

M.Sc. MICROBIOLOGY SYLLABUS  
DDU GORAKHPUR UNIVERSITY, GORAKHPUR

SEMESTER-I

<u>Theory paper</u>	Marks
Paper 1: General Microbiology and Bacteriology	50
Paper 2: Virology	50
Paper 3: Microbial Physiology and Biochemistry	50
Paper 4: Biostatistics and Instrumentation	50
Practical	100
Practical based on paper 1 to 4.	

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**PAPER 1: GENERAL MICROBIOLOGY AND BACTERIOLOGY**

UNIT 1

Historical development of Microbiology and its Scope. Brief account of organization and classification. History of bacterial classification. Basis of classification, Haeckel's three kingdom concept, Whittaker's five kingdom concept, Bergey's manual of determinative bacteriology.

UNIT 2

Overview of bacterial cell structure (size, shape, arrangement of membrane and cell wall), cytoplasmic inclusions, mesosomes, flagella and motility, slime, capsule, pili, chemotaxis and endospore. Bacterial chromosome, nucleoid, plasmid (types and function). Reproduction and Recombination in bacteria.

UNIT 3

Microbial growth and life cycle of bacteria. Population growth and its measurement, effect of environmental conditions on growth (pH, temperature, aeration). Continuous and batch culture, diauxic synchronous growth cultures and anaerobic cultures.

UNIT 4

Control of growth of Microbes: Sterilization, disinfection, antiseptic, sanitizer, germicide, antimicrobial agent, physical methods of sterilization- dry-heat, moist-heat, filtration, radiation, chemical controls- dye alcohols, alkali, halogen, heavy metals, formaldehyde, phenols its derivatives, ethylene oxide, detergents.

**PAPER 2: VIROLOGY**

UNIT 1

General characteristics of viruses, Nomenclature and classification, morphology, ultrastructure, capsid and classification, morphology, ultrastructure, capsid and its arrangement, types of envelopes and its composition, viral genome, its type and structure. Viroids, virusoids, cyanophages and mycoviruses. Prions and its diseases.

UNIT 2

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Bacteriophages: structural organization, multiplication cycle, eclipse phase, phage production, burst size, lytic and lysogenic cycle with special reference to T4, QX174 and M13 phage. Bacteriophage typing, application in bacterial genetics and uses.

UNIT 3

Plant viruses and Animal viruses: classification and nomenclature, disease symptoms, histology, physiology and cytology of plants. Diagnostic techniques and transmission of plant viruses.

Animal viruses: ICTV (International Committee on Taxonomy of Viruses). Baltimore system of classification, families of animal viruses, Human viruses, life cycle, pathogenicity, diagnosis and treatment of viruses eg- RNA viruses and DNA viruses.

UNIT 4

General methods of viral diagnosis and serology- cultivation of viruses in embryonated eggs, cell culture cell lines, serological methods- haemagglutination, complement fixation, assay of viruses, physical and chemical methods (protein, nucleic acid and radioactive tracer, infectivity assay (plaque method, end point method))

**PAPER 3: MICROBIAL PHYSIOLOGY AND BIOCHEMISTRY**

UNIT 1

Nutrition and Metabolism: Concepts and nutritional categories. Transport of nutrients (diffusion, active transport, group translocation). Introduction to oxidative and substrate level phosphorylations, brief account of metabolism of carbohydrates, EMP, ED, TCA and glyoxylate cycles.

UNIT 2

Amino acids, classification, chemical reaction, physical properties, primary, secondary, tertiary and quaternary structure of enzyme, inhibition, mechanism of action. Enzyme kinetics, allosteric enzymes and its kinetic analysis and regulation.

UNIT 3

Bacterial photosynthesis: type of photosynthesizing bacteria and their characteristic features, photosynthetic pigments, metabolism in photosynthetic bacteria, photosynthetic electron transport system; Dark reaction (Calvin Benson cycle), chemolithotrophy (energy from oxidation of inorganic electron donors), Hydrogen

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oxidizing bacteria, sulfur bacteria, Iron oxidizing bacteria, Ammonium and Nitrate oxidizing bacteria

#### UNIT 4

Fat and phospholipid hydrolysis: Hydrocarbon transformation (Aliphatic/ Aromatic) Nitrogen fixation; Nitrogenase physiology and genetics, physiological difference in nitrogen fixing cells, free living, symbiotic and associative symbiotic organisms.

### **PAPER 4: BIOSTATISTICS AND INSTRUMENTATION**

#### UNIT 1

Basic protocols of Microbiology lab. Types of cultures, sterilization and culture techniques. Techniques for purifying cultures. Culture preservation and maintenance. Brief principle and working of major instruments used in Microbiology.

#### UNIT 2

Microscopy; Principles and application in microbiology, brightfield microscopy, dark field microscopy fluorescence and immune fluorescence microscopy, phase contrast, electron (SEM & TEM) microscopy. Staining for microscopy.

#### UNIT 3

Diagnostic tools in bacteriology- Biochemical techniques, serological (ELISA, Dot Blot) based techniques, molecular tools used for microbial diagnostics. Uses in academic industrial, pathological and medical fields.

#### UNIT 4

Definition of statistics, population, sampling. Interval data construction of histogram and its interpretation, mean, median, mode and standard deviation, comparisons of means of variances.

Analysis of variance: analysis of co-variance; Introduction, procedure and tests, multiple comparisons, correlation and regression and line fitting through graph points; curves; correlation, linear regression, statistical basis of biological assays: Response-Dose metameter. Delusion assays, Direct and Indirect assays. Quantal Responses probit, logit, LD<sub>50</sub>, ED<sub>50</sub>, PD<sub>50</sub>- standard line interpolation assay, parallel line assay (4 point, 6 point assays), slope ratio assay.

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SEMESTER II

<u>Theory paper</u>	Marks
Paper 1: Molecular Biology and Genetic Engineering	50
Paper 2: Immunology and Cellular Microbiology	50
Paper 3: Medical and diagnostic Microbiology	50
Paper 4: Food and Pharmaceutical Microbiology	50
Practical 1- Practical based on paper 1 – 4	100

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**PAPER 1: MOLECULAR BIOLOGY AND GENETIC ENGINEERING**

UNIT 1

Organization of DNA in eukaryotic cell; functions, replication, DNA damage and repair. Structure and types of RNA, tRNA, superhelicity in DNA, modern concept of torsion angles in DNA, enzymes involved in DNA replication. Molecular mechanism of recombination, proteins involved, transposons; types and mechanism of transposition. Recombination in Bacteria and its uses.

UNIT 2

Transcription: chain initiation, chain elongation, chain termination, RNA turnover, Translation- charging of tRNA, initiation of polypeptide synthesis, elongation of polypeptide chain, translocation, termination of polypeptide chain. Salient features of gene expression and lac and trp operon.

UNIT 3

Molecular cloning- Techniques, types of vectors ex., plasmids, phages, cosmids, phagemids, Ti plasmids, other viral vectors; used for construction of library, artificial chromosomes; BAC vectors, YAC vectors, cloning and selection of individual genes; gene libraries, cDNA and genomic libraries.

UNIT 4

PCR- principle variations and applications, sequencing of DNA and protein in brief. Recombinant products.

**PAPER 2: IMMUNOLOGY AND CELLULAR MICROBIOLOGY**

UNIT 1

Types of immunity, innate, adaptive. Features of immune response memory, specificity and recognition of self and non-self. Lymphoid cells, heterogeneity of lymphoid cells, T cells, Null cells, monocytes, polymorphs, primary and secondary lymphoid organs. HLA tissue typing, MHA: Immuno-diffusion immunoelectrophoretic technique, ELISA and its types.

UNIT 2

Humoral and cell mediated immunity. Antigen antibody interaction. Antigens and antibodies: structure and properties, haptens, adjuvants, antigen specificity. T cell subsets and surface markers, T-dependent and T-independent antigens, recognition of antigens by T cell and role of MHC, structure of T-cell antigen receptors, TCR, BCR.

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UNIT 3

Complement pathways, Hypersensitivity- anaphylaxis, cytotoxic reaction. Auto immunity, transplantation immunology and tumor immunology. Immunological disorders, etiology, diagnostics, prognosis and prophylactic aspects. AIDS.

UNIT 4

Cell signalling mechanism: Eukaryotic cell to cell signalling, prokaryotic signalling, signal transduction pathway, cell- cell interaction, bacterial adherence, effect of adherence on bacteria, effect of adhesion on host cells, mechanism of bacterial invasion on host cells, consequences of Invasion, survival after invasion.

**PAPER 3: MEDICAL AND DIAGNOSTIC MICROBIOLOGY**

UNIT 1

Early discovery of pathogenic microorganisms, development of bacteriology as scientific discipline. Contributions made by eminent scientists. Classification of medically important microorganisms. Normal microflora of human body, role of resident flora, normal flora and the human host. Epidemiology: Disease cycle (sources of disease, reservoirs and carriers). Transmission of pathogens, route of infection. Primary and secondary infections, epidemic, endemic, pandemic.

UNIT 2

Establishment, spreading, tissue damage and antiphagocytic factors. Mechanism of bacterial adhesion, colonization and invasion of mucous membranes of respiratory, enteric and urogenital tracts. Role of adhesins, depolymerising enzymes, organotropisms, variation and virulence. Organs and cells involved in the immune system and immune response.

UNIT 3

Classification of pathogenic bacteria *Staphylococcus*, *Streptococcus*, *Pneumococcus*, *Neisseria*, *Corynebacterium*, *Bacillus*, *Clostridium*, non sporing anaerobes, organism belonging to Enterobacteriaceae, *Vibrio*, non fermenting Gram negative bacilli, *Yersinia*, *Hemophilus*, *Bordetella*, *Brucella*, *Mycobacterium*, Spirochaetes, Actinomycetes, *Rickettsiae*, *Chlamydiae*.

UNIT 4

Fungal diseases- Dematophytes, opportunistic fungal infections. Protozoal infection: *Plasmodium*, *Trypanosoma*, *Entamoeba*, *Balantidium*, *Pneumocystis*. Laboratory control of antimicrobial therapy- various methods of drug susceptibility testing, acting

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of antibiotics and drug resistance, antibiotic assay in body fluids. Brief account on available vaccines and schedules, passive prophylactic measures. Nosocomial infections, common types of hospital infections and their diagnosis and control. Clinical features, laboratory diagnosis, treatment and prevention of: Cholera, diphtheria and DPT vaccination, Tuberculosis DOT treatment, MDR tuberculosis pneumonia, Typhoid, Hepatitis: type of hepatitis, vaccine schedule of hepatitis and AIDS. Control of communicable diseases.

#### **PAPER 4: FOOD AND PHARMACEUTICAL MICROBIOLOGY**

##### UNIT 1

Food as substrate for microorganisms: Microorganisms important in food microbiology. Principles of food preservation. Asepsis- Removal of microorganisms, (anaerobic conditions, high temperatures, low temperatures, drying). Factors influencing microbial growth- Extrinsic and intrinsic factors. Chemical preservatives and food additives. Canning, processing for Heat treatment- D% and F values and working out treatment parameters.

##### UNIT 2

Contamination and spoilage: Cereals, sugar products, vegetables, fruits, meat and meat products. Milk and milk products. Fish and sea products. Poultry- spoilage of canned foods. Detection of spoilage and characterization. Food borne infections and intoxications: Bacterial and non bacterial with examples of infective and toxic types- *Brucella*, *Bacillus*, *Clostridium*, *Escherichia*, *Salmonella*, *Shigella*, *Staphylococcus*, *Vibrio*, *Yersinia*, Nematodes, protozoa, algae, fungi and viruses.

##### UNIT 3

Food fermentations: bread, cheese, vinegar, fermented vegetables, fermented dairy products. Experimental and industrial production methods. Food produced by microbes: fermented foods, microbial cells as food (single cell proteins), mushroom cultivation. Bioconversions- industrial enzymes production- amylases, proteinases, cellulases; Amino acid production- glutamic acid and lysine production. Oriental foods: Mycoprotein, Tempeh, Soya sauce, Idle, Notto, Poi.

##### UNIT 4

Antimicrobial chemotherapeutic Agents; their types, antibiotic generations, chemical nature and mode of action. Industrial production of antibiotics , purification and testing.

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SEMESTER III

<u>Theory paper</u>	mark
Paper 1: Environmental Microbiology	50
Paper 2: Soil and Agriculture Microbiology	50
Paper 3: Microbial Technology	50
Paper 4: Microbial genomics and Bioinformatics	50
Practical 1: Based on paper 1-4	100

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**PAPER 1: ENVIRONMENTAL MICROBIOLOGY**

UNIT 1

Aerobiology: Droplet nuclei, aerosols, assessment of air quality, solid, liquid impingent methods. Brief account of air borne transmission of microbes- viruses, bacteria and fungi and their diseases and preventive measures. Aeroallergy and Aeroallergens.

UNIT 2

Aquatic Microbiology: Water ecosystem- types- fresh water (ponds, lakes, streams)- Marine habitats (estuaries, mangroves, deep sea, hydrothermal vents, salt pans, coral reefs). Zonations of water ecosystem- upwelling- eutrophication- food chain. Potability of water- microbial assessment of water quality- water purification- brief account of major water borne disease and their control measures.

UNIT 3

Water treatment: Waste types- solid and liquid wastes characterization, solid- liquid treatments physical, chemical, biological- aerobic- anaerobic- primary- secondary- tertiary solid treatments- Saccharification- gasification- composting, utilization of solid wastes. Fuel (Ethanol, methane) fertilizer (composting), liquid waste treatment- trickling-activated sludge- oxidation pond, oxidation ditch. Subterranean microbes and bioremediation.

UNIT 4

Positive and negative roles of microbes in environment: biodegradation of recalcitrant compounds- lignin- pesticides: bioaccumulation of metals and detoxification and biopesticides; biodeterioration of paper- leather-wood- textiles- cosmetics- metal corrosion- mode of deterioration, organisms involved, its disadvantages and mode of prevention. GMO and their impact, microbial plastics.

**PAPER 2: SOIL AND AGRICULTURE MICROBIOLOGY**

UNIT 1

Soil Microbiology: Classification of soil- physical and chemical characteristics, soil as a habitat for micro-organisms, microflora of various soil types, Rhizosphere and rhizoplane. Nitrogen fixation: Asymbiotic and symbiotic nitrogen fixation systems- root nodulation symbiotic bacteria (process of root nodule formation), Leghemoglobin. Microbial interactions- symbiosis, mutualism, commensalisms,

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amensalism, commensalisms, competition, antibiosis; Actinorrhiza; Mycorrhizal fungi and its effect on plants.

#### UNIT 2

Production of biofertilizers and biopesticides- Quality control, BIS norms of biofertilizers; Biofertilizers (rhizobial inoculants, mass production and method of application); biopesticides (viral, bacterial and fungal biopesticides); Biopolymers- Polyhydroxybutyrate (PHB), xantham gum, Biopesticides, BT gene and its uses.

#### UNIT 3

Rhizosphere and rhizoplane microorganisms: reasons for increased microbial activity in rhizosphere. Composition of root exudates, factors affecting exudation, rhizosphere microorganisms, rhizosphere effect. Effect of microflora on host plants. Factors affecting microbial community in soil- soil moisture, organic and inorganic chemicals, soil organic matter, types of vegetation and its growth stages, different seasons.

#### UNIT 4

Organic matter decomposition, factors affecting litter decomposition; Biogeochemical cycling of C, N, P and S; Microbial biomass and soil fertility; Biodegradation of hydrocarbons and xenobiotics, Microbial leaching of iron and copper.

### **PAPER 3: MICROBIAL TECHNOLOGY**

#### UNIT 1

General considerations: Metabolic pathways and metabolic control mechanisms, primary and secondary metabolites. Biotechnological innovations in the chemical industry, biocatalyst in organic chemical synthesis, efficiency of growth and product formation, growth stoichiometry, maintenance of energy requirement and maximum biomass yield. P/O quotients, metabolite over production and growth efficiency.

#### UNIT 2

Shake flask cultures. Fermentation in batch cultures, microbial growth kinetics, measurement of growth (cell number, direct, and indirect methods), growth and nutrient, growth and product formation, heat evolution, effect of environment (temperature, pH, high nutrient concentration). Media formulation, kinetics of thermal death of microorganisms, batch and continuous sterilization, stirred tank, airlift fermenter, fed batch, continuous and immobilized cell reactors. Fermentor design, instrumentation and control. Large scale production.

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UNIT 3

Aeration and agitation, oxygen transfer kinetics, concepts of Newtonian and Non-Newtonian fluids. Plastic fluids, apparent viscosity, foam and antifoam. Industrial strains. Strategies for selection and improvement, preservation and maintenance. Aseptic operation and containment of recombinant organisms. Scale up, large scale production using recombinant microorganisms. Product recovery (down streaming).

UNIT 4

Industrial production of antibiotics ,citric acid, acetic acid, lactic acid, ethanol, enzymes (pectinases, amylases, lipases, proteases, cellulases). Amino acids (glutamic acid and lysine), vitamins, steroids. Biofertilizers, biopesticides, mushroom production, fermented food beverages, biopolymers.

**PAPER 4: MICROBIAL GENOMICS AND BIOINFORMATICS**

UNIT 1

Introduction on concept and principles of genomics preparation of genetic maps, molecular markers and use of softwares.

UNIT 2

Molecular genetic maps, types and its uses. Molecular physical maps ex.- using large inserts YACs, BACs and BIBACs, ISH mapping.

UNIT 3

Comparative genomics, and collinearity, Micro- collinearity in DNA sequences. Molecular transcripts (EST) maps. Genomics for Evolutionary studies.

UNIT 4

Bioinformatics: Sequence alignment, scoring matrices, local and global alignments, dynamic methods, Needleman and Wunsch algorithm, database search for homologous sequencer, BLAST and FASTA versions.

Database, (NCBI, Pubmed, EMBL, PDP), search engines, phylogenetic tree, sequence submission and retrieval.

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SEMESTER IV

THEORY PAPERS	MARKS
Paper 1: Industrial Microbiology	50
Paper 2: Microbial Diversity and Extremophiles	50
Practical: Practical based on paper 1 to 2	100
Dissertation/ project work	100

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**PAPER 1: INDUSTRIAL MICROBIOLOGY**

UNIT 1

Microbial biodiversity and its importance in industrial microbiology, methods of isolation of microbes. High throughput screening (HTS) of microbes and metagenomic libraries for industrially important enzymes, amino acids, bio-molecular (anticancer, anti inflammatory antimicrobial compounds.)

UNIT 2

Strain development by mutagenesis, protoplast fusion and transformation, methods for cloning the genes, system biology (genome transcriptome, proteome, metabolome, fluxome) in strain development.

UNIT 3

Important microbial products and technology for production of beer, bioethanol from cellulose waste, citric acid, amino acids, enzymes, lovastatin, penicillin. Industrially important biotransformations, immobilization of whole cells and enzymes.

UNIT 4

Production of recombinant proteins (Hepatitis vaccines, HGH) protein engineering, metabolic engineering, combinatorial chemistry, intellectual property rights (IPR) and patent laws in Industry.

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Paper 2: Microbial Diversity and Extremophiles

UNIT 1

Introduction to Microbial diversity Molecular characterization of organisms. Overview of phylogenetic tree and diversity. Principal of molecular phylogeny methods in taxonomy of Bacteria, Archae and Fungi. Chemotaxonomy, rRNA sequencing.

UNIT 2

Methodology of identification of unknown pure cultures: Strategy and methods. Newer approaches for explaining unculturable bacteria from environmental samples. Culture independent molecular methods.

UNIT 3

Metabolic diversity among microorganisms. Photosynthesis, Chemolithotrophy, Hydrogen- iron nitrite, Nitrate and sulphate reduction. Methanogenesis and acetogenesis.

UNIT 4

Fermentation- diversity, purple and green bacteria, cyanobacteria, acetic acid bacteria, Pseudo monads, lactic and propionic acid bacteria, endospore forming rods and cocci, Mycobacteria and Mycoplasma, Archaea; halophiles, Methanogens, Hyper thermophilic Archaea, Thermoplasma, psychrophiles, acidophiles, thermophiles and barophiles.