Course work Syllabus for Ph.D. program in Watson-Crick Centre for Molecular Medicine, Islamic University of Science and Technology, Awantipora

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

Unit I: **Research Methodology** **(30 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. 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 II: 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 as an extension of sequence pair alignment by dynamic programming. Phylogenetic analysis, Definition and description of phylogenetic trees and various types of trees.

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

Biostatistics-Using statistics to summarize Data Sets (mean, mode, median; Sample Variance and Sample Standard Deviation). Testing 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; NewDelhi: 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**

Unit I: Introduction to Cancer and its Models (15 Lectures)

Introduction and hallmarks of cancer. Etiological factors and, cancer Microbiome. Oncogenes, tumor suppressor genes, and aberrant signaling pathways. Tumor microenvironment and its components. Tissue Culture, its types, and cell-lines. Cell culturing, media selection, and cell freezing techniques. Two dimensional (2D) and Three-dimensional (3D) cultures. Various types of cell-infections and their remedies. **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 II: Cell Biology and Immunology (15 Lectures)

Cell Membrane: Structure and function. Cytoskeleton: Structure & function. Mitosis and meiosis: Cell cycle regulation and control. Hormones and their receptors, cell surface receptors, signaling through G-protein coupled receptors, signal transduction pathways, second messengers, and regulation of signaling pathways.

Innate and adaptive immune system: Cellular and Molecular components. Antigens, antigenicity, and immunogenicity. Humoral and cell-mediated immune responses, primary and secondary immune modulation, and the complement system. B and T cells: activation and differentiation of B and T cells, receptors, Receptors, MHC molecules, antigen processing and presentation. Structure and function of antibody molecules. Generation of antibody diversity, Monoclonal antibodies, antibody engineering, antigen - antibody interactions. Cell-mediated effector functions, inflammation, hypersensitivity and autoimmunity, immune response during bacterial (tuberculosis), parasitic (malaria), and viral (HIV) infections, congenital and acquired immunodeficiency, and Vaccines.

Unit III: Recombinant DNA Technology (15 Lectures)

Introduction to recombinant DNA technology. Restriction enzymes, their nomenclature & mode of action. Application of Type II restriction enzymes, Terminal deoxynucleotidyl transferase, Kinases, Phosphatases, DNA ligases, DNA polymerases, Reverse Transcriptase, Bacteriophage RNA polymerases, Exonuclease III, BAL-31, mung bean nuclease, and S1 nuclease in genetic engineering.

Vectors: E. coli cloning and expression vectors-lac, tac and T7 promoter-based vectors, pET-based vectors. Yeast expression vectors, Baculovirus based vectors. Mammalian Expression Vectors- SV40, Vaccinia, Retroviral promoter-based vectors, LentiVirus Vectors.

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

Polymerase chain reaction (PCR), DNA polymerases and their fidelity, primer design and applications, Cloning vectors, Transformation, Screening of clones, PCR in gene recombination,

deletion, addition, overlap extension, and SOEing, site directed mutagenesis. Cloning using linkers and adaptors. Real Time PCR and other PCR types. **Gene silencing techniques:** Introduction to siRNA and shRNA technology, microRNA, construction of shRNA vectors, principle and application of gene silencing. CRISPR/Cas9 technology. Gene delivery by liposome and viruses. **Construction of genomic libraries: Genomic and cDNA libraries:** Preparation and screening of libraries by colony hybridization and colony PCR. Maxam-Gilbert's and Sanger's methods. Uses of genomic libraries, Next Generation Sequencing, Whole genome and whole Exome sequencing, RNA-Seq analysis (SOLiD, Ilumina and pyrosequencing).

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. Glick and Pasternak (2003). Molecular Biotechnology. ASM Press
5. Kracher. Molecular Biology - A Practical Approach.
6. Krenzer and Massey (2000). Recombinant DNA and Biotechnology. ASM
7. Micklos and Freyer (1990). DNA Science. CSHL
8. Primrose (2001). Molecular Biotechnology. Panima
9. Robertson et al (1997). Manipulation & Expression of Recombinant DNA. AP
10. Sambrook et al (2010). Molecular Cloning. CSHL
11. Twyman (1999). Advanced Molecular Biology. Viva

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Paper III: Comprehensive **Credits: 04**
Course Code: WC-C803 **Total Marks: 100**

Unit I: Comprehensive

In this course work, Ph.D. student will prepare a research proposal aligning with the ongoing research in the Department/lab. The existing literature will be used as preliminary data in the grant proposal. After the submission of the grant proposal, S/he has to defend the proposal before the DRC. It will be mandatory to qualify the comprehensive for finishing the course work.