



PART A

RESEARCH METHODOLOGY

Unit 1- Foundations of Research: Meaning, Objectives, Motivation, Utility; Concept of theory, empiricism, deductive and inductive theory; Characteristics of scientific method, Understanding the language of research – Concept, Construct, Definition, Variable; Research Process; Problem Identification & Formulation, Research Question, Investigation Question, Measurement Issues; Hypothesis - Qualities of a good Hypothesis, Null Hypothesis & Alternative Hypothesis; Hypothesis Testing – Logic & Importance.

Unit 2- Research design and types: Research Design- Concept and Importance in Research, Features of a good research design, Exploratory Research Design – concept, types and uses; Descriptive Research Designs – concept, types and uses; Experimental Design- Concept of Independent & Dependent variables.

Unit 3- Qualitative and Quantitative Research: Qualitative research, Quantitative research; Concept of measurement, causality, generalization, replication; Merging the two approaches; Concept of measurement– what is measured? Problems in measurement in research, Validity and Reliability; Levels of measurement – Nominal, Ordinal, Interval, Ratio.

Unit 4- Interpretation of Data and Report writing: Meaning and Technique of interpretation; Precautions in interpretation; Significance of report writing; Different steps in writing a report; Layout of a Research report; Types of report; Mechanics of writing a research report; Precautions for writing a research report.

Unit 5- Scientific Writing: Layout of a Research Paper, Impact factor of Journals, When and where to publish; Poster preparation and Presentation, Oral presentations; Reference management, Web-based literature search engines; Plagiarism and Self-Plagiarism.

Suggested Reading Material:

- Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.
- Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
- Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, Ess Ess Publications. 2 volumes.
- Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.

PART B

Microbiology

(I) Microbial Genetics and Molecular Biology:

Unit 1: Organization of genetic material in bacteria; Gene transfer mechanisms, Introduction to conjugation, transformation and transduction; Recombination in bacteria; Drug resistance in bacteria, Mutations; Types of mutations; Mutagenesis – spontaneous and induced; Types of

mutagens; Applications of mutagenesis; Molecular implications of mutations – disorders, Reverse mutation, Mutant selection, Mutant enrichment, Reversions and suppression; Overview of fungal genetics and sexuality.

Unit 2: Introduction to Nucleic acid, DNA double helical structures; A, B & Z forms of DNA, Supercoiled and relaxed DNA, quadruplex DNA, denaturation and renaturation of DNA; melting temperature (T_m); DNA quantification; transfer RNA, ribosomal RNA, and mRNA, secondary structures of RNA and DNA, hairpin and loop formation: Prokaryotic and eukaryotic DNA replication: Meselson Stahl experiment, mechanisms of DNA repair, the fidelity of replication enzymes and proteins involved in DNA replication; RNA polymerase; holoenzyme and apoenzyme; sigma factors; Protein initiation, elongation and termination; Eukaryotic transcription: Types of RNA polymerases, transcription factors; Molecular mechanisms and biological functions of siRNA and miRNA; Aptamers and types of aptamers, aptamer library and screening.

Unit 3: Posttranscriptional modifications-mRNA processing, processing, capping, cleavage and polyadenylation; splicing of nuclear pre-mRNA; mRNA stability; Gene code-characteristics, deciphering the code; Wobble hypothesis, tRNA structure and their role in translation; ribosomes, their types and role in Protein biosynthesis; Prokaryotic and eukaryotic translation; the translational machinery, mechanism of initiation, elongation, and termination; Posttranslational modifications.

Suggested reading material:

- Fundamental Bacterial Genetics by Nancy Trun and Janine Trempy, 1st edition; Blackwell Science Publishers; 2004.
- Modern Microbial Genetics by U.N. Streips and R.E. Yasbin, 2nd edition; Wiley Publishers; 2002.
- Microbial Genetics by Stanly R. Maloy, John E. Cronan, Jr. & David Freifelder, 2nd edition; Narosa Publishing House; 1987
- Alberts Bruce (2014) Molecular Biology of Cell (6th edition), Garland Science
- David Clark, Nanette Pazdernik, Michelle McGehee . Molecular biology. Cell Press, 2018
- Benjamin Lewin. Gene VIII. Pearson Education Inc. NJ, 2004
- Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication

(II) Biochemistry and Microbial Physiology:

Unit 1: Microbial nutrient requirements, macro and micro nutrients; nutritional classification of bacteria- phototroph, chemotroph, autotroph, heterotroph, photoautotroph, photoheterotroph, chemoautotroph, chemoheterotroph; nutritional patterns of pathogens – saprophytes, auxotroph; Entry of nutrition in the cell, passive diffusion, facilitated diffusion and active transport; Utilization of nutrients that cannot enter the cell.

Unit 2: Characteristics and metabolism of autotrophs- Photosynthetic Bacteria and Cyanobacteria; Autotrophic CO₂ Fixation and Mechanisms of Photosynthesis, Photosystem I and II in cyanobacteria; Sulfur bacteria and the oxidation of sulfur compounds;

Methanogenesis & Methanotrophy; Carbon assimilation by methylotrophs; Energy efficiency in C1 metabolism.

Unit 3: Regulation through modulation of enzyme activity- fine regulation, Feedback inhibition, Enzyme activity modulation through structural changes, Phosphorylation, Adenylation, Acetylation, Other chemical modifications; Regulation through physical modification and dissociation/association; Allosteric regulation and Feedback control- Regulation of *E. coli* aspartate carbamoyl transferase.

Suggested reading material:

- Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Microbiology-An Introduction. 11th edition Pearson, 2013
- Madigan MT, and Martinko JM (2014). Brock Biology of Microorganisms. 14th edition. Prentice Hall International Inc.
- Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.
- Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
- David White., 2007 The Physiology and Biochemistry of Prokaryotes, 3rd edn, Oxford University Press.

(III) General Microbiology, Bacteriology and Virology:

Unit 1: History of microbiology- Refutation of a biogenesis, Discovery of penicillin, Discovery of vaccination; General principles of light microscopy - magnification, resolving power and numerical aperture; Principle and application of light, dark-field, phase contrast, differential interference contrast (DIC), fluorescence, scanning and transmission electron microscopy; Different types of growth media (natural synthetic, complex, enriched, selective etc); Sterilization and disinfection techniques; principles and methods of sterilization - physical methods – heat, filters and radiation and chemical methods; Isolation and Preservation of microbial cultures; Biology of algae and cyanobacteria; Biology of yeast and fungi mycoplasma; Prions.

Unit 2: Overview of bacterial classification based on Bergey's manual of determinative bacteriology – Gram negative bacteria, Gram positive bacteria, Mycoplasmas and Archaea; Classification based on serology, Biochemistry, 16s rRNA, G+C content and Molecular tools; Bacterial ultrastructure and organelles; Staining of bacteria and organelles, Human microbiome; Microbiomes in health and disease; Gut-brain conversation, effects of diet on microbiome.

Unit 3: Definitive properties of viruses - Morphology, Ultra structure; Chemical composition - proteins, nucleic acids, and enzymes; Classification and nomenclature - Group I, Group II, Group III, Group IV, Group V, Group VI, Group VII; Sub-viral particles - Discovery, Structure, Classification, replication and diseases caused; General aspects of animal viral diseases; Antiviral drugs, antiviral libraries, antiretrovirals—mechanism of action and drug resistance; Modern approaches for virus control: Antisense RNA, siRNA, ribozymes, T-phages, Cyanophages, Baculovirus; viruses as therapeutic agents, viruses for gene delivery, viruses to destroy other viruses.

Suggested reading material:

- Brock Biology of Microorganisms, 15th edition by Madigan, Bender, Buckley, Sattley and Stahl, Published by Pearson (2020).
- Prescott's Microbiology, 11th edition by Willey et. Al. Published by McGraw Hill (2019).
- Bergey's Manual of Systematic Bacteriology, 2nd Edition, Vol. 1, 2, 3, 4 and Springer-Verlag. New York, NY.
- Basic Virology. Edward K. Wagner, Martinez J. Hewlett, David C. Bloom, David Camerini
- Principles of Virology, Multi-Volume, 4 or 5th Edition Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Theodora Hatzioannou, Anna Marie Skalka
- Principles of Molecular Virology 4th Edition, Alan J. Cann

(IV) Applied Microbiology

Unit 1: Historical account of microbes in industrial microbiology; sources and characters of industrially important microbes; their isolation, purification and maintenance; Screening of useful strains; primary screening and secondary screening; Strain improvement through random mutation and genetic engineering; microbes in food spoilage; Microbial production of Primary and secondary metabolites, Large scale production of recombinant molecules; Commercial production of antibiotics; General principles of food safety risk management.

Unit 2: Importance of Agricultural microbiology; Distribution and importance of soil microorganisms; Microorganisms role in Bio-geo chemical cycles; Major plant disease symptoms caused by various microorganisms; Stages of disease development; relationship between disease cycles and factors influencing them; Mechanism of cuticle and cell wall degradation by microbes; Principles of plant disease control; biocontrol of plant pests and diseases; Integrated pest and disease management; Traditional and advanced methods of agricultural waste management.

Unit 3: Marine ecosystem and marine microbial communities; Seafood associated food spoilage microbes; Extremophiles – adaptations and mechanisms; abiotic and biotic factors in microbial ecosystem; Microbial Communities: Microenvironment and niche; Major environmental conditions influencing microflora, Microbiology of drinking water; Decomposition of organic matter; Bioleaching and biodeterioration of natural and synthetic materials; Bioremediation by microorganisms; Factors affecting the bioremediation process.

Suggested reading material:

- Doyle, M. P. & Beuchat, L. R., 2007, Food Microbiology- Fundamentals and Frontiers, ASM Press.
- Nduka Okafor, Benedict C. Okeke (2017). Modern Industrial Microbiology and Biotechnology. 2nd Edition: CRC Press Publishers.
- Soil Microbiology, Ecology and Biochemistry, 4th edition, edited by Eldor A. Paul, Published by Elsevier (2015)
- Biofertilizers, volume 1: Advances in Bio-inoculants, edited by Rakshit, Meena, Parihar, Singh and Singh, Published by Elsevier (2021).
- Marine Biology by Peter Castro and Michael, 10th edition by McGraw Hill (2015)

- Extremophiles: Microbial Life in Extreme Environments by Horikoshi and Grant, Published by Wiley (1998)
- Environmental Microbiology: Fundamentals and Applications: Microbial Ecology by Bertrand et al. (2015), Published by Springer Nature.

(V) Immunology

Unit 1: Principles of innate and adaptive immunity; Effector mechanisms – The first-lines of defense; complement system, Pattern recognition, induced innate responses to infection; Antigen recognition by B-cell and T-cell receptors; Structure of antibody molecule, the interaction of antibody molecule with specific antigen.

Unit 2: Antigen recognition by T cells; structural variation in Ig constant regions; antigen presentation to T lymphocytes, generation of T-cell receptor ligands, the MHC and its functions; T cell-mediated immunity, entry of naive T cells and APCs into peripheral lymphoid organs, priming of naive T cells by DCs; General properties of effector T cells and their cytokines, T cell-mediated cytotoxicity, macrophage activation by Th1 cells, Th2 cells, Th17 cells & Tregs; Humoral Immune Response- B cell activation by helper T cells; Distribution and functions of Ig classes; Destruction of antibody-coated pathogens via Fc receptors, Dynamics of adaptive immunity.

Unit 3: Antigen-antibody interactions - Principles, types and applications of agglutination, precipitation, complement fixation, viral neutralization, immunodiffusion, immunoelectrophoresis, IgG and IgM ELISA and RIA; Monoclonal antibodies – Hybridoma technology, Chimeric, Humanised and Therapeutic neutralising antibodies; Immunological methods- Serotyping, Immunoprecipitation, flocculation, complement fixation, tetramer technology, HLA-typing, Immunoblotting, flow cytometry based cell sorting of immune cells, cytokine arrays.

Suggested reading material:

- Janeway Immunobiology. 9th Edition. Publisher-Garland Science, 2016
- Abul K Abbas, Andrew H Lichtman & Shiv Pillai, Cellular & Molecular Immunology, 8th Edition 2014, Elsevier
- Roitt's Essential Immunology, 13th Edition, Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt 2016, Wiley-Blackwell.
- William E. Paul. Fundamental Immunology. 7th Edition. Lippincott Williams and Wilkins, 2012.