Klabunde, K.J. & Richards, R.M. (2009).** *Nanoscale Materials in Chemistry.* Wiley.
3. **Ahmed, S. et al. (2016).** Green synthesis of silver nanoparticles using Azadirachta indica aqueous leaf extract. *Journal of Radiation Research and Applied Sciences.*
4. **Bhushan, B. (2017).** *Springer Handbook of Nanotechnology.*
5. **Sastry, M., Mayya, K.S. & Bandyopadhyay, K. (2005).** *Nanoscience and Nanotechnology: Perspectives and Emerging Directions.*
6. **Rai, M. & Duran, N. (2011).** *Metal Nanoparticles in Microbiology.* Springer.

ON JOB TRAINING (OJT)/INTERNSHIP/PROJECT

Credit 4

Total Marks: 100 (70+30)

SEMESTER III

MEDICAL MICROBIOLOGY

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. To impart basic knowledge of Medical Microbiology.
2. To train the students to pursue further education.
3. To be familiar with Medical Microbiology tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Medical Microbiology and key principles of it.
2. Awareness of the major issues at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.
4. Ability to design experiments and understand the limitations of the experimental approach.

Module I

Early discovery of pathogenic microorganisms; scopes and development of bacteriology as scientific discipline; contributions made by eminent scientists. Classification of medically important micro organisms; Normal microbial flora of human body; role of the resident flora; normal flora and the human host.

Module II

Establishment, spreading, tissue damage and anti-phagocytic factors; mechanisms of bacterial adhesion,colonization and invasion of mucous membranes of respiratory, enteric and urino-genital tracts. Role of aggressins, depolymerising enzymes, organotropisms, variation and virulence. Organs and cells involved in immune system and immune response.

Module III

Classification of pathogenic bacteria *Staphylococcus, Streptococcus, Pneumococcus, Neisseria, Corynebacterium, Bacillus, Clostridium*, Non sporing Anaerobes, Organisms belonging to Enterobacteriaceae, Vibrios, Non fermenting gram negative bacilli *Yersinia; Haemophilus; Bordetella, Brucella; Mycobacteria, Spirocheates, Anctimycetes; Rickettsiae, Chlamdiae*.

Module IV

General properties of Viruses; Viruses host interactions; Pox viruses; Herpes virus, Adeno viruses; Picarno viruses; Orthomyxo viruses; Paramyxo viruse; Arboviruses; Rhabdoviruses, Hepatitis viruses; Oncogenic viruses; Human Immuno deficiency viruses. Dermatophytes, dimorphic fungi, Opportunistic fungal pathogens. Description and classification of pathogenic fungi and their laboratory diagnosis.

Module V

Laboratory control of antimicrobial therapy; various methods of drug susceptibility testing, antibiotic assay in body fluids. Brief account on available vaccines and schedules; passive prophylactic measures; Nosocomial infection, common types of hospital infections and their diagnosis and control.

SUGGESTED READINGS:

- A text book of Medical Parasitology: Jayaram Panicker
- A text book of Microbiology: Chakraborty
- Medical Microbiology Vol. I and II: Mackie and Mc Carthy
- A text book of Microbiology: R. Ananthnarayanan
- Text book of immunology by Kubey

MICROBIAL GENETICS

Credit 3

Total Marks: 100 (70+30)

Course Objectives:

1. To impart basic knowledge of Microbial Genetics.
2. To train the students to pursue further education.
3. To be familiar with Genetics tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Microbial Genetics and key principles of it.
2. Awareness of the major issues at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.
4. Ability to design experiments and understand the limitations of the experimental approach.

Module I

Bacterial plasmids: structure and properties, types -Fertility factors, drug resistance plasmids, Col Plasmids Ti plasmids, and other types of plasmids, detection, purification and transfer of plasmid DNA,*In vitro* plasmid transfer, plasmid- replication, amplification and incompatibility.

Transposition: Discovery, structure and types of bacterial transposons, mechanism of transposition, spread of antibiotic resistance.

Module II

Bacterial Transformation: Discovery, Biology of transformation, Molecular mechanism of transformation, mapping by transformation, transformation in nature. Bacterial conjugation: F Factor, Hfr Transfer, Gene mapping, artificially induced competence, Transduction: Generalized and specialized transduction.

Module III

Phage Biology: General properties of phage, structure of phage, lytic and lysogenic cycle, Counting phage, properties of phage infected bacterial culture, specificity in phage infection, host restriction and modification.

Module IV

Mutation: Biochemical basis of mutation, Silent mutation, spontaneous mutations, Induced mutation, physical and chemical mutagens, base pair substitution and frame shift mutation; reversion, detection ofmutagens and carcinogens (Ames test).

DNA damage and repair: Biological indications of DNA damage, UV radiation and thymine dimmer, photoreactivation, Dark repair, Excision repair, Recombinational repair and SOS repair.

Module V

Genetic Engineering: Introduction, vectors, restriction enzymes, cloning of restriction fragments, , DNA ligase, insertion of DNA in to vector, cDNA library and genomic library, detection of recombinant molecules, Applications of genetic engineering: Restriction mapping, site directed mutagenesis, production of proteins from cloned genes, and some other applications.

Suggested Readings:

- Text book of Microbiology: Pelczar, Creig and Chan
- Text book of Microbiology: Pawar and Daginwalla. Vol I & II
- General Microbiology: Stanier *et al*.,
- Microbial genetics: Maylor, Cronan and Freifelder
- Microbiology: Presscott *et al*.,
- Microbiology: Talaro & Talaro

LAB COURSE V

Credit 1

Total Marks: 50 (35+15)

Course Objectives:

1. To impart practical knowledge.
2. To train the students to pursue further education.
3. Become familiar with microbiological tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Good quantitative skills such as the ability to accurately and reproducibly prepare reagents for experiments.
2. Ability to dissect a problem in to its key features.
3. Ability to design experiments and understand the limitations of the experimental approach.

1. Demonstration of Bacterial flora of skin.
2. Demonstration of catalase test by bacterial flora of skin.
3. Isolation and Gram staining of Microbial flora of mouth-teeth crevices.
4. Staining techniques – Acid Fast staining, Capsular staining
5. Microorganisms and examination of upper respiratory tract (throat).
6. Isolation and examination of dermatophytes from skin.
7. Primary isolation and examination of enteric pathogens.
8. Immuno diagnosis - ELISA tests
9. Widal test to determine the presence of *Salmonella* infection.
10. Slide agglutination reaction: Blood group determination.
11. Slide agglutination reaction: Rh factor determination.
12. VDRL test/ RPR serological test for syphilis.
13. HBs-Ag test.

LAB COURSE VI

Credit 1

Total Marks: 50 (35+15)

Course Objectives:

1. To impart practical knowledge.
2. To train the students to pursue further education.
3. Become familiar with microbiological tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Good quantitative skills such as the ability to accurately and reproducibly prepare reagents for experiments.
2. Ability to dissect a problem in to its key features.
3. Ability to design experiments and understand the limitations of the experimental approach.

1. Isolation of Genomic DNA from Bacteria species
2. Isolation of Plasmid DNA.
3. Molecular size determination of DNA.
4. Restriction digestion and ligation of DNA.

GENERAL PARASITOLOGY

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To impart basic knowledge of General Parasitology.
2. To train the students to pursue further education.
3. To be familiar with parasitological tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of General Parasitology and key principles of it.
2. Awareness of the major issue at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.

Module I:

General introduction to parasitology, Definition of terminology, Taxonomy and classification, History and scope, major discoveries, Host and parasite interaction, mechanism of disease produce or cause by parasites, immunity in parasitic infections.

Module II:

Taxonomy of protozoa, classification of pathogenic protozoa, Amoebae, life cycle of *Entamoeba histolytica*, other *Entamoeba* species (comparative study), (*Naegleria fowleri* and *Acanthamoeba*), characteristic feature, laboratory diagnosis, serological investigation. Endolimax (*E. nana*).

Module III:

Mastigophora: *Giardia lamblia, Giardia intestinalis, Trichomonasvaginalis, Trichomonashominis, Enteromonas, Trypanosomabrucei*, *Trypanosomacruzi* and Other intestinal flagellates (comparative study) Leishmania I: Introduction and classification; coetaneous leishmaniasis, visceral leishmaniasis; Status of Leishmaniasis in India.

Module IV:

Sporozoa: Pasmodium (*P. vivax, P. falciparum, P. malariae, P. ovale*), Isospora, Cryptosporidium, Toxoplasma, Babesia. Ciliophora: *Balantidium coli*. Helminths: General features and classification. Intestinal Nematodes, Cestodes (Tapeworms): General features, Intestinal Cestodes. Introduction and classification of trematodes.

Module V:

Laboratory diagnosis of Parasitic Diseases: Examination of faeces, blood, tissue, other specimens, immunodiagnosis. Antiparasitic agents: Antiprotozoan agents, intestinal protozoa, Trypanosomes, Leshmania, Malaria, Toxoplasma, Antibacterial antiparasitic agents

SUGGESTED READINGS:

1. Paniker's Book of Parasitology, 7th edition by C.K. Jayaram Paniker and Sougata Ghosh, Jaypeebrothers Medical Publishers (P) Ltd. New Delhi, India.

2. Parasitology (Protozoology and Healminthology), 13th edition by K.D. Chatterjee, EKTA PublishingHouse, Kathmandu, Nepal.
3. Text Book of Medical Parasitology 6th edition by C.K. Jayaram Paniker, Jaypee brothers MedicalPublishers (P) Ltd. New Delhi, India.
4. Parasitology for Medical and Clinical Laboratory Professionals by John W. Ridley.
5. Advance in Parasitology by Das Gupta
6. The Short Textbook of Medical Microbiology (Including Parasitology), 10th edition by Satish Gupte,Jaypee brothers Medical Publishers (P) Ltd. New Delhi, India
7. Veterinary Parasitology by Hany Elsheikha, Jon S Patterson, CRC Press, Taylor & Francis Group

GENERAL PATHOLOGY

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To impart basic knowledge of General Pathology.
2. To train the students to pursue further education.
3. To be familiar with pathological tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of General Pathology and key principles of it.
2. Awareness of the major issue at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.

Module I

Introduction, history and scope of pathology. Definitions. Etiology of the disease. Predisposing factors, intrinsic and extrinsic factors responsible for the disease. Physical agents, mechanical injuries. Heat, coldand decreased atmospheric pressure, light (photosensitization) UV light, microwaves, electricity, chemical agentsexogenous chemicals (toxin, poisons, drugs and food substances), endogenous chemicals (metabolites, cytolytic or inhibitory immune complexes, free radicles, oxidants)

Module II

Immunopathology Immunopathology – anibody and cells, immuno-competence of foetus and new-born. Immune mediated tissue injury, hypersensitivity reactions- anaphylaxis, Arthus reaction, cyototoxic antibody reaction, immune complex disease, delayed hypersensitivity to chemicals, immuno-deficiency diseases, defective immunocompetence, autoimmune diseases.

Module III

Inflammation – definitions associated with inflammatory phenomenon, etiology of inflammation, cardinal signs, pathogenesis of inflammation, chemical mediators released from injured tissues and inflammatory cells. Cellular reponse in inflammation, structure and functions of cells associated with inflammation. Role of humoral and cell mediated defenses. Various classifications of inflammation. Healing, cellular regeneration capability of different body cells.

Module IV

Cellular Adaptations of Growth and Differentiation: Hyperplasia, Hypertrophy, Atrophy, Metaplasia. Cell Injury and Cell Death: Necrosis, Apoptosis, Acute and Chronic Inflammation. Tissue Regeneration and Repair, Role of cells (macrophages, fibroblasts, myofibroblasts, endothelial cells), extracellular matrix components and growth factors in healing.

Module V

Common Infectious Diseases Categories of Infectious Agents: Viruses, Bacteria, Fungi, Protozoa Helminths. Environmental and Nutritional Diseases. Industrial and Agricultural Exposures, Effects of Tobacco and Alcohol. Adverse Drug Reactions: Drug Abuse, Poisoning, Radiation Injury.

Nutritional Deficiencies: Vitamins, Minerals • Obesity

SUGGESTED READINGS:

- Histology for Pathologists. Stephen S. Sternberg (Ed), Raven Press, New York.
- General Pathology JB Walter, MS Israel. Churchill Livingstone, Edinburgh
- Robbin's Pathologic Basis of Disease Ramzi S.Cotran, Vinay Kumar, Stanley L Robbins WB SaundersCo., Philadelphia.
- Pathology Emanuel Rubin, John L Farber. JB Lippincott Co., Philadelphia
- Anderson's Pathology. John M Kissane (Ed). The CV Mosby Co., St. LouisMicrobiology: KatherineBlack
- Fundamental Principles of Bacteriology: A J Salle, Tata McGraw-Hill.
- Textbook of Virology: Vinod Singh.
- Diagnostic Surgical Pathology. Stephen S Sternberg. Lippincott, William Wilkins. Philadelphia
- Systemic Pathology. W St. C Symmers (Series Ed) Churchill Livingstone, Edinburgh

ENVIRONMENTAL MICROBIOLOGY

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To impart in-depth knowledge related to environmental microbiology
2. Become familiar with the environment.
3. To train the students to pursue further education.
4. Gain experience with standard tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of environmental microbiology and key principles of its.
2. Awareness of the major issue at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.

Module I

Definition and scope of environmental microbiology. Aero microbiology: Microorganisms in air, nature of bioaerosols, their fate and transport, extramural aerobiology: Agriculture, waste disposal, intramural aerobiology: buildings, spaceflight, hospitals and labs.

Module II

Microbes in soil and subsurface, surface and deep soil environments, microbes as the source of clean energy. Interaction among soil microorganisms: natural; positive; negative association, Biogeochemical cycling: carbon, nitrogen and sulfur cycle.

Module III

Microbes in aquatic and extreme environments. Techniques for the study of aquatic microorganisms. Fresh water, brackish water, marine water and subterranean, thermophiles, barophiles, acidophiles, alkalophiles, psychrophiles. Role and importance of aquatic microbial ecosystem.

Module IV

Microorganisms in removal of organic and metal pollutants, biodegradation, bioremediation, bioaugmentation. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industry. Microbiology of degradation of xenobiotics in environment; decay behavior and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, Surfactants and pesticides.

Module V

Microbiology of domestic water and waste water: Water purification; bacteriological techniques, Waste water treatment methods including oxidation ponds, treatment of solid wastes, concept of indicator organism, BOD, COD, activated sludge process, composting, Bioremedation of contaminated oil and waste land.

SUGGESTED READINGS:

- Comprehensive Biotechnology (Vol. 1-4): M.Y. Young (Eds.), Pergamon Press, Oxford.

- Environmental Microbiology: W.D. Grant & P.E. Long, Blakie, Glassgow and London.
- Bio-treatment Systems, Vol. 22, D. L. Wise (Ed.), CRC Press, INC.
- Standard Methods for the Examination of Water and Waste Water (14th Education),1985. American Public health Association
- Alan and Scragg, 1999, Environmental Biotechnology. Pearson Education Ltd.England.
- S. N. Jogdand, 1995, Environmental Biotechnology Himlaya Publishing House Bombay.
- Waste Water Engineering – Treatment, Disposal and reuse. Metcalf and Eddy, Inc.,
- TATA McGraw Hill, New Delhi.
- A. K. De, Environmental Chemistry Willey Eastern Ltd. New Delhi.

INDUSTRIAL MICROBIOLOGY

Credit 4

Total Marks: 100 (70+30)

Course Objectives:

1. To impart in-depth knowledge of Industrial Microbiology.
2. To train the students to pursue further education.
3. To be familiar with industrial microbiology tools.
4. To gain experience of standard molecular tools.

Course Outcome:

Skills that students obtain after completion of the course:

1. Understanding of the fundamentals of Industrial Microbiology and key principles of it.
2. Awareness of the major issues at the forefront of the discipline.
3. Ability to dissect a problem in to its key features.
4. Ability to design experiments and understand the limitations of the experimental approach.

Module I

Introduction to industrial microbiology. Definition, scope, history, microorganisms, properties and industrial products. Screening for microbes of industrial importance. Primary screening, screening for amylase, organic acid, antibiotic, amino acid and vitamin producing microorganisms. Secondary screening. Further evaluation of primary isolates.

Module II

Detection and assay of fermentation products. Physico-chemical methods and biological assays. Fermentation equipment and its use. Design of fermentor, types of fermentor, agitation, aeration, antifoam, pH and temperature control.

Module III

Inoculum media, inoculum preparation. Raw materials: Saccharides, starchy and cellulosic materials. Fermentation media and sterilization. Types of fermentations processes: Solid state, surface and submerged fermentations.

Module IV

Batch, fed batch and continuous fermentations. Direct, dual or multiple fermentations. Scale up of fermentations. Product recovery methods. Fermentation type reactions: alcoholic, lactic acid, mixed acid, propionic acid, butandiol and acetone-butanol types.

Module V

Strain development strategies. Environmental factors and genetic factors for improvement. Immobilization methods: Absorption, covalent linkage, entrapment and cross linkage, types of carriers, advantage and disadvantages.

SUGGESTED READINGS:

- Industrial Microbiology: Casida, L E.

- Industrial Microbiology: Patel, A. H.
- Industrial Microbiology: Miller, B. M. and Litsky.
- Industrial Microbiology: Prescott and Dunn.
- Microbial Technology: Peppler, J. H. and Perlman, D.
- Biochemistry of Industrial Microorganisms: Rainbow and Rose
- Economic Microbiology Vol. I-V: Rose.
- Microbial Enzymes and Biotechnology: Fogarty W. M. and Kelly, C. T.
- Comprehensive Biotechnology All volumes Ed. Murray Moo-Yong.
- Biotechnology (A text book of industrial Microbiology) Ed. Cruger & Cruger.
- Advances in Applied Microbiology Ed. Perlman Series of volumes.

RESEARCH PROJECT & PROPOSAL WRITING

Credit 6

Total Marks: 150 (105+45)

Course objectives:

1. Understand principles of scientific research.
2. Equip life science students with skills to design and implement biological research.
3. Enhance scientific writing skills, especially for thesis and funding proposals**.**
4. Design experimental or observational studies suitable for life science research.
5. Write a structured research proposal aligned with life science standards.

Course outcomes:

Skills that students obtain after completion of the course:

1. Define and explain research concepts specific to life sciences.
2. Formulate testable hypotheses and objectives for biological research.
3. Conduct systematic literature reviews using biological databases.
4. Develop laboratory or field-based data collection methods and protocols.
5. Apply appropriate statistical and bioinformatics tools for biological data analysis

MODULE I

Introduction to Life Science Research: Nature and purpose of biological research, Types of life science research: experimental, observational, field-based, molecular, etc., Scientific method in biological contexts, Research ethics: animal care, human samples, informed consent, biosafety, institutional review boards (IRBs)

MODULE II

Research Problem and Hypothesis Formulation: Identifying gaps in life science research, Researchable questions in biology, biotechnology, ecology, etc., Writing SMART objectives, Formulating null and alternative hypotheses.

Literature Review and Information Management: Accessing life sciences databases: PubMed, Scopus, Web of Science, AGRIS, Reading and synthesizing scientific articles, Critical evaluation of scientific evidence, Writing an annotated bibliography, Referencing tools: Zotero, Mendeley, EndNote, Use of AI and digital tools responsibly in literature review.

MODULE III

Experimental Design and Methodology: Experimental vs observational designs in biology, Designing in-vitro, in-vivo, or field experiments, Controls and replication in biological studies, Sampling methods in biodiversity, ecology, microbiology, Data collection tools: lab protocols, field logs, observation sheets, Pilot studies and protocol standardization, Risk assessment and biosafety level (BSL) protocols.

MODULE IV

Writing a Research Proposal: Key sections of a biological research proposal- Background and rationale, Objectives and hypotheses, Experimental/field methodology, Materials, methods, and instrumentation, Ethical considerations and regulatory approvals, Budgeting: lab supplies, fieldwork, sequencing, travel, Work plan (Gantt chart). Review and critique of published proposals (e.g., DBT, DST, CSIR templates). Writing executive summaries and abstracts.

MODULE V

Writing the Project Report: Structure of a biological research thesis/project- Abstract, Introduction, Materials & Methods, Results, Discussion, Conclusion. Presenting data with figures and tables. Writing effective figure legends and captions. Common writing errors in biological sciences. Plagiarism detection and referencing styles (e.g., Harvard, APA, Vancouver). Formatting and submission guidelines.

SUGGESTED READINGS:

1. Booth, W. C., Colomb, G. G., & Williams, J. M. (2016). *The craft of research* (4th ed.). University of Chicago Press.
2. Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications.
3. Day, R. A., & Gastel, B. (2012). *How to write and publish a scientific paper* (7th ed.). Cambridge University Press.
4. Kothari, C. R. (2004). *Research methodology: Methods and techniques* (2nd ed.). New Age International.
5. Kumar, R. (2022). *Research methodology: A step-by-step guide for beginners* (6th ed.). SAGE Publications.
6. Punch, K. F. (2006). *Developing effective research proposals* (2nd ed.). SAGE Publications.
7. Turabian, K. L., Booth, W. C., Colomb, G. G., & Williams, J. M. (2018). *A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers* (9th ed.). University of Chicago Press.
8. Singh, Y. K. (2006). *Fundamental of research methodology and statistics*. New Age International.
9. Singh, Y. K. (2006). *Fundamental of research methodology and statistics*. New Age International.

SEMESTER IV

DISSERTATION

Credit: 22
Total Marks: 650 (550+50+50)

(A) : Dissertation work and Thesis Writing
Topic will be based on the major elective opted by students. Project will include laboratory/field-based work followed by submission of report and presentation.

(B) : Dissertation Seminar
Students are required to deliver a seminar on a current topic related to the subject and to be evaluated by a panel of examiners.

(C) : Viva -Voce