COURSEWORK SYLLABUS FOR THE PhD PROGRAM IN THE WATSON-CRICK CENTER FOR MOLECULAR MEDICINE

WATSON-CRICK CENTER FOR MOLECULAR MEDICINE

ISLAMIC UNIVERSITY OF SCIENCE & TECHNOLOGY KASHMIR

Coursework Syllabus for the Ph.D. program in Watson-Crick Centre for Molecular Medicine, Islamic University of Science and Technology, Kashmir

Course Code	Title of Paper	Hrs./ week	L	T	P	S	Credits	Marks
WC-RMBB801	Research Methodology, Bioinformatics and Biostatistics	4	3	1	0	0	4	**100** Midterm:50 Endterm:50
WC-MBDM802	Molecular Biology and Disease Models	4	3	1	0	0	4	**100** Midterm:50 Endterm:50
WC-MI803	Microbiology and Immunology	2	1	1	0	0	2	**100** Midterm:50 Endterm:50
WC-PW804	Project Writing	2	0	2	0	0	2	**50** Midterm:25 Endterm:25
WC-JC805	Seminar/Journal Club	1	0	1	0	0	1	**50** Endterm:50

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Paper I: Research Methodology, Bioinformatics, and Biostatistics **Credits: 04**
Course Code: WC-RMBB801 **Marks: 100**

Course Objectives:

- To equip students with a comprehensive understanding of research methodologies, including hypothesis formulation, experimental design, and literature review.
- To develop proficiency in scientific writing, manuscript preparation, and reference management tools for research documentation.
- To introduce fundamental concepts of bioinformatics, biostatistics, and computational tools essential for data analysis and interpretation.

Course Learning Outcome:

- Upon completing this course, students can design, conduct, and document scientific research using appropriate methodologies, analyze biological data using statistical and computational tools, and effectively communicate their findings through research manuscripts and presentations.

Unit I: **Research Methodology** **(15 Lectures)**

Definition and types of research (Descriptive, Analytical, Applied, Fundamental, Qualitative, Quantitative, Conceptual, and Empirical), Significance of Research, formulation of research problem, hypothesis and research objectives, Types of Research Designs, Basic Principles of Experimental Designs, Design of experiments, Literature survey, writing a research report, Synopsis, Research paper, Review article.

Unit II: Preparation of Research Manuscript **(15 Lectures)**

Literature Survey, identification of research topic, compilation of information, Preparation of transcript: Special elements: title page, table of contents, headings and sub-headings, footnotes, tables and figures, appendix, bibliography (EndNote, Mendeley, Reference Manager), etc.

Unit III: Basics of Bioinformatics and Databases **(15 Lectures)**

History of bioinformatics. Major Bioinformatics resources, Nucleic Acids Research database. Protein three-dimensional databases, Protein sequence databases. Commonly used sequence formats (FASTA and Swissprot format, European Molecular Biology Laboratory data library format). **Phylogeny: Sequence alignment**. Sequence comparison scoring systems: PAM and BLOSUM family of matrices, Basics of Global and local alignments, Pair-wise alignment: Dot matrix analysis. Multiple sequence alignment is an extension of sequence pair alignment by dynamic programming. Phylogenetic analysis, Definition, and description of phylogenetic trees and various types of trees.

Unit IV: Biostatistics & Biostatistics Tools **(15 Lectures)**

Biostatistics-Using statistics to summarize Data Sets (mean, mode, median; Sample Variance and Sample Standard Deviation). Testing the statistical hypothesis: Hypothesis Tests and Significance Levels; Tests concerning the mean of a Normal Population: Case of known Variance; The t-test for the mean of a Normal Population: Case of Unknown Variance. Chi-squared

goodness-of-fit tests. Computer application to statistical packages like SPSS & GraphPad Prism, use of computers in data analysis: MS Excel and Sigma plot analysis.

Recommended Books:

1. Research Methodology: Methods and Techniques. Kothari, C. R. New Age International Publishers.
2. How to Write and Publish a Scientific Paper?; Robert A. Day, Barbara Gastel; Cambridge: Cambridge University.
3. Research Methodology, Methods, and Statistical Techniques; Santosh Gupta; New Delhi: Deep & Deep Publications.
4. Fundamentals of Biostatistics, Rosner. Brooks/Cole, Boston, MA.
5. Introduction to the Practice of Statistics, Moore, and McCabe. Freeman and Co., New York.
6. Introduction to Mathematical Statistics, Hoel. John Wiley & Sons, Inc, New York.

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Paper II: Molecular Biology and Disease Models **Credits: 04**
Course Code: WC-MBDM802 **Total Marks: 100**

Course Objectives:

- To provide a fundamental understanding of recombinant DNA technology and its applications.
- To familiarize students with key enzymes and vectors used in genetic engineering.
- To introduce molecular biology techniques such as PCR, cloning, gene silencing, gene editing, and sequencing.

Course learning Outcome:

- By the end of the course, students will be able to apply recombinant DNA techniques for cloning, gene editing, and sequencing and explore their applications in genomics, therapeutics, and biotechnology.

Unit I: Cell Biology (15 Lectures)

Cell Membrane: Structure and function. Cytoskeleton: Structure and function. Cell Cycle Regulation, Cell Division, Protein Trafficking and Secretion, Autophagy and Apoptosis, Stem Cell Biology, Cellular Bioenergetics, Tissue Culture, its types and cell lines, Organoids, and 3D Cell Culture, Techniques in Cell Biology.

Unit II: Cancer Biology (15 Lectures)

Introduction and hallmarks of cancer. Etiological factors, Oncogenes, tumor suppressor genes, and aberrant signaling pathways. Tumor microenvironment and its components. **Mouse models**: Athymic Nude mice, NICD, Genetically Engineered Mouse Models (GEMM), and xenograft models (subcutaneous xenografts, orthotopic implants) in cancer research. Anesthetizing the animals, aseptic surgery, and euthanasia.

Unit III: Recombinant DNA Technology (15 Lectures)

Introduction to recombinant DNA technology. Restriction enzymes: nomenclature, mode of action, and applications of Type II restriction enzymes. Enzymes in genetic engineering: Terminal deoxynucleotidyl transferase, kinases, phosphatases, DNA ligases, DNA polymerases, reverse transcriptases, and nucleases (Exonuclease III, BAL-31, mung bean nuclease, and S1 nuclease).

Cloning and expression vectors in E. coli, Yeast expression vectors, and mammalian expression vectors (retroviral and lentiviral vectors).

Unit IV: Tools and Techniques of Recombinant DNA Technology (15 Lectures)

Polymerase Chain Reaction (PCR): Primer design, applications, and specialized PCR techniques Real-Time PCR, deletion, addition, overlap extension, SOEing. Transformation and screening of clones. Cloning using linkers and adaptors.

Gene silencing: siRNA and shRNA technology, construction of shRNA vectors, principles, and applications. CRISPR/Cas9 technology. Gene delivery methods: liposomes and viral vectors.

Genomic and cDNA libraries: Preparation, screening (colony hybridization, colony PCR), and applications. DNA sequencing methods: Maxam-Gilbert and Sanger sequencing.

Suggested Readings:

1. Robert A. Weinberg (2013). The Biology of Cancer (2nd Edition)
2. Primrose and Twyman (2006). Principles of Gene Manipulation and Genomics. Blackwell

3. Brown (2006). Gene Cloning and DNA Analysis - An Introduction. Blackwell
4. Kracher. Molecular Biology - A Practical Approach.
5. Robertson et al. (1997). Manipulation & Expression of Recombinant DNA. AP
6. Sambrook et al (2010). Molecular Cloning. CSHL
7. Twyman (1999). Advanced Molecular Biology. Viva
8. Alberts et al. (2015) - Molecular Biology of the Cell
9. Cooper and Hausman (2019) - The Cell: A Molecular Approach
10. Milo and Phillips (2015) - Cell Biology by the Numbers
11. Lodish et al. (2021) - Molecular Cell Biology
12. Alberts et al. (2018) - Essential Cell Biology

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Paper – III: Microbiology and Immunology **Credits: 02**

Course Code: WC-MI803 **Total Marks: 50**

Course Objectives:

- To provide an in-depth understanding of microbial genetics, including horizontal gene transfer and mobile genetic elements.
- To explain mechanisms of microbial pathogenesis, including virulence factors and host-pathogen interactions
- To discuss emerging and re-emerging infectious diseases and antimicrobial resistance mechanisms

Course learning Outcome:

- By the end of the course, students will understand microbial genetics, virulence factors, and host-pathogen interactions. They will analyze antimicrobial resistance and emerging infectious diseases.

UNIT I: Microbiology (15 Lectures)

Microbial Genetics: Horizontal gene transfer and significance in microbial evolution. Plasmids and transposons. Host-Microbe Interactions: Mechanisms of colonization, invasion, and immune evasion. Virulence Factors: Role of adhesins, toxins, and biofilms in microbial pathogenesis. **Antimicrobial Resistance**: Enzymatic degradation, efflux pumps, target modifications, biofilm-associated resistance. Spread of multidrug-resistant organisms and global health implications.

UNIT II: Immunology (15 Lectures)

Cells and Organs of the Immune System: Key components and their roles in immunity. Innate Immunity: Molecular and cellular mechanisms, pattern recognition, and inflammatory responses. Adaptive Immunity: T cells, B cells, and antigen presentation. Cytokines and Chemokines: Functions in immune signaling and inflammation. Immune Checkpoints: Role in regulation and implications for therapy. Tumor Immunology: Mechanisms of immune surveillance and tumor escape.

Suggested Books:

1. Madigan, Bender, Buckley, Sattley, Stahl (2021) - Brock Biology of Microorganisms
2. Mark Gladwin and Bill Trattler (2018) - Clinical Microbiology Made Ridiculously Simple
3. Murray, Rosenthal, and Pfaller (2020) - Medical Microbiology
4. James W. Brown (2015) - Principles of Microbial Diversity
5. Murphy and Weaver (2022) - Janeway's Immunobiology
6. Abbas, Lichtman, and Pillai (2022) - Cellular and Molecular Immunology
7. Owen, Punt, and Stanford (2018) - Kuby Immunology
8. Robert C. Rees and Jennie L. Good (2015) - Tumor Immunology and Immunotherapy

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Paper IV: Project Writing **Credits: 02**
Course Code: WC-PW804 **Total Marks: 50**

Course Objectives:

- To develop the ability to formulate a well-structured research proposal that aligns with ongoing departmental research.
- To enhance critical analysis and synthesis of existing literature as preliminary data for grant writing.
- To prepare students for successfully defending their research proposal before the Departmental Research Committee (DRC).

Course Learning Outcome:

- Upon completing this course, students can design and articulate a compelling research proposal, effectively integrate existing literature as supporting evidence, and confidently present and defend their proposal before an academic committee.

Unit I: Project Writing

In this course, the Ph.D. student will prepare a research proposal that aligns with the ongoing research in the department/lab. The existing literature will be used as preliminary data in the grant proposal. After submitting the grant proposal, the student has to defend it before the DRC. Qualifying for the comprehensive for finishing the course work will be mandatory.

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Paper V: Journal Club/Seminar **Credits: 01**
Course Code: WC-JC805 **Total Marks: 50**

Course Objectives:

- To enhance students' ability to critically analyze and present high-impact research papers across various scientific domains.
- To foster interdisciplinary learning by encouraging discussions beyond students' research interests.
- To provide exposure to diverse expertise and emerging trends through participation in invited talks.

Course Learning Outcome:

- Upon completing this course, students will develop critical thinking and presentation skills, gain interdisciplinary knowledge, and stay updated with cutting-edge research through engagement with high-impact scientific literature and expert talks.

Unit I: Journal Club

As part of their academic coursework, Ph.D. students must present a high-impact research paper that could address topics within and beyond their specific research interests, offering fresh perspectives to the audience. Moreover, attending all invited talks is mandatory, providing scholars with exposure to diverse expertise and current trends in their field of study.