SYLLABUS FOR M.Sc. ENTRANCE 2020 (MICROBIOLOGY)
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

Unit 1 History of Development of Microbiology **No. of Hours: 15**

Development of microbiology as a discipline, Spontaneous generation *vs*. biogenesis. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming.

Role of microorganisms in fermentation, Germ theory of disease, Development of various microbiological techniques and golden era of microbiology, Development of the field of soil microbiology: Contributions of Martinus W. Beijerinck, Sergei N. Winogradsky, Selman A.Waksman

Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Elie Metchnikoff, Edward Jenner.

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

A. Systems of classification

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

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

• **Algae**

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

• **Fungi**

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

• **Protozoa**

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

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

BACTERIOLOGY

Unit 1 Cell organization **No. of Hours: 14**

Cell size, shape and arrangement, glycocalyx, capsule, flagella, endoflagella, fimbriae and pili.

Cell-wall: Composition and detailed structure of Gram-positive and Gram-negative cell walls, Archaebacterial cell wall, Gram and acid fast staining mechanisms, lipopolysaccharide (LPS), sphaeroplasts, protoplasts, and L-forms. Effect of antibiotics and enzymes on the cell wall.

Cell Membrane: Structure, function and chemical composition of bacterial and archaeal cell membranes.

Cytoplasm: Ribosomes, mesosomes, inclusion bodies, nucleoid, chromosome and plasmids

Endospore: Structure, formation, stages of sporulation.

Unit 2 Bacteriological techniques **No. of Hours: 5**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, maintenance and preservation/stocking of pure cultures; cultivation of anaerobic bacteria, and accessing non-culturable bacteria.

Unit 3 Microscopy **No. of Hours: 2**
Bright Field Microscope: Principle and functions.

Unit 4 Growth and nutrition **No. of Hours: 8**
Nutritional requirements in bacteria and nutritional categories.
Culture media: components of media, natural and synthetic media, chemically defined media, complex media, selective, differential, indicator, enriched and enrichment media.
Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation, osmotic pressure, radiation.
Chemical methods of microbial control: disinfectants, types and mode of action.

Unit 5 Reproduction in Bacteria **No. of Hours: 4**
Asexual methods of reproduction, logarithmic representation of bacterial populations, phases of growth, calculation of generation time and specific growth rate.

Unit 6 Bacterial Systematics **No. of Hours: 8**
Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy, evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria.

Unit 7 Important archaeal and eubacterial groups **No. of Hours: 19**
Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota (*Nanoarchaeum*), Crenarchaeota (*Sulfolobus*, *Thermoproteus*) and Euryarchaeota [Methanogens (*Methanobacterium*, *Methanocaldococcus*), thermophiles (*Thermococcus*, *Pyrococcus*, *Thermoplasma*), and Halophiles (*Halobacterium, Halococcus*)].
Eubacteria: Morphology, metabolism, ecological significance and economic importance of following groups:
Gram Negative:
Non proteobacteria: General characteristics with reference to *Deinococcus, Chlamydia, Chlorobium* and *Spirochaetes*,
Alpha proteobacteria: General characteristics with reference to *Rhizobium, Ricketssia* and *Agrobacterium*.
Beta proteobacteria: General characteristics with reference to *Neisseria, Burkholderia* and *Thiobacillus*.
Gamma proteobacteria: General characteristics with reference to *Pseudomonas,* Purple Sulfur bacteriaand Enterobacteriaceae family.
Delta proteobacteria: General characteristics with reference to Myxobacteria and *Bdellovibrio*.
Epsilon proteobacteria: General characteristics with reference to *Helicobacter* and *Campylobacter*.
Zeta proteobacteria: General characteristics with reference to *Mariprofundus ferrooxydans*.
Gram Positive:
Low G+C (Firmicutes): General characteristics with reference to *Lactobacillus, Bacillus, Clostridium, Mycoplasma, Staphylococcus, Streptococcus* and *Heliobacterium.*
High G+C (Actinobacteria): General characteristics with reference to *Corynebacterium, Streptomyces, Bifidobacterium, Propionibacterium, Frankia, Mycobacterium*and *Nocardia*.
***Cyanobacteria*:** General characterstics.

BIOCHEMISTRY

Unit 1 Bioenergetics **No. of Hours: 8**
First and second laws of Thermodynamics. Definitions of Gibb's Free Energy, Enthalpy,and Entropy and mathematical relationship among them, Standard free energy change and equilibrium constant

Coupled reactions and additive nature of standard free energy change, Energy rich compounds: Phosphoenolpyruvate, 1,3- Bisphosphoglycerate, Thioesters, ATP.

Unit 2 Carbohydrates **No. of Hours: 12**

Families of monosaccharides: aldoses and ketoses, trioses, tetroses, pentoses, and hexoses.
Stereo-isomerism of monosaccharides, epimers, Mutarotation and anomers of glucose. Furanose and pyranose forms of glucose and fructose, Haworth projection formulae for glucose; chair and boat forms of glucose, Sugar derivatives, glucosamine, galactosamine, muramic acid, N- acetyl neuraminic acid, Disaccharides; concept of reducing and non-reducing sugars, occurrence and Haworth projections of maltose, lactose, and sucrose, Polysaccharides, storage polysaccharides, starch and glycogen. Structural Polysaccharides, cellulose, peptidoglycan and chitin.

Unit 3 Lipids **No. of Hours: 12**

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

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

Functions of proteins, Primary structures of proteins: Amino acids, the building blocks of proteins. General formula of amino acid and concept of zwitterion. Titration curve of amino acid and its significance, classification, biochemical structure and notation of standard protein amino acids.
Ninhydrin reaction.Natural modifications of amino acids in proteins hydrolysine, cystine and hydroxyproline, Non protein amino acids: Gramicidin, beta-alanine, D-alanine and D- glutamic acid
Oligopeptides: Structure and functions of naturally occurring glutathione and insulin and synthetic aspartame, Secondary structure of proteins: Peptide unit and its salient features. The alpha helix, the beta pleated sheet and their occurrence in proteins, Tertiary and Quaternary structures of proteins. Forces holding the polypeptide together. Human haemoglobin structure.

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

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

VIROLOGY

Unit 1 Nature and Properties of Viruses **No. of Hours: 12**

Introduction: Discovery of viruses, nature and definition of viruses, general properties, concept of viroids, virusoids, satellite viruses and Prions. Theories of viral origin.
Structure of Viruses: Capsid symmetry, enveloped and non-enveloped viruses.Isolation, purification and cultivation of viruses.
Viral taxonomy: Classification and nomenclature of different groups of viruses.

Unit 2 Bacteriophages **No. of Hours**: **10**

Diversity, classification, one step multiplication curve, lytic and lysogenic phages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage.

Unit 3 Viral Transmission, Salient features of viral nucleic acids and Replication

No. of Hours: **20**

Modes of viral transmission: Persistent, non-persistent, vertical and horizontal.
Salient features of viral Nucleic acid : Unusual bases (TMV,T4 phage), overlapping genes (ϕX174, Hepatitis B virus), alternate splicing (HIV), terminal redundancy (T4 phage), terminal cohesive ends (lambda phage), partial double stranded genomes (Hepatitis B), long terminal repeats (retrovirus), segmented (Influenza virus), and non-segmented genomes (picornavirus), capping and tailing (TMV).
Viral multiplication and replication strategies: Interaction of viruses with cellular receptors and entry of viruses. Replication strategies of viruses as per Baltimore classification (phi X 174, Retroviridae, Vaccinia, Picorna), Assembly with example of Polio virus and T4 phage, maturation and release of virions.

Unit 4 Viruses and Cancer **No. of Hours: 6**

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

Unit 5 Prevention & control of viral diseases **No. of Hours: 8**

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

Unit 6 Applications of Virology **No. of Hours: 4**

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

MICROBIAL PHYSIOLOGY AND METABOLISM

Unit 1 Microbial Growth and Effect of Environment on Microbial Growth **No. of Hours: 12**

Definitions of growth, Batch culture, Continuous culture, generation time and specific growth rate
Effect of temperature andpH on microbial growth.
Effect of solute and water activity on growth.
Effect of oxygen concentration on growth.
Nutritional categories of microorganisms.

Unit 2 Nutrient uptake and Transport **No. of Hours: 10**

Passive and facilitated diffusion.
Primary and secondary active transport, concept of uniport, symport and antiport
Group translocation.
Iron uptake.

Unit 3 Chemoheterotrophic Metabolism - Aerobic Respiration **No. of Hours: 16**

Concept of aerobic respiration, anaerobic respiration and fermentation.
Sugar degradation pathways i.e. EMP, ED, Pentose phosphate pathway
TCA cycle.
Electron transport chain: components of respiratory chain, comparison of mitochondrial and bacterial ETC, electron transport phosphorylation, uncouplers and inhibitors.

Unit 4 Chemoheterotrophic Metabolism- Anaerobic respiration and fermentation

No. of Hours: 6

Anaerobic respiration with special reference to dissimilatory nitrate reduction (Denitrification; nitrate /nitrite and nitrate/ammonia respiration; fermentative nitrate reduction).

Fermentation - Alcohol fermentation and Pasteur effect; Lactate fermentation (homofermentative and heterofermentative pathways), concept of linear and branched fermentation pathways.

Unit 5 Chemolithotrophic and Phototrophic Metabolism **No. of Hours: 10**

Introduction to aerobic and anaerobic chemolithotrophy with an example each. Hydrogen oxidation (definition and reaction) and methanogenesis (definition and reaction).
Introduction to phototrophic metabolism - groups of phototrophic microorganisms, anoxygenic *vs.* oxygenic photosynthesis with reference to photosynthesis in green bacteria and cyanobacteria.

Unit 6 Nitrogen Metabolism - an overview **No. of Hours: 6**

Introduction to biological nitrogen fixation.
Ammonia assimilation.
Assimilatory nitrate reduction.

CELL BIOLOGY

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

Plasma membrane: Structure and transport of small molecules.
Cell Wall: Eukaryotic cell wall, Extracellular matrix and cell matrix interactions, Cell-Cell Interactions - adhesion junctions, tight junctions, gap junctions, and plasmodesmata (only structural aspects).
Mitochondria, chloroplasts and peroxisomes.
Cytoskeleton: Structure and organization of actin filaments, association of actin filaments with plasma membrane, cell surface protrusions, intermediate filaments, microtubules.

Unit 2 Nucleus **No. of Hours: 6**

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

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

Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing and quality control in ER, smooth ER and lipid synthesis, export of proteins and lipids
Golgi Apparatus – Organization, protein glycosylation, protein sorting and export from Golgi Apparatus.
Lysosomes.

Unit 4 Cell Signalling **No. of Hours: 12**

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

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

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

MOLECULAR BIOLOGY

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

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

cot curves. DNA topology: linking number, topoisomerases;Organization of DNA Prokaryotes,Viruses, Eukaryotes.RNA Structure,

Unit 2 Replication of DNA (Prokaryotes and Eukaryotes) No. of Hours: 10
Bidirectional and unidirectional replication, semi- conservative, semi- discontinuous replication.
Mechanism of DNA replication: Enzymes and proteins involved in DNA replication –DNA polymerases, DNA ligase, primase, telomerase – for replication of linear ends.
Various models of DNA replication including rolling circle, D- loop (mitochondrial), Θ (theta) mode of replication and other accessory protein, Mismatch and excision repair.

Unit 3 Transcription in Prokaryotes and Eukaryotes No. of Hours: 8
Transcription: Definition, difference from replication, promoter - concept and strength of promoter RNA Polymerase and the transcription unit.
Transcription in Eukaryotes: RNA polymerases, general Transcription factors.

Unit 4 Post-Transcriptional Processing No. of Hours: 8
Split genes, concept of introns and exons,RNA splicing, spliceosome machinery**,** concept of alternative splicing, Polyadenylation and capping, Processing of rRNA, RNA interference: si RNA, miRNA and its significance.

Unit 5 Translation (Prokaryotes and Eukaryotes) No. of Hours: 10
Translational machinery, Charging of tRNA, aminoacyl tRNA synthetases, Mechanisms of initiation, elongation and termination of polypeptides in both prokaryotes and eukaryotes, Fidelity of translation, Inhibitors of protein synthesis in prokaryotes and eukaryote.

Unit 6 Regulation of gene Expression in Prokaryotes and Eukaryotes No. of Hours: 12
Principles of transcriptional regulation, regulation at initiation with examples from *lac* and *trp* operons, Sporulation in *Bacillus,*Yeast mating type switching, Changes in Chromatin Structure - DNA methylation and Histone Acetylation mechanisms.

MICROBIAL GENETICS AND GENOMICS

Unit 1 Genome Organization and Mutations No. of Hours: 18
Genome organization: *E. coli, Saccharomyces, Tetrahymena*.
Organelle genome: Chroloroplast and Mitochondria.
Mutations and mutagenesis: Definition and types of Mutations; Physical and chemical mutagens; Molecular basis of mutations; Functional mutants (loss and gain of function mutants); Uses of mutations.
Reversion and suppression: True revertants; Intra- and inter-genic suppression; Ames test; Mutator genes.

Unit 2 Plasmids No. of Hours: 10
Types of plasmids – F plasmid, R Plasmids, colicinogenic plasmids, Ti plasmids, linear plasmids, yeast-2 μ plasmid, Plasmid replication and partitioning, Host range, plasmid-incompatibility, plasmid amplification, Regulation of copy number, curing of plasmids.

Unit 3 Mechanisms of Genetic Exchange No. of Hours: 12
Transformation - Discovery, mechanism of natural competence.
Conjugation - Discovery, mechanism, Hfr and F' strains,Interrupted mating technique and time of entry mapping.
Transduction - Generalized transduction, specialized transduction, LFT & HFT lysates,Mapping by recombination and co-transduction of markers.

Unit 4 Phage Genetics No. of Hours: 8

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

Unit 5 Transposable elements **No. of Hours: 12**

Prokaryotic transposable elements – Insertion Sequences, composite and non-composite transposons, Replicative and Non replicative transposition, Mu transposon.

Eukaryotic transposable elements - Yeast (Ty retrotransposon), Drosophila (P elements), Maize (Ac/Ds).

Uses of transposons and transposition.

ENVIRONMENTAL MICROBIOLOGY

Unit 1 Microorganisms and their Habitats **No. of Hours: 14**

Structure and function of ecosystems.

Terrestrial Environment: Soil profile and soil microflora.

Aquatic Environment: Microflora of fresh water and marine habitats.

Atmosphere: Aeromicroflora and dispersal of microbes.

Animal Environment: Microbes in/on human body (Microbiomics) & animal (ruminants) body.

Extreme Habitats: Extremophiles: Microbes thriving at high & low temperatures, pH, high hydrostatic & osmotic pressures, salinity, & low nutrient levels.

Microbial succession in decomposition of plant organic matter.

Unit 2 Microbial Interactions **No. of Hours: 12**

Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation.

Microbe-Plant interaction: Symbiotic and non symbiotic interactions.

Microbe-animal interaction: termite gut microflora, nematophagus fungi and symbiotic luminescent bacteria.

Unit 3 Biogeochemical Cycling **No. of Hours: 12**

Carbon cycle: Microbial degradation of cellulose, hemicelluloses, lignin and chitin.

Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction.

Phosphorus cycle: Phosphate immobilization and solubilisation.

Sulphur cycle: Microbes involved in sulphur cycle.

Other elemental cycles: Iron and manganese.

Unit 4 Waste Management **No. of Hours: 12**

Solid Waste management: Sources and types of solid waste, Methods of solid waste disposal (composting and sanitary landfill).

Liquid waste management: Composition and strength of sewage (BOD and COD), Primary, secondary (oxidation ponds, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.

Unit 5 Microbial Bioremediation **No. of Hours: 5**

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

Unit 6 Water Potability **No. of Hours: 5**

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

FOOD AND DAIRY MICROBIOLOGY

Unit 1 Foods as a substrate for microorganisms **No. of Hours: 8**
Intrinsic and extrinsic factors that affect growth and survival of microbes in foods,natural flora and source of contamination of foods in general.

Unit 2 Microbial spoilage of various foods **No. of Hours: 10**
Principles, Spoilage of vegetables, fruits, meat, eggs, milk and butter, bread, cannedfoods.

Unit 3 Principles and methods of food preservation **No. of Hours: 12**
Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, hydrostatic pressure, high voltage pulse, microwave processingand aseptic packaging, chemical methods of food preservation: salt, sugar, organicacids, SO_2, nitrite and nitrates, ethylene oxide, antibiotics and bacteriocins.

Unit 4 Fermented foods **No. of Hours: 10**
Dairy starter cultures, fermented dairy products: yogurt, acidophilus milk, kumiss,kefir, dahi and cheese, other fermented foods: dosa, sauerkraut, soy sauce andtampeh, Probiotics: Health benefits, types of microorganisms used, probiotic foods available in market.

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

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

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

INDUSTRIAL MICROBIOLOGY

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

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

Unit 3 Isolation of industrially important microbial strains and fermentation media
No. of Hours: 10
Sources of industrially important microbes and methods for their isolation, preservation and maintenance of industrial strains, strain improvement, Crude and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.

Unit 4 Down-stream processing **No. of Hours: 6**

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

Unit 5 Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses) **No. of Hours: 18**

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

Unit 6 Enzyme immobilization **No. of Hours: 4**

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

IMMUNOLOGY

Unit 1 Introduction **No. of Hours: 4**

Concept of Innate and Adaptive immunity; Contributions of following scientists to the development of field of immunology - Edward Jenner, Karl Landsteiner, Robert Koch, Paul Ehrlich, Elie Metchnikoff, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Rodney Porter and Susumu Tonegawa.

Unit 2 Immune Cells and Organs **No. of Hours: 7**

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

Unit 3 Antigens **No. of Hours: 4**

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

Unit 4 Antibodies **No. of Hours: 6**

Structure, Types, Functions and Properties of antibodies; Antigenic determinants on antibodies (Isotypic, allotypic, idiotypic); VDJ rearrangements; Monoclonal and Chimeric antibodies.

Unit 5 Major Histocompatibility Complex **No. of Hours: 5**

Organization of MHC locus (Mice & Human); Structure and Functions of MHC I & II molecules; Antigen processing and presentation (Cytosolic and Endocytic pathways).

Unit 6 Complement System **No. of Hours: 4**

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

Unit 7 Generation of Immune Response **No. of Hours: 10**

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

Unit 8 Immunological Disorders and Tumor Immunity **No. of Hours: 10**

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

Unit 9 Immunological Techniques **No. of Hours: 10**

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

MEDICAL MICROBIOLOGY

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

No. of Hours: 8

Normal microflora of the human body: Importance of normal microflora, normal microflora of skin, throat, gastrointestinal tract, urogenital tract.

Host pathogen interaction: Definitions - Infection, Invasion, Pathogen, Pathogenicity, Virulence, Toxigenicity, Carriers and their types, Opportunistic infections, Nosocomial infections. Transmission of infection, Pathophysiologic effects of LPS.

Unit 2 Sample collection, transport and diagnosis **No. of Hours: 5**

Collection, transport and culturing of clinical samples, principles of different diagnostic tests (ELISA, Immunofluorescence, Agglutination based tests,Complement fixation, PCR, DNA probes).

Unit 3 Bacterial diseases **No. of Hours: 15**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control:

Respiratory Diseases: *Streptococcus pyogenes*, *Haemophilus influenzae, Mycobacterium tuberculosis*.

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

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

Unit 4 Viral diseases **No. of Hours: 14**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control:

Polio, Herpes, Hepatitis, Rabies, Dengue, AIDS, Influenza with brief description of swine flu, Ebola, Chikungunya, Japanese Encephalitis.

Unit 5 Protozoan diseases **No. of Hours: 5**

List of diseases of various organ systems and their causative agents. The following diseases in detail with Symptoms, mode of transmission, prophylaxis and control:Malaria, Kala-azar.

Unit 6 Fungal diseases **No. of Hours: 5**

Brief description of each of the following types of mycoses and one representative disease to be studied with respect to transmission, symptoms and prevention:

Cutaneous mycoses: Tinea pedis (Athlete's foot).

Systemic mycoses: Histoplasmosis.

Opportunistic mycoses: Candidiasis.

Unit 6 Antimicrobial agents: General characteristics and mode of action **No. of Hours: 8**

Antibacterial agents: Five modes of action with one example each: Inhibitor of nucleic acid synthesis; Inhibitor of cell wall synthesis; Inhibitor of cell membrane function; Inhibitor of protein synthesis; Inhibitor of metabolism.

Antifungal agents: Mechanism of action of Amphotericin B, Griseofulvin.

Antiviral agents: Mechanism of action of Amantadine, Acyclovir, Azidothymidine

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

RECOMBINANT DNA TECHNOLOGY (THEORY)

Unit 1 Introduction to Genetic Engineering **No. of Hours: 2**
Milestones in genetic engineering and biotechnology.

Unit 2 Molecular Cloning- Tools and Strategies **No. of Hours: 20**
Cloning Tools; Restriction modification systems: Types I, II and III. Mode of action, nomenclature, applications of Type II restriction enzymes in genetic engineering.
DNA modifying enzymes and their applications: DNA polymerases. Terminal deoxynucleotidyltransferase, kinases and phosphatases, and DNA ligases.
Cloning Vectors: Definition and Properties.
Plasmid vectors: pBR and pUC series.
Bacteriophage lambda and M13 based vectors.
Cosmids, BACs, YACs.
Use of linkers and adaptors.
Expression vectors: *E.coli* lac and T7 promoter-based vectors, yeast YIp, YEp and YCp vectors, Baculovirus based vectors, mammalian SV40-based expression vectors.

Unit 3 Methods in Molecular Cloning **No. of Hours: 16**
Transformation of DNA: Chemical method, Electroporation.
Gene delivery: Microinjection, electroporation, biolistic method (gene gun), liposome and viral-mediated delivery, *Agrobacterium* - mediated delivery.
DNA, RNA and Protein analysis: Agarose gel electrophoresis, Southern - and Northern - blotting techniques, dot blot, DNA microarray analysis, SDS-PAGE, Gel Shift Assay and Western blotting.

Unit4 DNA Amplification and DNA sequencing **No. of Hours: 10**
PCR: Basics of PCR, RT-PCR, Real-Time PCR.
Sanger's method of DNA Sequencing: traditional and automated sequencing. Introduction to new generation sequencing.
Primer walking and shotgun sequencing.

Unit 5 Construction and Screening of Genomic and cDNA libraries **No. of Hours: 6**
Genomic and cDNA libraries: Preparation and uses, Screening of libraries: Colony hybridization and colony PCR, Chromosome walking and chromosome jumping.

Unit 6 Applications of Recombinant DNA Technology **No. of Hours: 6**
Products of recombinant DNA technology: Products of human therapeutic interest - insulin, hGH, antisense molecules. Bt transgenic - cotton, brinjal, Gene therapy, recombinant vaccines, protein engineering and site directed mutagensis.

PLANT PATHOLOGY

Unit 1 Introduction and History of plant pathology **No. of Hours: 5**
Concept of plant disease- definitions of disease, disease cycle & pathogenicity, symptoms associated with microbial plant diseases, types of plant pathogens, economic losses and social impact of plant diseases. Significant landmarks in the field of plant pathology- Contributions of Anton DeBary, Millardet, Burrill, E. Smith, Adolph Mayer, Ivanowski, Diener, Stakman, H.H. Flor, Van Der Plank, molecular Koch's postulates. Contributions of eminent Indian plant pathologists (K.C.Mehta, Mundkur, Dastur and Sadasivan).

Unit 2 Stages in development of a disease **No. of Hours: 2**
Infection, invasion, colonization, dissemination of pathogens and perennation.

Unit 3 Plant disease epidemiology **No. of Hours: 5**

Concepts of monocyclic, polycyclic and polyetic diseases, disease triangle & disease pyramid, forecasting of plant diseases and its relevance in Indian context.

Unit 4 Host Pathogen Interaction **No. of Hours: 19**

A. *Microbial Pathogenicity*

Virulence factors of pathogens: enzymes, toxins (host specific and non specific) growth regulators, virulence factors in viruses (replicase, coat protein, silencing suppressors) in disease development.

Effects of pathogens on host physiological processes (photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction).

B. *Genetics of Plant Diseases*

Concept of resistance (R) gene and avirulence (avr) gene; gene for gene hypothesis, types of plant resistance: true resistance– horizontal & vertical, apparent resistance.

C. *Defense Mechanisms in Plants*

Concepts of constitutive defense mechanisms in plants, inducible structural defenses (histological-cork layer, abscission layer, tyloses, gums), inducible biochemical defenses [hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis related (PR) proteins, plantibodies, phenolics, quinones, oxidative bursts].

Unit 5 Control of Plant Diseases **No. of Hours: 10**

Principles & practices involved in the management of plant diseases by different methods, *viz.*

regulatory - quarantine, crop certification, avoidance of pathogen, use of pathogen free propagative material.

cultural - host eradication, crop rotation, sanitation, polyethylene traps and mulches.

chemical - protectants and systemic fungicides, antibiotics, resistance of pathogens to chemicals.

biological - suppressive soils, antagonistic microbes-bacteria and fungi, trap plants.

genetic engineering of disease resistant plants- with plant derived genes and pathogen derived genes.

Unit 6 Specific Plant diseases **No. of Hours: 19**

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

A. Important diseases caused by fungi:

White rust of crucifers - *Albugo candida*.

Late blight of potato - *Phytophthora infestans*.

Ergot of rye - *Claviceps purpurea*.

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

Red rot of sugarcane - *Colletotrichum falcatum*.

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

INHERITANCE BIOLOGY

Unit 1 Introduction to Genetics **No. of Hours: 5**

Historical developments

Model organisms in genetic analyses and experimentation: *Escherichia coli*, *Saccharomyces cerevisiae, Neurospora crassa, Caenorhabditis elegans Drosophila melanogaster, Arabidopsis thaliana*.

Unit 2 Mendelian Principles **No. of Hours: 13**

Mendel's Laws: Dominance, segregation, independent assortment, deviation from Mendelian inheritance,Rediscovery of Mendel's principles, Chromosome theory of inheritance: Allele, multiple alleles, pseudoallele, complementation tests, Extensions of Mendelian genetics: Allelic interactions, concept of dominance, recessiveness, Incomplete dominance and co-dominance,Multiple alleles, Epistasis, penetrance and expressivity.

Unit 3 Linkage and Crossing over **No. of Hours: 9**

Linkage and recombination of genes, Cytological basis of crossing over, Crossing over at four-strand stage, Molecular mechanism of crossing over, mapping.

Unit 4 Characteristics of Chromosomes **No. of Hours: 15**

Structural organization of chromosomes - centromeres, telomeres and repetitive DNA, Packaging DNA molecules into chromosomes,Concept of euchromatin and heterochromatin, Normal and abnormal karyotypes of human chromosomes, Chromosome banding, Giant chromosomes: Polytene and lampbrush chromosomes, Variations in chromosome structure: Deletion, duplication, inversion and translocation, Variation in chromosomal number and structural abnormalities - Klinefelter syndrome, Turner syndrome, Down syndrome.

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

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

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

Introduction and Rules of extra nuclear inheritance, Organelle heredity - Chloroplast mutations in *Chlamydomonas*, mitochondrial, mutations in *Saccharomyces,* Maternal effects – Shell coiling in *Limnaea peregra*.
Infectious heredity - Kappa particles in *Paramecium*.
Epigenetics.

Unit 7 Human genetics **No. of Hours: 3**

Pedigree analysis, lod score for linkage testing, karyotypes, genetic disorders.

Unit 8 Quantitative genetics **No. of Hours: 3**

Polygenic inheritance, heritability and its measurements, QTL mapping.

MICROBIAL BIOTECHNOLOGY (THEORY)

Unit 1 Microbial Biotechnology and its Applications **No. of Hours: 10**

Microbial biotechnology: Scope and its applications in human therapeutics, agriculture (Biofertilizers, PGPR, Mycorrhizae), environmental, and food technology.
Use of prokaryotic and eukaryotic microorganisms in biotechnological applications.
Genetically engineered microbes for industrial application: Bacteria and yeast.

Unit 2 Therapeutic and Industrial Biotechnology **No. of Hours: 10**

Recombinant microbial production processes in pharmaceutical industries - Streptokinase, recombinant vaccines (Hepatitis B vaccine).
Microbial polysaccharides and polyesters, Microbial production of bio-pesticides, bioplastics
Microbial biosensors.

Unit 3 Applications of Microbes in Biotransformations **No. of Hours: 8**

Microbial based transformation of steroids and sterols.
Bio-catalytic processes and their industrial applications: Production of high fructose syrup and production of cocoa butter substitute.

Unit 4 Microbial Products and their Recovery **No. of Hours: 10**

Microbial product purification: filtration, ion exchange & affinity chromatography techniques
Immobilization methods and their application: Whole cell immobilization.

Unit 5 Microbes for Bio-energy and Environment **No. of Hours: 12**

Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste and algal biomass, Biogas production: Methane and hydrogen production using microbial culture.

Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.

INSTRUMENTATION AND BIOTECHNIQUES (THEORY)

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

Brightfield and darkfield microscopy, Fluorescence Microscopy, Phase contrast Microscopy, Electron Microscopy (Scanning and Transmission Electron Microscopy) and Micrometry.

Unit 2 Chromatography **No. of Hours : 14**

Principles and applications of paper chromatography (including Descending and 2-D), Thin layer chromatography. Column packing and fraction collection. Gel filtration chromatography, ion-exchange chromatography and affinity chromatography, GLC, HPLC.

Unit 3 Electrophoresis **No. of Hours : 14**

Principle and applications of native polyacrylamide gel electrophoresis, SDS- polyacrylamide gel electrophoresis, 2D gel electrophoresis Isoelectric focusing, Zymogram preparation and Agarose gel electrophoresis.

Unit 4 Spectrophotometry **No. of Hours : 10**

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

Unit 5 Centrifugation **No. of Hours : 12**

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