

**Central University of Haryana  
School of Interdisciplinary and Applied Sciences  
Department of Microbiology**

**SCHEME AND CURRICULUM**

**Ph.D. Microbiology  
(w.e.f. 2022)**



**Department of Microbiology  
CENTRAL UNIVERSITY OF HARYANA  
MAHENDERGARH, HARYANA**

## SCHEME AND CURRICULUM

### Ph.D. Microbiology

Semester	Core /Elective	Paper Code	Title of the Paper	Credit
I	Core	SIAS MB 02 01 01 C 4004	Research Methodology	4
	Core	SIAS MB 02 01 02 C 4004	Advanced Analytical Techniques	4
	Core	SIAS MB 02 01 03 C 2002	Research and Publication Ethics (RPE)	2
	Elective	SIAS MB 02 01 01 E 4004	Advanced Immunology	4
	Elective	SIAS MB 02 01 02 E 4004	Microbial Metabolism	4
	Elective	SIAS MB 02 01 03 E 4004	The Microbiome	4
	<b>Total</b>			<b>14</b>

**Course: Research Methodology**  
**Course code: SIAS MB 02 01 01 C 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** To provide knowledge about tools and techniques related with scientific communication, research methodology and biosafety in biological experiments.

**Learning outcomes:**

- Understanding the existence of scientific knowledge in ancient times
- Acquiring the skills of scientific reading, writing and presentations
- Appreciating the scientific ethics through case studies
- Understand the importance and level of biosafety at laboratory and industrial levels

**Unit 1. Identification and defining of the Research Problem:**

Familiarization of research areas; Review of literature using appropriate resources – reviews, research papers, books and patents; Use of tools for searching literature through electronic databases; Defining a research problem.

**Unit 2. Experimental Approaches and Methodology**

Experimental designs to address the research problem; Pros and cons of different experimental strategies; Finalization of experimental design; Tools and techniques to execute experiments; Means to validate and analyze data; Use of statistical tools for analyzing the significance and interpretation of the data; Measurement of central tendencies (Mean, Median, Mode); Measurement of variability (standard deviation, standard error of mean, range, mean deviation, coefficient of variation). Levels of significance; regression and correlation; t-test; Multiple range test; analysis of variance; chi square test.

**Unit 3. Ethics and Safety in Biological Research**

Guidelines for Biosafety and Bioethics; Institutional Biosafety Committee – Handling of Genetically modified organisms, Institutional Human and Animal Ethics Committee - compliance, concerns and approval; Safety practices and disposal of Bio-waste in the laboratory; Radioactivity and safety precautions; Handling and disposal of flammable and hazardous chemicals.

**Unit 4. Presentation, Publication and Protection of Research Data**

Development of skills for scientific writing and research presentation – Term paper, Research project, Research report, Thesis, Research article and Review; Organization of the research document in to different sections (Introduction, Methodology, Results, Discussion, and Summary and Conclusions, Bibliography); Use of electronic tools for bibliographic formatting and checking Plagiarism; Development of Oral presentation skills; Patents and Intellectual property rights.

**Students are expected to undertake the following assignments, exercises for evaluation.**

1. Identification and selection of the broad area of research
  2. Review of literature, formulation of research plan and submission of term paper along with references
  3. Oral presentation of research plan and experimental design
- Evaluation will be based on term paper and oral presentation

## Suggested readings

1. Communicate Science Papers, Presentations, and Posters Effectively (2015) Patience GS, Boffito DC, Patience P, Academic Press, ISBN: 978-0128015001.
2. Research Methodology: Methods And Techniques (2019) 4th ed., Kothari CR and Garg G, New Age International Publishers, ISBN: 978-9386649225.
3. Successful Scientific Writing: A Step-by-Step Guide for the Biological and Medical Sciences (2014) 4th ed., Matthews JR and Matthews RW, Cambridge University Press ISBN: 978-1107691933.
4. Doing Science: Design, Analysis, and Communication of Scientific Research. (2001) Valiela I, Oxford: Oxford University Press, ISBN 10:019538573X.
5. Beauchamp T.L., Walters L., Kahn J.P. & Anna C. Contemporary issues in Bioethics. Wardsworth Publishers. Co. 2013. Print
6. Cross C.L. and Wayne W.D. Biostatistics: Basic Concepts and Methodology for the Health Sciences. 10th edition, Wiley. 2014. Print
7. Davis, G.B. and Straub D.W. Writing the doctoral dissertation. 3rd edition. Barron's Educational series. 2012. Print
8. Deepa Goel. IPR, Biosafety and Bioethics. 1st edition. Pearson Education. 2013. Print
9. Krishnaswamy, K.N., Mathiranjani M., and Sivakumar, A.I. Management Research Methodology; Integration of Principles, Methods and Techniques. Pearson Education. 2011. Print
10. Montgomery, Douglas C. Design and Analysis of Experiments. 8th edition. Wiley. 2013. Print
11. Rao S and Richard J. Introduction to Biostatistics and Research Methods. 5th edition. Prentice Hall India Learning Private Limited. 2012. Print
12. IPR, Biosafety and Bioethics (2013) Parashar S, Goel D, Pearson Publishing India, ISBN: 9788131774700.
13. An Introduction to Ethical, Safety and Intellectual Property Rights Issues in Biotechnology (2017) Nambisan P, Academic Press, ISBN: 9780128092316.
14. <http://dbtindia.gov.in/guidelines-biosafety>

**Course: Advanced Analytical Techniques**  
**Course code: SIAS MB 02 01 02 C 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** To provide an advanced understanding of the core principles of various techniques used in biological experiments.

**Learning outcomes:**

- Demonstrate principles of various basic and advanced techniques used in biological experiments
- Critically analyze and interpret the results obtained from biological experiments

**Unit 1. Recombinant DNA techniques and Genomics**

Use of Restriction and modification enzymes in cloning; Plasmid vector; Transformation and Plasmid isolation; PCR; DNA sequencing methods (Sanger's chain termination method, and automated DNA sequencing); Next generation sequencing (NGS); Global expression profiling; Whole genome analysis of mRNA and protein expression; Real time PCR and Microarrays and their applications

**Unit 2. Proteomics and Nanotechnology**

UV and fluorescence spectroscopy; Circular Dichroism; Mass spectrometry - Principles and their applications; Protein separation techniques and instrumentation (Gel filtration, Ion exchange and Affinity chromatography, 1D and 2D Polyacrylamide gel electrophoresis); Immunochemical detection of proteins.; Introduction and overview of Metabolomics; Nanotechnology and its Applications in pharmaceutical Industry, Agriculture, Food Industry, Manufacturing Industry, and Renewable Energy Sector.

**Unit 3. Microbial and Cellular Techniques**

Microscopic techniques; Microbial growth and kinetics (synchronous culture, continuous and batch and fed-batch cultures, chemostat and turbidostat); Methods for identifying microbes (polyphasic approach); Cell disruption and fractionation of organelles; Isolation and purification of membrane proteins; Various methods to study cell-cell and cell-virus fusion; Flow cytometry techniques; Confocal and Atomic Force Microscopy; Types of Biosafety cabinets

**Unit 4. Experimental Models and instrumentation in Biology**

Rodent and non-rodent models, worms as models for studying human-microbe interactions, Handling and maintenance of animals, Ventilated cages, Different routes of injections and collection of various biological components, Formulation of feed and design of experiments. Principle, instrumentation and environmental applications of Neutron Activation Analysis, X- Ray Fluorescence, X-Ray Diffraction, AAS, Hyphenated techniques-LC-MS/MS, GC-MS/MS, HPTLC-MS, ICP-MS.

**Suggested readings**

1. Ausubel FW. Current Protocols in Molecular Biology. Wiley-Blackwell. 2011. Print
2. Burgess R. and Deutcher MP. Guide to Protein Purification. Academic Press, San Diego, USA. 2009. Print

3. Butler, M. Animal Cell Culture & Technology. 1<sup>st</sup> edition. Taylor & Francis Publishers (UK). 2004. Print
4. Freshney, R.I. Culture of Animal cells: A Manual of Basic Technique and specialized applications. 7<sup>th</sup> edition. Wiley-Blackwell. 2016. Print
5. Green M.R. and Sambrook J. Molecular Cloning: A Laboratory Manual. Vol. I, II, III. 4<sup>th</sup> edition. Cold spring harbor laboratory press. 2013. Print
6. Principles and Techniques of Biochemistry and Molecular Biology (2018) 8<sup>th</sup> ed. Wilson K and Walker J, Cambridge University Press, ISBN No. 131661476X.
7. Physical Biochemistry: Principles and Applications (2010) 2nd ed., Sheehan, D., Wiley Blackwell (West Sussex), ISBN: 978-0-470-85602-4 / ISBN: 978-0-470-85603-1.
8. Physical Biochemistry: Applications to Biochemistry and Molecular Biology (1982) 2nd ed., Freifelder D, W.H. Freeman and Company (New York), ISBN:0-7167-1315-2 / ISBN:0-7167-1444-2.
9. Instrumental methods of analysis (1988) 7th ed. H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle (United States).
10. D.S. Goodsell 2013 Bionanotechnology: Lessons From Nature, John Wiley
11. C. N. Banwell and E. M. McCash; Fundamentals of Molecular Spectroscopy, 4th Edition. Tata McGraw Hill, 1994.
12. D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan, Introduction to Spectroscopy, 5th Edition. Cengage India, 2015.

**Course: Research and Publication Ethics**  
**Course code: SIAS MB 02 01 03 C 2002**

**Credit: 2**

**Lectures: 30**

**Course objective:** To learn philosophy of science, research misconduct and integrity, publication plagiarism and ethics.

**Learning Outcomes:**

- Learn to identify the FFP in research and ethics of publication.
- Hands on session help to find research misconduct, predatory publication, publications metrics and plagiarism.
- To learn database citation and indexing of publication.

**Part A: THEORY**

**Unit1 Philosophy & ethics**

Introduction of Philosophy; definition, nature and scope, concept, branches. Ethics; definition, moral philosophy, nature of moral judgments and reactions.

**Unit II Scientific Conduct**

Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific Misconduct; falsification, fabrication and Plagiarism (FFP), Redundant publications; duplicate and overlapping publications, salami slicing.

**Unit III Publication Ethics**

Publication ethics; definition, introduction and importance. Best Practices/ standards setting initiatives and guidelines: COPE, WAME etc., Conflict of Interest, Publication misconduct: definition, concept, problems lead to unethical behavior and vice-versa, types, Violation of publication ethics, authorship and contributor-ship, Identification of publication misconduct, complaint and appeals, Predatory publications and journals.

**Part B: PRACTICE**

**Unit IV Open Access publishing**

Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-achieving policies, Software tools to identify predatory publications developed by SPPU, Journal finder Journal suggestion tools vis. JANE, Elsevier journal finder, Springer journal suggester etc.

**Unit V Publication Misconduct**

Group discussion; Subject specific ethical issues, FFP, Authorship, Conflict of interest, Complaint and appeals; example and fraud from India and abroad. Software tools; turnitin, urkund and other open source plagiarism tools.

**Unit VI Database and Research Metrics**

Database: Indexing citation database; Web of Science and Scopus etc., Research metrics; Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite score, Metrics; h index, g index, i10, altmetrics.

**Course: Advanced Immunology**  
**Course code: SIAS MB 02 01 01 E 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** To understand overall organization of the immune system and to identify the cellular and molecular basis of immune responsiveness.

**Learning outcomes:**

- Understanding the working mechanism of the immune system
- Understanding of antibody, MHC, complement system, cytokines, cancer, and organ transplant hypersensitivity

**Unit 1. Receptors of the immune cells**

Detailed structure of B and T cell receptors, co-receptors and accessory proteins; Structural features of CD4, CD8 receptors and; Cellular adhesion molecules *viz.* ICAM, VCAM, MadCAM, selectins and integrins; Structure and distribution of Major Histocompatibility Complex I and II and their interaction with antigens; Markers of suppressor / regulatory cells *eg.* CD4<sup>+</sup> CD25<sup>+</sup> Foxp3<sup>+</sup> T<sub>reg</sub>; Natural killer T cells (NKT)

**Unit 2. Genetic organization of the receptor genes:**

Genetic organization of B and T cell receptors coding genes; Genetic organization of MHC-I and MHC-II complex (both HLA and H-2); Mechanisms responsible for generating antibody diversity and diversity of T cell receptor specificities

**Unit 3. Mechanisms of Immune recognition and response:**

Detailed mechanisms of humoral and cell-mediated immune responses; Antigen presentation by MHC-I and MHC-II molecules; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, IL-6, IL-10, IL-12, IL-17, TGFβ; Complement System; Pattern recognition receptors (PRRs) and Toll-like receptors (TLR); Cell signaling through NF-κB; Natural Killer - Dendritic cells (NK-DC) interactions; CD-1 restricted T cells;

**Unit 4. Applied Topics in Immunology:**

Autoimmune diseases induced by microbes; Deficiencies / defects of T cells and B cells; Mucosal immunology; Comparative analysis of type I-IV hypersensitivities; Alloreactive T cells; Graft rejection and GVHD; Sequence based HLA-matching; Immunodiagnostics; CRISPR-Cas9 system and transgenic animals for xenotransplantation; Immunotherapy for tumors in humans

**SUGGESTED READINGS**

1. Kuby Immunology (2018) 8<sup>th</sup> ed., Punt J, Stranford S, Jones P and Owen JA, W.H Freeman and Company, ISBN: 978-1319114701.
2. Janeway's Immunobiology (2017) 9<sup>th</sup> ed., Murphy KM and Beaver C, WW Norton and Company, ISBN: 978-0815345510.
3. Roitt's Essential Immunology (2017) 13<sup>th</sup> ed., Delvis PJ, Martin SJ, Burton DR and Roitt, IM, Wiley-Blackwell, ISBN: 978-1118415771.

4. Lehninger: Principles of Biochemistry (2017) 7<sup>th</sup> ed., Nelson, DL and Cox, MM, WH Freeman and Company (New York), ISBN: 978-1319108243.
5. Lippincott's illustrated Reviews Immunology (2012) 2<sup>nd</sup> ed., Doan T, Melvold R, Viselli S and Waltenbaugh, C, Wolters Kluwer India Pvt, Ltd, ISBN: 978-8184737639.

**Course: Microbial Metabolism**  
**Course code: SIAS MB 02 01 02 E 4004**

**Credit: 4**

**Lectures: 60**

**Course objective:** The course is designed to describe metabolic and physiological diversity among prokaryotes.

**Learning outcome:**

- Learning of principles of microbial catabolic and anabolic pathways
- Understanding the transport systems and the mechanisms of energy conservation in microbial metabolism
- Identifying various physiological groups of bacteria with their special features

**Unit 1. Microbial growth and growth kinetics:**

Bacterial growth curve, generation time, measurement of microbial growth, growth kinetics, synchronous culture, continuous and batch culture, chemostat and turbidostat, environmental factors that affect growth, nutritional diversity in bacteria; Nutrient transport in microbes - Active and passive transport, Primary and secondary transport, Transport kinetics, ABC transporter, PEP-PTS system

**Unit 2. Diversity and regulation of glucose metabolism in microbes:**

Embden-Meyerhof-Parnas pathway; Variations of EMP pathway in different groups of bacteria; Overall energy balance sheet; Regulation of the EMP pathway; Modes of NAD regeneration; Pentose phosphate pathway – HMP pathway and its link with glycolysis; Fermentative mode of glucose oxidation - Entner-Doudoroff pathway; Variations of ED pathway in different groups of microbes and its implications; Fates of pyruvate; Alcoholic and lactic acid fermentation; Citric acid pathway – Stoichiometry and energy gain; Regulation; Alternate forms of TCA - Reductive TCA, Branched TCA; Glyoxylate cycle

**Unit 3. Nitrogen metabolism:**

Nitrogen assimilation; GS-GOGAT pathway and its regulation; Utilization of other modes of nitrogen, nitrate and nitrite utilization; amino acid biosynthetic pathways and their regulation; Amino acid utilization – reductive amination and deamination, decarboxylation; Stickland reaction; Amino acid oxidases, Polyamine biosynthesis and utilization

**Unit 4. Metabolic engineering:**

Introduction to primary and secondary metabolism; Classification of secondary metabolites; Introduction to metabolic engineering – strain development and pathway engineering; Case studies on primary metabolites viz. citric acid, succinic acid, lactic acid, ethanol fermentation, amino acid pathways (glutamate, lysine, shikimic acid); Case studies on secondary metabolites viz. polyhydroxyalkanoates, polyketides and antibiotics

**Suggested Readings**

1. Albert G. Moat, John W. Foster, Michael P. Spector. *Microbial Physiology*. 4<sup>th</sup> edition. John Wiley & Sons. 2002. Print

2. Michael M. Madigan, Kelly S. Bender, Daniel H. Buckley, W Matthew Sattley, David A. Stahl, 15<sup>th</sup> edition, 2018, ISBN-13: 9780134261928 Pearson publications
3. Stanier RY, Adelberg EA, Ingraham JL. *General Microbiology*. 4<sup>th</sup> edition. Macmillan Press, London. 1976. Print
4. An Introduction to Microbiology (2019), 3<sup>rd</sup> ed., Tauro P, Kapoor KK, Yadav KS, and Sequeira MG, New Age International Publishers. ISBN: 0852268785
5. Microbial Biochemistry (2014) Cohen GN, 3rd edition. Springer Netherlands. ISBN 978-90-481-9437-7
6. The Physiology and Biochemistry of Prokaryotes. (2011) White D, Dummond J and Fuqua, C, 4th edition. Oxford University Press. ISBN: 9780195393040
7. Prescott's Microbiology (2017) 10<sup>th</sup> ed., Willey J, Sherwood L and Woolverton CJ. McGraw-Hill Education, ISBN: 1259281590
8. A text book of Microbiology (2013), Dubey RC and Maheswari, DK Revised S. Chand and Company Ltd, New Delhi. ISBN: 9788121926201

**Course Title: The Microbiome**  
**Course Code: SIAS MB 02 01 03 E 4004**

**Credit: 4**

**Lectures: 60**

**Unit-I**

History of the study of the microbiome; designing a microbiome study (hypotheses, methods, technologies); methods to study microbiome- DNA-based analysis of microbial communities, 16S rRNA gene amplicon sequencing and shotgun metagenomics sequencing methods; Functional analysis of the microbiome from DNA sequence functional analysis, metatranscriptome, metabolome, proteome, and glycome; **Overview of online tools and databases for microbiome analysis.**

**Unit-II**

Techniques used to analyse microbiome data- assignment of taxonomy; generating OTU tables, quality control: Describing the complexity of the microbiome eg. alpha and beta-diversity; comparing microbial communities, phylogenetic trees, UniFrac, principal coordinate analyses, Venn diagrams, heat maps; development of new bioinformatics methods for microbiome studies. Functional studies of the Microbiome- Measurement of microbial products (the metabolome, proteome and glycome; role of microbiome and its products, nutrition, metabolism, the gut brain axis, and in immune-inflammatory processing.

**Unit-III**

Introduction to the Human Microbiome; The Human Microbiome Project (HMP); Diversity of the Human Microbiome- Oral microbiome, Gut microbiome, Skin microbiome, Vaginal microbiome; Gut microbiome changes in various diseases including liver diseases, obesity, diabetes, and other disorders; the mycome and virome in health and disease. Direct health effects of gut microbiome; modification of the microbiome- Effects of antibiotics, probiotics and prebiotics. Faecal transplant; microbiome in treatment of diseases.

**Unit-IV**

The plant microbiome: structure and function: above and below ground plant microbiome. Plant microbiome engineering to improve plant health. Soil microbiome- Structure, functions and its manipulation for better soil health. Rumen microbiome: composition, abundance and diversity. Animal behavior and the microbiome. Environmental microbiome; Insect gut microbiome-structure and ecological importance. Microbiomes of the built environments; Human health and microbiomes of the built environment.

**Suggested readings:**

1. Unravelling the Soil Microbiome: Perspectives for Environmental Sustainability (2020) 1<sup>st</sup> ed., Dubey RK, Tripathi V, Prabha R, Chaurasia R, Singh DP, Rao CS, El-Keblawy A and Abhilash PC, Springer Cham, ISBN: 978330155155.

2. Microbiome and Metabolome in Diagnosis, Therapy and other strategic Applications (2019) 1<sup>st</sup> ed., Faintuch J and Faintuch S. Academic Press (New York) ISBN: 9780128152492.
3. Diet, Microbiome and Health (2018) 1<sup>st</sup> ed., Holban AM, Grumezescu AM. Academic Press (New York), ISBN: 9780128114407.
4. Functional importance of the plant microbiome: Implications for agriculture, forestry and bioenergy (2017) 1<sup>st</sup> ed., Doty SL. Springer Cham. ISBN: 978-3-319-65896-4.
5. Microbiome Analysis: Methods and Protocols. (2018) 1<sup>st</sup> ed., Beiko RG, Hsiao W and Parkinson J. Springer New York. ISBN: 9781493987269.
6. The Gut Microbiome in Health and Disease (2018). 1<sup>st</sup> ed., Haller D. Springer International Publishing. ISBN 978-3-319-90544-0.