DEPARTMENT OF MICROBIOLOGY

University of Delhi South campus

New Delhi-110021

Ph.D. Coursework

Passed in DRC held on 29th August, 2017

Ph.D. in Microbiology

All students admitted to the Ph.D. programme at the Department of Microbiology have to take **a minimum of 2 courses of 4 credits each**. One of these, **MICROB-I Research Methodologies, is a compulsory course**. Students have to take **at least 1 additional course** which may be from the 4 optional papers of the Department (MICROB-II, MICROB-III, MICROB-IV, MICROB-V) or from the optional papers floated by the other departments of the FIAS. Students can also opt for one / two additional courses if they wish.

The detailed syllabi for the courses offered by the Department is appended with a list of suggested readings. **All courses offered by the Department of Microbiology are 4 credit courses** (4 h/week x 16 weeks)

The proposed Programme shall be governed by the Department of Microbiology, Faculty of Interdisciplinary and Applied Sciences, University of Delhi South Campus.

PROGRAMME STRUCTURE

Paper Number	Name of the Paper	No. of credits	Maximum Marks
Compulsory Paper			
MICROB-I	Research Methodologies	4	100
Optional Papers			
MICROB-II	Microbial Metabolism	4	100
MICROB-III	Principles of Genetic Engineering	4	100
MICROB-IV	Advanced Immunology	4	100
MICROB-V	Fermentation Technology	4	100

MICROB-I

RESEARCH METHODOLOGIES

An introduction to research methods and methodology. Meaning of the research. What constitutes a research topic? How to select a research topic? Thinking like a researcher – understanding concepts. **6**

Importance of literature review. Need for reviewing literature, what to review and for what purpose, literature search procedure, sources of literature. **6**

Hypothesis generation and hypothesis testing. Defining the research problem, Formulation of the research hypotheses, the importance of problems and hypotheses. Qualities of a good hypothesis. Procedure for hypothesis testing. **8**

Research Design. The planning process. Selection of a problem for research. Research design: concept and importance in research. Recognizing and minimizing bias. The importance of controls. **8**

Data interpretation; objectivity, quantification, double blind studies and necessity of statistics. Data Analysis: frequency tables, bar charts, pie charts, percentages, testing hypothesis of association, student t test for statistical significance. **6**

Research work presentation and knowledge dissemination. Writing research paper, paper presentation in scientific conference, preparing PowerPoint presentation. Layout of a Research Paper, impact factor of journals, when and where to publish? **8**

Good lab practices, Biosafety, radiation safety, Record keeping, organizing data, organizing the lab space. **6**

Ethical issues related to publishing, plagiarism and self-plagiarism. Ethical issues in conducting research. What is ethics, the different interpretations & historical instances of unethical science? Case studies: data fraud/ plagiarism and human ethics violation. **8**

Use of tools / techniques for Research: methods to search required information effectively, reference management software, software for detection of plagiarism, image processing software. **8**

Study material and reference books:

1. Research Methodology: Methods and Techniques by C. R. Kothari, New Age International Publishers, ISBN:81-224-1522-9

2. Evans, I., Thornton, H., & Chalmers, I. . Testing treatments: Better research for better healthcare. 2nd Ed. London: Pinter & Martin., 2011. Type: Text: ISBN: 978-1-905177-48-6. This book is available for free download at http://www.testingtreatments.org/

MICROB-II

MICROBIAL METABOLISM

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 affecting growth, nutritional diversity in bacteria **8**

Solute transport: Active and passive transport, Primary and secondary transport, Transport kinetics, ABC transporter, PEP-PTS system, catabolite repression, inducer expulsion **6**

Diversity and regulation of glucose metabolism in microbes: Embden-Meyerhof-Parnas pathway - Variations of EMP pathway in different groups of bacteria; Overall balance sheet; Regulation; Modes of NAD regeneration; alcoholic and lactic acid fermentation, 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, Fate of pyruvate, Citric acid pathway – Stoichiometry and energy gain; Regulation; Alternate forms of TCA; Reductive TCA; Branched TCA; Glyoxylate cycle **18**

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 – reduction amination and deamination; decarboxylation; Stickland reaction; amino acid oxidases, polyamine biosynthesis and utilization **6**

Lipid metabolism: Biochemistry of lipids, lipid distribution in different groups of microbes, fatty acid biosynthesis, synthesiws of different types of lipids – neutral lipids; phospholipids and glycolipids, biosynthesis of archaeal lipids, synthesis of storage lipids, lipid utilization, beta-oxidation pathway – regulation and energy calculation, Lipid accumulation pathway, biochemical and molecular distinction between oleaginous and non-oleaginous microbes **8**

Programming metabolism in relation to overproduction of selected metabolites: 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 **18**

Study material and reference books:

1. "Physiology and Biochemistry of Prokaryotes" by David White, published by Oxford University Press, 4th edition, 2011
2. "Microbial Biochemistry" by G. N. Cohen published by Springer Netherlands, 3rd edition, 2014
3. "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, published by John Wiley & Sons, 4th edition, 2002
4. "Biochemistry" by Geoffrey Zubay, published by William C Brown, 4th edition, 2002
5. "The Metabolic Pathway Engineering Handbook" by Christina Smolke, published by CRC Press, 2009

MICROB-III

PRINCIPLES OF GENETIC ENGINEERING

DNA cloning techniques: Basics of DNA cloning. Use of linkers and adaptors in cloning. Use of different vectors: plasmids, lambda phage, M13 phage, phagemids, cosmids, P1 phage, PACs, BACs and YACs. Selection of clones by insertional inactivation, screening by RFLP analysis. **6**

Analysis of DNA and proteins: Agarose gel electrophoresis and polyacrylamide gel electrophoresis for analysis of DNA. Pulsed Field Gel Electrophoresis. Southern and Northern Blotting. Selection and design of probes to be used. Radiolabelling of probes. DNA fingerprinting and its application in forensics, disease diagnosis and parentage. Analysis of proteins by native PAGE, SDS-PAGE and two-dimensional PAGE. Western Blotting analysis. **4**

Polymerase Chain Reaction: Concept of PCR. Primer design. Cloning of PCR products. Use of Inverse PCR, Ligation Chain Reaction, Overlapping PCR. Identification of strains by RAPD. Reverse-transcription –PCR and its uses: 5' and 3' RACE, MOPAC, Real time PCR. **8**

Construction of genomic and cDNA libraries: Vectors used in the construction of cDNA versus genomic DNA libraries. Library construction. Library screening by colony hybridization and colony PCR. Screening of expression libraries. Use of subtractive hybridization and positive selection in enrichment. **6**

Genome sequencing: DNA sequencing by Sanger's method. Whole genome shotgun sequencing. Clone-by-clone shotgun sequencing of genome – from preparation of BAC/YAC library to finished sequence. The sequencing of the human genome. Use of STSs in physical mapping of the human genome. Genome annotation at the nucleotide level, protein level and process level. Overview of next generation sequencing methods. **6**

Analysis of gene expression and transcriptomics: Use of reporter genes - enzymatic and bioluminescent reporters. Promoter analysis – deletion analysis and linker scanning analysis coupled to reporter assays, S1 nuclease mapping, primer extension / 5' RACE. Transcriptome analysis by differential Display-PCR, EST analysis, DNA microarrays, Serial Analysis of Gene Expresion (SAGE), RNA-Seq. **8**

Overexpression of recombinant proteins: Expression in *E.coli* driven by different promoters. Expression systems in *S.cerevisiae* and *P.pastoris*. Baculovirus expression system. Mammalian expression systems. **6**

Analysis of protein-DNA and protein-protein interactions: Electrophoretic mobility shift assays, DNA footprinting by DNase I and dimethyl sulphate, ChIP- chips. Yeast two hybrid, three-hybrid, split hybrid and reverse hybrid systems. Co-immunoprecipitations and pull-downs. Use of GFP and FRET. Phage display. **8**

Protein engineering and proteome analysis: Insertional and deletion mutagenesis. Site directed mutagenesis by conventional and PCR-based methods. Proteome analysis by 2D gel electrophoresis coupled to mass spectrometric analysis. Protein arrays and their applications. **8**

Pharmaceutical products of DNA technology: Human protein replacements – insulin, hGH and Factor VIII. Human therapies – TPA, interferon, antisense molecules. Vaccines – Hepatitis B, AIDS, and DNA vaccines. **4**

Study material and reference books:

1. Molecular Biology by David P. Clarke, 2012.
2. Molecular Cloning: A laboratory manual by Joseph Sambrook & David Russell, 2001.
3. DNA Technology : The Awesome Skill by I. Edward Alcamo, 2001.
4. Molecular Biology of the Gene by James Watson, Tania Baker, Stephen Bell, Alexander Gann, Michael Levine & Richard Losick, 2007.

MICROB-IV

ADVANCED IMMUNOLOGY

Receptors of the immune cells: Detailed structure of B and T cell (TcR) receptors, co-receptors and accessory molecules; Structure of CD4, CD8 receptors and, cellular adhesion molecules *viz.* ICAM, VCAM, MadCAM and selectins; Structure and distribution of major histocompatibility I and II antigens or molecules, integrins. Markers of suppressor / regulatory cells - $CD4^+$ $CD25^+$ $Foxp3^+$ T_{reg}; Markers of invariant natural killer T cells (iNKT). **12**

Genetic organization of the receptor genes: Organization of the genes for B and T cell receptors. Genetic organization of MHC-I and MHC-II complex (both HLA and H-2). Mechanisms responsible for generating diversity of antibody specificities and diversity of T cell receptor specificities. **12**

Mechanisms of Immune response: Peptide loading and expression of MHC-I and MHC-II molecules; Detailed mechanisms of humoral and cell-mediated immune responses; Major cytokines and their role in immune mechanisms: TNF, IFN, IL-1, IL-2, IL-4, 1L-6, 1L-10, 1L-12, IL-17, TGFβ; **10**

Paradigm shift in immunology: Pattern recognition and innate immunity, 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. Interaction between specific and innate immune responses. **10**

Bacterial and viral infections leading to immunological disorders – Microbial role in development of autoimmune diseases, deficiencies / defects of T cells, and B cells; Mucosal immunology; Comparative analysis of type I-V hypersensitivities. **10**

Applied immunology: Alloreactive T cells; Managing graft rejection and GVHD; Sequence based HLA-matching; Immunodiagnostics; CRISPR-Cas9 and transgenic animals for xenotransplantation; Immunotherapy of tumors in humans. **10**

Study material and reference books:

1. Current Opinion in Immunology (Systemic Reviews Journal with educational platform), Available online through Science Direct, Supports OA, Available from 2016 backwards, Elsevier.
2. Cellular and Molecular Immunology by Abbas AK, Lichtman AHH, Pillai S:7^{th} edition. Saunders; 2014.
3. Fundamental Immunology by Paul WE: 7^{th} edition. New York. Lippincott Williams and Wilkins; 2013.
4. Janeway's Immunology by Murphy K: 8^{th} edition. New York. Garland Science (Taylor and Francis Group) Publishing; **2012**.

MICROB-V

FERMENTATION TECHNOLOGY

Introduction: History and development, Microbes for different fermentation processes

Isolation, preservation and improvement of microbial strains: Source of microbes, Isolation, selection and culture collection banks, Preservation of industrially important microbes; Sterilization techniques, Strain development (*mutagenesis*, metabolic engineering and recombinant DNA techniques) **8**

Upstream bioprocess development: Growth, elemental balances, Stoichiometric coefficient for cell growth and product formation. Growth and product formation Kinetics, processes optimization, Types of fermentation processes: Solid state and submerged fermentation, Batch, fed-batch and continuous fermentation strategies and their application, Types of fermenters (airlift, stirred tank and bubble column fermenter) **16**

Bioreactor design and control: Basic functions and design (Body construction, agitators, mechanical seal, magnetic drives, baffles, sampling port) reynolds number, power input, fluid dynamics, oxygen transfer and utilization rate, measurements of volumetric mass-transfer coefficient K_La, instrumentation for online monitoring and controls **12**

Downstream process development: Membrane filtration, centrifugation and different types of industrial centrifuges designs, sedimentation, flocculation, cell disruption (physico-chemical, mechanical, enzymatic), liquid–liquid extraction, crystallization, spray drying and chromatography based techniques for product recovery **12**

Process economics: Cost determination of bioprocesses, capital investment in equipment's and raw material, scale up and scale down of fermentation processes (industrial potential, Recovery costs, water usage and recycling, effluent treatment) **6**

Industrial fermentation processes for production of: Antibiotics (*penicillin*, *streptomycin, cephalosporins)* amino acids (*glutamic acid*, *lysine and phenylalanine)*, industrial alcohol (ethanol, butanol), recombinant enzymes and bio-therapeutic products, products of bioconversion processes **10**

Study material and reference books:

1. Principles of Fermentation Technology (2nd Edition, 2013) by P.F. Stanbury, W. Whitaker & S.J. Hall, Elsevier India Pvt. Ltd. New Delhi-110001.
2. Bioprocess Engineering Principles (2nd Edition, 2012) by Academic Press/Elsevier India Pvt. Ltd. New Delhi-110001.
3. Bioprocess Engineering: Basic Concepts (2nd Edition, 2011) by Michael L. Shuler and Fikert Kargi Prentice Hall India learning Pvt. Ltd. New Delhi;
4. Biotechnology: A Text Book of Industrial Microbiology (2000) by W. Crueger & A. Crueger, Panima Publishing Corporation, New Delhi/Bangalore.
5. Modern Industrial Microbiology & Biotechnology (2007) by N. Okafer, Scientific Publishers, Enfield, USA.