INSTITUTE OF BIOCHEMISTRY AND BIOTECHNOLOGY

Ph.D. Biochemistry

SCHEME OF STUDIES

AND

COURSES OF STUDIES

UNIVERSITY OF THE PUNJAB
LAHORE

PH.D. BIOCHEMISTRY

COURSE NO.	COURSE TITLE	CREDIT HOURS
IBB. Biochem. 701	Advanced Molecular Biology	3
IBB. Biochem. 702	Immunodiagnostics and Therapeutics	3
IBB. Biochem. 703	Stem Cell Biology	3
IBB. Biochem. 704	Applications of Recombinant DNA Techniques	3
IBB. Biochem. 705	Advances in Glycobiology	3
IBB. Biochem. 706	Human Genetics	3
IBB. Biochem. 707	Plant Cell Physiology	3
IBB. Biochem. 708	Signal Transduction	3
IBB. Biochem. 709	Advances in Endocrinology	3
IBB. Biochem. 710	Biostatistics and Data Analysis	3
IBB. Biochem. 711	Advanced Microscopy	3
IBB. Biochem. 712	Biochemistry Lab.	3
IBB. Biochem. 713	Research Proposal/Project Writing/Journal Club	3
RESEARCH WORK FOR THESIS		

Course No.: **IBB. Biochem. 701**
Course Title: **Advanced Molecular Biology**
Course Rating: **3 Credits**

Course Objectives

Aim of this course is to give the students an appreciation, at an advanced level, of the mechanisms that regulate the flow of genetic information, fine-tune the gene expression, and normalize the alterations/mutations that lead to a diseased state. Students will also gain an appreciation for the past scientific achievements that have helped pave the way for tackling and answering the complex biological problems.

Course Contents

An overview of the DNA replication, cell cycle, transcription, translation, recombination and repair processes. Chromosome organization and gene rearrangements; Gene clusters, tandem repeats and segmental gene duplications in evolution. Regulating the flow of information; Histone modifications and chromatin remodeling during transcription; Gene switching-on/-off mechanisms operative in prokaryotic and eukaryotic systems.

Manipulating gene expression using "Designer Genes" and synthetic transcription factors. Eukaryotic mRNA synthesis, processing, modifications, stability, translation, degradation and manipulation of these processes to effect selective gene expression. Genome editing (CRISPER-Cas9 technology); Molecular interactions and recognitions; Development of new therapies for cancer.

Apart from lectures, the course shall include small group discussions (based upon interactive student learning model) on the topics related to this course with a perspective of how cutting edge biochemical principles and approaches are applied to tackle the research questions in molecular biology. Each student shall also choose an international journal paper (Nature, Science, Cell, etc.) in consultation with the Course Instructor and will critically review and present the related work, described in the literature, to the fellow students in a Seminar.

Course Impact

At the end of this course, the students will have raised awareness of the recent advances in some of the actively pursued areas of the molecular biology.

Recommended Books

1. Molecular Cell Biology by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Anthony Bretscher 8th Edition (2016), W. H. Freeman.
2. Molecular Biology: Principles of Genome Function by Nancy Craig, Rachel Green, Carol Greider, 2nd Edition (2014), OUP Oxford.
3. Molecular Biology by Robert F. Weaver 5th Edition (2011), McGraw-Hill Education.

Course No.: **IBB. Biochem. 702**
Course Title: **Immunodiagnostics and Therapeutics**
Course Rating: **3 Credits**

Course Objectives

This course is designed to equip the students with advanced understanding of the developments made in the fields of immunodiagnostics and therapeutics. The course will enable the students to comprehend the immunoregulatory systems, operative in the human body, and better appreciate their potential applications in disease diagnosis and therapy.

Course Contents

Concepts in immunodiagnostics and therapeutics; Overview of the immune system, innate immunity, humoral and cell mediated immunity, receptors of B and T cells. Infection and defense. Anaphylaxis and allergic responses; Respiratory, food, skin and drug-associated allergies, their clinical manifestations, diagnosis and treatment. Immune responses in endocrine disorders, thyroid-related diseases and diabetes. Immunity in gastrointestinal diseases such as gastritis, celiac disease, Crohn's disease, etc.

Scientific basis and clinical interpretation of the common categories of immunological laboratory tests; Concepts of normality and abnormality as applied to the immunological status; Clinical performance criteria of autoimmune and cellular-based laboratory tests used for diagnosis, monitoring and exclusion of immunological diseases.

Advances in the production of monoclonal antibodies and vaccines. Cytokine therapy for cancer treatment. Applications of white blood cells and their products in nano-immunotherapy. Problem-based learning exercises and case studies related to immunotherapeutics.

Course Impacts

At the end of this course, students would be able to correlate many biological factors that are responsible for pathological conditions. The students would also be able to understand the role of immune regulatory proteins and cells for combating the pathological conditions. The students should be able to prepare the reagents for use in immunotherapy and immunodiagnosis (*in vitro and in vivo*).

Recommended Books

1. Immunology, A short course, 7th edn. Richard Coico and Geoffery Sunshine, Wiley-Blackwell, 2014.
2. Essential of Clinical Immunology. 5th edn. Helen Chapel, Mansef Haeney, Siraj Misbah, Neil Snowden. Blackwell publishing, 2006.
3. Kuby Immunology, 6th edn. Thomas J. Kindt, Richard A Goldby, Barbara A. Osborne, Janis Kuby. W.H Freeman and Company, 2004.
4. Medical Immunology. 9th edn, Daniel P. Stites, Abba I Terr, Tristram G Parslow.Prentice-Hall International Inc. 1997.
5. Problem based immunology, 1st edn. Reginald M Gorczynski, Jacqueline Stanley, Saunders, Elsevier, 2006.

Course No.: **IBB. Biochem. 703**
Course Title: **Stem Cell Biology**
Course Rating: **3 Credits**

Course Objectives

This course aims to give students a comprehensive overview of stem cell biology and it's applications as well as the controversies surrounding the field.

Course Contents

Basics of stem cell biology. Types of stem cells, their origin and plasticity. Cell cycle control, checkpoints, key signaling pathways. Regulation of stem cell. Adult stem cells and their applications; Importance of induced pluripotent stem cells. Stem cells and genetic diseases; stem cells epigenetics. Tumor stem cells; development of treatment-resistant remnant cells and their impact on cancer treatment strategies. Role of stem cells in tissue engineering and regenerative medicines. Fate mapping of stem cells, controversies.

Course Impact

At the end of this course, students will have learnt about the basic principles and various types of stem cells being used in stem cell research.

Recommended Books

1. Stem Cell Biology, edited by D.R. Marshak, R.L. Gardner and D. Gottlieb (2001), Cold Spring Harbor Laboratory Press.
2. Essentials of Stem Cell Biology, R.Lanza *et al*. (2005), Academic Press.
3. Stem Cells and Cell Therapy, Mohamed Al Rubiea and Mariam Naciri, (2013), Springer
4. Stem Cells in Regenerative Medicine Science Regulations and Business Strategies, Alain A Vertes et al., (2015), Wiley Black Well.

Course No.: **IBB. Biochem. 704**
Course Title: **Applications of Recombinant DNA Techniques**
Course Rating: **3 Credits**

Course Objectives

This course emphasizes on developing better understanding of research methodologies used in the field of recombinant DNA. The ability to manipulate nucleic acids has transformed almost all aspects of life science research. This course aims at introducing students with the extensive molecular tool box available at their disposal to tackle biological questions.

Course Contents

Enzymes of restriction, ligation, polymerization, phosphorylation and dephosporylation systems; Cloning vectors for *E. coli*, cloning vectors for eukaryotes; obtaining clone of a specific gene; Genomic and cDNA libraries; Transformation techniques; Expression of cloned genes; mammalian expression vectors; Library screening/detection techniques; sequencing genes and genomes; next generation sequencing techniques; PCR and qRT-PCR; *in vitro* transcription and translation of cloned genes. Mapping and quantifying transcripts, measuring transcription rates in vivo: nuclear run-on transcription, reporter gene transcription, measuring protein accumulation in vivo; Assaying DNA-Protein interactions: filter binding, gel mobility shift, DNase foot-printing, DMS foot-printing. Gene Knockdowns; RNAi methods and validation techniques, gene knockout methods; CRISPR cas9 systems

Course Impact

After studying this course, students will gain a deeper understanding of the principal techniques used to explore various aspects of molecular biology. This techniques focused course will help students; better plan their bench-work and enhance critical thinking.

Recommended Books

1. Gene Cloning and DNA Analysis: An Introduction, T. A. Brown, 7th edition (2016) Wiley-Blackwell
2. Principles and Techniques of Biochemistry and Molecular Biology, Keith Wilson, John Walker, 7th edition (2010), Cambridge University Press
3. Recombinant DNA: Genes and Genomes - A Short Course, James D. Watson, Richard M. Meyers, Amy A. Caudy, Jan A. Witkowski, 3rd Edition (2007), Cold Spring Harbor Laboratory Press
4. Molecular Cloning: A Laboratory Manual, Michael R. Green, Joseph Sambrook, 4th edition (2012), Cold Spring Harbor Laboratory Press

Course No.: **IBB. Biochem. 705**
Course Title: **Advances in Glycobiology**
Course Rating: **3 Credits**

Course Objectives

This course is planned to acquaint the students with new and rapid expansion of carbohydrate chemistry and glycobiology. This course gives an overview about the structural and functional significance of natural glycosylation and its related proteins. It also covers their role in health and disease.

Course Contents

Concepts of glycobiology. Complex glycoconjugates such as glycoproteins, proteoglycans and glycolipids. Natural glycosylation; N-linked glycosylation, O-linked glycosylation, structural diversity and functions. Glycosylphosphatidylinositol anchors, their structure, synthesis and functions. Glycolipids and membrane protein glycosylation. Synthesis and degradation of glycosphingolipids. Conformations of oligosaccharides. Effects of glycosylation on protein structure and function. Carbohydrate recognition in cell adhesion and signaling. Glycoprotein trafficking. Protein-carbohydrate interactions. History of lectinology; bacterial and viral lectins, plant lectins, animal and human lectins. Structural glycobiology, analysis of glycan structures, structural role of carbohydrates in immune recognition: cancer, organ transplantation, and infection. Sugars as pharmaceuticals. Glycosylation and disease. The future of glycobiology.

Course Impacts

At the end of this course, the student will be able to have a solid background of knowledge about central features, functions and categories of glycosylation, biosynthesis and their degradation. The student will learn about the impact of carbohydrates on protein structure, in immune recognition system and development of new therapeutic approaches.

Recommended Books

1. Essentials of glycobiology. Varki A et al. 3rd edition (2015). Cold Spring Harbor Laboratory Press.
2. Essentials of Carbohydrate Chemistry and Biochemistry. Thisbe K. Lindhorst (2007). John
   Wiley & Sons.
3. Structural Glycobiology. Yuriev and Ramsland (2012) CRC Press, Taylor & Francis.
4. The Sugar Code: Fundamentals of Glycosciences. Hans-Joachim Gabius (2010) Willey-VCH Verlag GmbH & Co. KGaA, Weinheim
5. Introduction to Glycobiology. Taylor and Drickamer (2011). 3rd edition. Oxford University Press
6. Carbohydrate Chemistry: State of the Art and Challenges for Drug Development, edited by Laura Cipolla (2015), Imperial College Press.
7. Glycobiology and Human Diseases, edited by G. Wiederschain (2016). CRC Press
8. Cell surface and extracellular glycoconjugates: structure and function. David D. Roberts and Robert P. Mecham (2012). Academic Press.

Course No.: **IBB. Biochem. 706**
Course Title: **Human Genetics**
Course Rating: **3 Credits**

Course Objectives

The aim of this course is to equip students with detailed understanding of the molecular basis of human genetics and genetic diseases.

Course Contents

Course Objectives:

The aim of the course to equip the students with detailed understanding and molecular elucidation of human genetics and genetic diseases.

Course Content

DNA Structure and Functions, Chromosome Structure and Functions, Genes in pedigree; Mosaicism and Chimerism, Cell based DNA cloning; DNA hybridization assays; PCR based DNA cloning and analyses; Organization and expression of Human Genome; Organization and expression of Human Genes; Human multigene families and repetitive DNA, Mutation and instability of human DNA, Mapping the Human Genome; Physical mapping; Genetic mapping; The Human Genome Project, Human Genetic Diseases; Identifying human disease genes; Molecular pathology; Genetic testing in individuals and populations; Somatic mutations and cancer; Complex diseases, Dissecting and manipulating genes; Studying human gene structure and function; Animal models of genetic diseases.

Course Impact

At the end of this course, students will have gained a thorough knowledge about the molecular mechanisms underlying human genetics and techniques used for mapping the human genome.

Books Recommended

1. Human Molecular Genetics, Tom Strachan and Andrew P. Read (2003).Wiley Liss.
2. Medical Genetics, L.B.Jorde et al., 3rd edition (2005), Mosby.
3. The Cell, A Moleular Approach, Geoffrey M.Cooper and Robert E Hausman, Sixth Edition (2013).Sinauer.

Course No.: **IBB. Biochem. 707**
Course Title: **Plant Cell Physiology**
Course Rating: **2 Credits**

Course Objective:

This designed course will help the student to gain advance knowledge pertaining to biochemical and physiological processes that are ongoing at cell, tissue, organ and whole plant level. Moreover, this course will shed light on regulatory, both physiological and metabolic mechanisms opted by plants against endogenous and environmental signals.

Course Contents:

Introduction to plant Physiology, Water balance in plants, Cell wall: function and biosynthesis, Solute transport across membranes, Mineral nutrition: uptake and translocation of mineral nutrients, nutritional needs of plants, Assimilation of nitrogen, sulphur, phosphate, oxygen and cations, Biological nitrogen fixation, Mycorrhiza, Photosynthesis: organisation of photosynthetic membranes; photochemical reactions. Photorespiration, C3-, C4- and CAM plants, Physiological and ecological aspects of photosynthesis, Translocation in the phloem, Heterotrophy in plants; parasitic and carnivorous plants, Respiration process, respiration in intact plants and tissues, Lipid metabolism. Secondary metabolism in plants. Plant growth regulators: auxins, gibberellins, cytokinins, abscisic acid, ethylene and brassinosteroids – structure, biosynthesis, translocation, physiological effects. Effects of temperature and light on plants: dormancy,

photoreceptors, photoperiodism, Signal transduction, Stress physiology: plant response to abiotic and biotic stress, Physiology of movements in plants, Physiological aspects and problems of major crops (case study).

Recommended books

1. Plant Physiology, Taiz and Griger, 5th edition (2010), Sinauer Associate, Inc. Sunderland, Massachusetts.
2. Introduction to Plant Physiology, Hopkins WG & Huner NPA, (2004), John Wiley & Sons.
3. Plant Biochemistry, Hans-Walter Heldt, 3rd edition (2005), Elsevier Inc.
4. Plant Physiology, Gupta, (2005), Oxford & IBH Publishing Company Pvt. Limited.
5. Plant Biochemistry: The Structure of PLants explained by Edwin Oxlade, Ed. Graham Lawler. GMPL ltd (1999).
6. Biochemistry and Molecular Biology of Plants, Buchanan, Gruisserm, Jones (2000), ASPB

Course No.: **IBB. Biochem. 708**
Course Title: **Signal Transduction**
Course Rating: **3 Credits**

Course Objectives

Objective of this course is to equip the students with latest developments in the cellular signaling mechanisms. The course signifies the biochemical basis of the transmission of molecular signals from a cell's exterior to its interior and emphasizes the involvement of signal transduction in physiology and pathophysiology.

Course Contents

An overview of the signaling molecules (receptors, transducers, second messengers, response regulators, effectors, etc.) and the mechanisms involved in the signal transduction/cellular responses. Modular architecture and evolution of signaling proteins; Specificity versus affinity SH2 example. Information transfer across the biological membranes: lipid compartments and signaling; membrane recruitment; G protein coupled receptors; RTK signaling example.

Wiring and rewiring in signal transduction; monomeric G-proteins GEFs and GAPs (example Ras). Molecular signaling pathways in response to disease and inflammation; BCR-ABL modular allostery. Signaling networks; integration and cross-talk of signaling pathways.

Engineering the signal transduction pathways. Emphasis will be on the techniques by which novel signal transduction pathways are elucidated. This part will largely involve extensive review of latest articles and data interpretation by the students.

Course Impact

At the end of this course, the students shall better appreciate as how organisms can detect and respond to events in their ever-changing intra- and extra-cellular environments. They will also have improved understanding of the response specificity, signal integration and cross-talks of signaling pathways.

Recommended Book

1. Molecular Biology of the Cell, Bruce Albert et al., 6th edition (2014), Garland Science.
2. Signal Transduction, Gompers BD et al., (2009), Elsevier Academic Press.
3. The Biochemistry of Cell Signaling, Ernst J. and Helmreich M (2001), Oxford University Press.

Course No.: **IBB. Biochem. 709**
Course Title: **Advances in Endocrinology**
Course Rating: **3 Credits**

Course objective

The course provides the knowledge and understanding of normal physiology and pathophysiology of major endocrine organs in the body, emphasizing the importance of clinical and biochemical parameters in the diagnosis, treatment and monitoring of disease.

Course content

Endocrinology and factors effecting the endocrine system: stress; diseases; environment; genetics. Endocrine glands and secretory mechanisms, regulation of polar and nonpolar hormone secretion. Chemical signaling: endocrine, paracrine, autocrine and intracrine mechanisms. Physiology and pathophysiology of endocrine system, endocrine and nutritional assays, disorders associated with malnutrition, malabsorption and obesity, biochemical testing for diagnosis and management. Reproductive endocrinology and infertility, hormone in male and female reproduction, hormone imbalance and lactation. Structure and activity relationship of peptide hormones. Neuroendocrinology, Pediatric endocrinology, Psycho neuroendocrinology. Endocrine cancer: adrenal gland tumor, parathyroid tumor, pituitary gland tumor, thyroid cancer.

Course Impacts

At the end of the course, the students will be able to understand hormone mechanism of action and their secretion as well as signaling mechanisms. The students would also be able to comprehend their crucial role in reproduction, lactation and in the development of various endocrine tumors.

Recommended Books

1. Molecular Biology of the Cell, Bruce Albert et al., 6th edition (2014), Garland Science.
2. Essential Endocrinology and Diabetes, Neil A. Hanley and Richard I. G. Holt, 5th edition (2007), John Willey & Sons
3. Endocrinology: Adult and Pediatric, J. Larry Jameson and Leslie J. De Groot, 7th edition (2015), Saunders
4. Clinical Gynecologic Endocrinology and Infertility, Marc A. Fritz and Leon Speroff, 8th edition (2012), Lippincott Williams & Wilkins
5. Principles and Practice of Endocrinology and Metabolism, Kenneth L. Becker, 3rd edition (2001), Lippincott Williams & Wilkins
6. Clinical biochemistry, Allan Gaw et al.,5th edition (2013), Elsevier Health Sciences,UK

Course No.: **IBB. Biochem. 710**
Course Title: **Biostatistics and Data Analysis**
Course Rating: **3 Credits**

Course objectives

This course has been designed to familiarize the students with the applications of probability and statistical techniques to the biological sciences. Students will learn as to how statistical methods enable us to formulate a public health question in statistical terms, explain the genetic differences and their impact in biomedical field of study, simplify the complexities of dry- and wet-lab experimental data, compare and critically assess the experimental results, and check the effectiveness of different treatment modalities in a study population.

Course Contents

An introduction to the descriptive and univariate statistical analysis. The use of summary statistics to describe data (mean, median, skewness, histograms, boxplots, standard deviation, standard error, confidence intervals). The concept of statistical testing/p-values; Statistical tests for two group-comparisons (chi-square test, t-test, rank tests).

Exercises to descriptive and univariate statistics using SPSS or R-program. Introduction to the first steps with SPSS or R; importing data files and organizing data into data frames; installing packages and finding help; initial data processing.

Introduction to more advanced statistical methods and their applications in biological sciences; ANOVA and post-hoc tests, multiple testing correlation; scatter plots and linear regression; survival analysis (censored observations, Kaplan-Meier and logrank test); exercises using SPSS or R.

Recommended Books

1. Statistics with applications to the Biological and Health Sciences, R.D. Remington, M.A. Schork, 2nd edition (2014), Prentice Hall, Inc.
2. Primer of Biostatistics, Stanton A. Glantz, 5th edition (2001), McGraw-Hill Co.
3. Fundamentals of Biostatistics, Bernard Rosner, 5th edition (2000), Thomson Learning.

Course No: **IBB. Biochem. 711**
Course Title: **Advanced Microscopy**
Course Rating: **3 Credits**

Course Objectives

Objective of this course is to provide an introduction to the principles and applications of optical and electron microscope systems, covering theoretical and practical aspects.

Course contents

Fundamentals of light and phase-contrast microscopy, illumination filters and isolation of specific wavelengths; Lenses and geometrical optics, diffraction and interference in image formation, diffraction and spatial resolution, phase contrast microscopy, dark field microscopy, differential interference contrast microscopy, fluorescence microscopy, fluorescent tags, bleedthrough, quenching and photobleaching, fluorescence imaging of dynamic molecular processes, confocal laser scanning microscopy, two photon excitation fluorescence microscopy, super-resolution imaging, live cell imaging, fundamentals of digital imaging and digital image processing.

Introduction to electron microscopes including transmission electron microscopy (TEM) and scanning electron microscopy (SEM), specimen preparation, negative staining and immunogold labelling techniques

Course Impact

The course will provide students with knowledge and information about optical and EM microscopy techniques and their relevant use in various areas of research. After completing this course students will be able to practice the methods and use the instruments for their research projects.

Recommended books

1. Introduction to Optical Microscopy, Jerome Mertz, 1st Edition (2009) Roberts and Company Publishers

2. Electron Microscopy: Methods and Protocols (Methods in Molecular Biology), John Kuo 3rd edition (2014) Humana Press
3. Basic Methods in Microscopy: Protocols and Concepts from Cells: A Laboratory Manual, David L Spector and Robert D Goldman (2005) Cold Spring Harbor Laboratory Press

Course No: **IBB. Biochem. 712**
Course Title: **Biochemistry Lab.**
Course Rating: **3 Credits**
Course Objectives
Objective of this laboratory course is to familiarize the students with cell and molecular biology techniques that are important for their future research projects.
Course contents
Fundamentals of mammalian cell culturing; instrumentation and working in the cell culture lab. Establishment of primary cell culture, subcellular fractionation and isolation of membrane organelles, use of antibodies as cell biological tool, fluorescent proteins as live cell imaging tool. Use of optical and fluorescent microscopes in molecular and cell biology research; immunogold electron microscopy. Cell proliferation analysis, flow cytometry, assessment of apoptosis, *in vitro* transcription and translation, cell adhesion and migration, ectopic expression of recombinant proteins in mammalian cells, transfection of mammalian cells, virus based expression systems, gene knock-in and knock-down.

Course Impact
After completing this course students will be able to practice advance techniques in cell and molecular biology and independently use the instruments for their research projects.

Recommended books
1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, R. Ian Freshney, 7th Edition (2016) Wiley-Blackwell
2. Short Protocols in Cell Biology, Juan S. Bonifacino, Mary Dasso, Joe B. Harford, Jennifer Lippincott-Schwartz, Kenneth M. Yamada (2004) Wiley

Course No: **IBB. Biochem. 713**
Course Title: **Research Proposal/Project Writing/Journal Club**
Course Rating: **3 Credits**
The students will learn how to write research synopsis/thesis and project proposals for competitive research grants. They will present two latest research articles on cutting-edge technologies in bi-weekly Seminars/Journal club and also prepare a comprehensive review on the assigned topic. The topics to be covered and the mode of assessment shall be defined by the course instructor.

RESEARCH WORK FOR THESIS
The students will undertake experimental work on the topic of research allotted to them and submit a thesis in accordance with the rules prescribed by the University.