INSTITUTE OF BIOCHEMISTRY AND BIOTECHNOLOGY

Ph.D. Biotechnology

SCHEME OF STUDIES

AND

COURSES OF STUDIES

UNIVERSITY OF THE PUNJAB
LAHORE

PH.D. BIOTECHNOLOGY

COURSE NO.	COURSE TITLE	CREDIT HOURS
IBB. Biotech. 701	Advanced Molecular Biology	3
IBB. Biotech. 702	Advances in Nanobiotechnology	3
IBB. Biotech. 703	Industrial Enzymology	3
IBB. Biotech. 704	Trends in Omic Technologies	3
IBB. Biotech. 705	Biosensors and Bioelectronics	3
IBB. Biotech. 706	Biotechnology Patents and Public Health	3
IBB. Biotech. 707	Bioinformatics and Functional Genomics	3
IBB. Biotech. 708	Environmental Biotechnology	3
IBB. Biotech. 709	Advances in Agricultural Biotechnology	3
IBB. Biotech. 710	Biostatistics and Data Analysis	3
IBB. Biotech. 711	Biotechnology Business and Entrepreneurship	3
IBB. Biotech. 712	Biotechnology Lab.	3
IBB. Biotech. 713	Research Proposal/Project Writing/Journal Club	3
RESEARCH WORK FOR THESIS		

Course No.: **IBB. Biotech. 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; Switching-on and -off mechanisms of genes 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. Biotech. 702**

Course Title: **Advances in Nanobiotechnology**

Course Rating: **3 Credits**

Course Objectives:

This course aims to deal with the nanobiotechnology, a multidisciplinary field encompassing diverse array of technologies from physics, chemistry and biology disciplines. After teaching the fundamental concepts of nanoscience, students will be guided towards skills necessary for designing and developing the devices used for probing the healthy and diseased status in human, animal and plant systems.

Course Contents

Overview of the nanobiotechnology; Nanoparticles (silver, iron, polylactide, dextran) and nanomedicines in medical diagnosis and therapeutics; Self-assembled surface layer proteins for biotechnology and bioanalysis. Carbon nanotubes for biological materials; Nanoimmunoassay on protein chips; Nanosensors for identification of biomarkers. Nanotechnology for targeted drug delivery; Nanscale devices and antennas in diagnosis.

Quantum dots (Cd/Zn/Se) their preparation and applications. Bimetallic nanoparticles, their properties, synthesis, characterization and applications. Preparation and uses of silicon and gold nanoparticles in diagnosis and therapeutics. Recent advances in theranostic nanomedicines. Impact of nanotechnology on health, environment and economy.

Course impact

The students would have learnt various factors that participates in the development of nanobiotechnology materials. After completing the course, students will be able to design the various biomaterials at nanoscale for using in health and agriculture.

Recommended Books

1. Nanobiotechnology, BioInspired devices and materials for future, by Oded Shoseyov and Ilan Levy, (2008). Humana press.
2. Protein nanotechnology, protocol instrumentation and applications by Tuan Vo-Dinh, (2005), Humana press.
3. Nanotechnology in biology and medicine by Tuan Vo-Dinh, (2007), CRC press.

Course No.: **IBB. Biotech. 703**

Course Title: **Industrial Enzymology**

Course Rating: **3 Credits**

Course Objectives

This course aims to give students an idea of the wide range of enzyme applications in paper, leather, textile and food industries.

Course Contents

General review of enzyme nature and functions; Enzyme assays; Quality of enzyme preparations; Applied biocatalysis; Reactions catalyzed by enzymes; Enzymes as processing aids and final products: detergent industry, textile industry, leather tanning industry, petroleum industry, enzymes as feed additives. Case studies in the application of biocatalysts for the production of biochemicals: high fructose syrup, glucose production, aspartame, L-Lysine; Immobilized biocatalysts: cross-linking with glutaraldeyhde, adsorption on carriers, covalent attachment, granulation, gel entrapment, membranes, immobilized viable cells; Enzyme production, isolation and purification; Enhancing enzyme expression and designing for improved properties.

Course Impact

At the end of this course, students will have gained an appreciation of the immense scope for use of enzymes in industry as well as technology employed for their effective production, purification and expression.

Recommended Books

1. Industrial Biotechnology, edited by D. Thangadurai and J. Sangeetha (2016), Apple Academic Press.
2. Applied Biocatalysis, edited by A. J. J. Straathof and P. Adlercreutz, 2nd edition (2000), Harwood academic publishers.

3. Industrial Biotechnology: problems and remedies, I.S. Thakur (2013), IK International Publishing House.
4. Biochemistry, D. Voet, J.G. Voet, 4th edition (2011), John Wiley and Sons Inc
5. The Complete Technology Book on Detergents, edited by NIIR board of consultants engineers,
   2nd edition (2013), Niir project consultancy services publishers.
6. Innovations in Biotechnology, edited by E. Agbo, (2012), InTech Publisher
7. Advances in Applied Biotechnology**, e**dited by M. Petre, (2012) InTech Publisher
8. Immobilized Enzyme: Principles and Applications, edited by N. M. Nhut (2016), Delve Publishing LLC.

Course No.: **IBB. Biotech. 704**

Course Title: **Trends in Omic Technologies**

Course Rating: **3 Credits**

Course Objectives

This course is designed to extend students' familiarity to the Omic techniques that underpin many of the recent advances in our understanding of the biological systems. Examples will be used to explain the step changes that occur between the analysis of a single gene, protein, metabolite, etc. and the analysis of the most, or all of the genes, proteins and metabolites, within an organism. While discussing the coding potential of DNA through to the regulated activity of proteins and large protein complexes, this course will also illustrate how essential are the cross-disciplinary approaches in modern research.

Course Contents

An introduction to the genomics, transcriptomics, proteomics, metabolomics and interactomics. Modern "Omic" technologies, their potential, applications and challenges. Overview of the workflows for the resolution and characterization of complex mixtures of biomolecules; from DNA and proteins to small metabolites. Use of omic information in the disease diagnosis. Data processing, analysis and validation methods. Dealing with large-scale datasets generated from the 'omic-scale' experiments.

The study design, sample preparation [through data collection and analysis], relative benefits and challenges of each -omic technique shall be discussed using an example-driven approach. A series of case studies with exemplar datasets based on latest reviews and the scientific research published in the relevant leading journals will be used to illustrate as how –omic technologies engender a better understanding of the complex biological systems.

Course Impact

After studying this course, the students will have an extended appreciation of the applications of -omic approaches in biomedical research. It is anticipated that they will be able to critically evaluate and summarize the workflows that are exploited to identify, quantify and characterize the large and small molecule metabolites in complex mixtures and better able to compare, contrast and integrate the information obtained from the different "-omic" data collection approaches.

Recommended Books

1. Lewin's Gene XI by Jocelyn E. Krebs et al. (2014) Jones and Barlett Learning LLC, USA.

2. Proteins and Proteomics-A Laboratory Manual by Richard J Simpson. (2008) Cold Spring Harbor Laboratory Press USA
3. Discovering Genomics, Proteomics and Bioinformatics by Malcolm Campbell and Lauria J. Heyer. 2nd Edition (2007) Pearson Education, Inc.
4. Latest reviews and research articles published in leading Scientific Journals like LANCET, Nature Reviews, Journal of Clinical Investigation, Molecular and Cellular Proteomics, Scientific Reports, Nucleic Acid Research, etc.

Course No.: **IBB. Biotech. 705**
Course Title: **Biosensors and Bioelectronics**
Course Rating: **3 Credits**

Course objectives

This course is designed to introduce the students with the concepts of bioelectricity and biosensing in the context of biological systems. The most important biosensing techniques, their physical concepts, underlying engineering principles, common application examples and fundamental challenges of measuring the biological signals shall also be introduced to the students.

Course Objectives

An introduction to the biosensors and bioelectronics. Biosensing concepts; commercially available bio-sensing technologies, types, basic designs, device physics and applications; examples of integrated biosensors. Biological (enzymatic and non-enzymatic) recognition elements and their immobilization. Biosensor arrays and biomedical implantable devices.

Bioelectronics history, its applications and overview of the field; Basic notions of molecular adsorption and electron transfer; bioelectric potentials, channels, amplification, signal gating, and patch clamp. Action potentials and impulse propagation; Functional electric stimulation and recording; Biomeasurement techniques with electrons and photons; Fundamentals of quantum and classical noise in measuring biological signals; Engineering principles of optical probes for measuring molecular and cellular processes; Brain machine interfaces and critical thinking. Biomaterials and biocompatibility issues; mixing in microfluidics: fluid Control, miniature bioreactors and microsystems.

Course Impact

At the end of this course, the students will have thorough understanding of the basic principles of biosensors, bio-analytical systems and biochips with an emphasis on different transduction technologies, biomolecular detection assays and the coupling of the biorecognition elements on the transduction system to obtain a functional bio-analytical device for food, environmental and medical diagnostics.

Recommended Books

1. Cases Studies, Reviews and Research articles from the Journals specific for Biosensors and Bioelectronics research.

Course No.: **IBB. Biotech. 706**
Course Title: **Biotechnology Patents and Public Health**
Course Rating: **3 Credits**

Course Objectives

The science of biotechnology has been pushing the frontiers of human knowledge and intellectual property (IP) for the last four decades. As the scientists developed techniques for

isolating and creating genetic material and began to apply them commercially, a new industry grew and so did its appetite for patent protection. This course has specially been designed to aware the biotechnology students with potential applications of intellectual property laws and their impact on public health, in general. Students will not only be exposed to the International Treaties for deposit of microorganisms and access to food and agriculture but also trained on International Conventions for the protection of new biopharmaceuticals and plant varieties along with guiding them about the ethical and legal issues raised by biotechnology-associated IP.

Course Contents

Background of biotechnology and intellectual property (IP), range and different types of IP rights (patents, plant breeders' rights, industrial design, trade secrets, trademarks, copyright, geographical indication). What is protected by patent laws? Conditions for patentability; rights conferred by patent; enforcing inventership and ownership.

Biotechnology research and IP rights management; IP awareness, research practicalities, guidance for keeping lab notes, collaborative research with international scientists and joint venture agreements, working with legal documents and seeking expert advice/hiring services of IP law attorney. Process of getting a biotechnology patent: application, examination, publication, acceptance, opposition, grant, maintenance and transfer of rights.

International framework for biotechnology associated IP rights and where do we stand. The WTO's agreement on TRIPS; The Budapest Treaty for deposit of microorganisms; The International Convention for the protection of new plant varieties; The Convention on Biological Diversity (CBD); Food and Agriculture Organization (FAO) on plant genetic resources; Treaty on access to food and agriculture. Ethical issues raised by biotechnology-associated IP. Case studies 1) Diamond vs Chkrabarty, 2) Harvard Oncomouse.

Recommended Books

1. Cases Studies from the "Nature Biotechnology".
2. Grubb B. Biotechnology Patents (2008), Wiley Publishing Inc.
3. Pogge T, Rimmer M, Rubenstein K. Incentive for Global Public Health, Patent Law and Access to Essential Medicines (2010), Cambridge University Press.

Course No.: **IBB. Biotech. 707**
Course Title: **Bioinformatics and Functional Genomics**
Course Rating: **3 Credits**

Course Objectives

Bioinformatics is an exciting and rapidly developing area, which is expanding significantly in scope. The experimental sciences can provide detailed structures of biological macromolecules such as proteins, but it is hard to study directly how the structures of individual molecules change on short time scales as they function. Computational tools and simulation techniques based on fundamental principles of physics offer the potential of analyzing the biological molecules and their interaction at atomic details. The course therefore aims at familiarizing the students with potential applications of computational resources/tools that are applicable to a range of different problems in biomolecular science.

Course Contents

An overview of the bioinformatics and web services in bioinformatics; Algorithms and softwares; major biological databases and data management. MySQL database management system. Tools for gene prediction; building a multiple sequence alignment, use of ClustalW, TCoffee and MUSCLE programs. Structure prediction and visualization; predicting the

secondary structure of a protein; working with protein 3D structure; model design and evaluation, pattern and fold recognition, displaying interactive 3D-molecular models. Building of phylogenetic trees; clustering and classification. Studying the protein-protein and DNA-protein interactions using the computational tools.

Computational methods in genomics, epigenomics and trascriptomics. Insights into microarrays; Data acquisition, analysis and interpretation. Next generation sequencing and high throughput image processing.

Recommended Books

1. Bioinformatics for Dummies, Jean-Michel Claverie and Cedric Notredame, 4th edition (2014), Wiley Publishing Inc.
2. Bioinformatics - Databases and Systems, S.I. Letovsky, (2009), Kluwer Academic Publishers.
3. Discovering Genomics, Proteomics and Bioinformatics by Malcolm Campbell and Lauria J. Heyer. 2nd Edition (2007) Pearson Education, Inc.

Course No.: **IBB. Biotech. 708**
Course Title: **Environmental Biotechnology**
Course Rating: **3 Credits**

Course Objectives

This course provides the student with an appreciation and understanding of the fundamental concepts and theoretical background of environmental science. It involves the study of scientific principles and their applications to the current, local and the global environmental issues. The knowledge for the generation of valuable resources using biotechnology, for the human society, will also be delivered.

Course Contents

Environmental biotechnology and its impact on society; environmental assessment of biotechnological processes; marine environment and microbiology, interaction of microbes with plant and animal ecosystems. Interaction among microbial populations; Biofilm formation and biofouling. Biogeochemistry; role of microbes in the biogeochemical cycles of elements like carbon, nitrogen and sulfur. Biodegradation; bioremediation and phytoremediation; soil and water pollutants monitoring techniques, waste water treatment. Development of transgenic microbes for improved environmental clean-up. Biotechnological processes for the conversion of organic waste, biofuels, microbiology of extreme environments, microbial mining, microbial deodorisation, coal and oil desulphurization.

Course Impacts

At the end of this course the student will be able to explore the use of biotechnology as it relates to various environmental technologies. The student will not only learn about socio-economic importance of environmental biotechnology but also study several factors causing environmental pollution and application of techniques to degrade and eliminate toxic pollutants and solid waste.

Recommended Books

1. Environmental Biotechnology-Theory and Application. 2nd Edition. Evan, Gareth M, and Judith C. Furlong. (2010).
2. Environmental biotechnology: principles and applications. McCarty, Perry L. Tata McGraw-Hill Education, 2012.
3. Brock Biology of Microorganisms, 14th Ed. Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, John M. Martinko, David A. Stahl. (2014). Pearson.

4. Environmental Biotechnology. M. H. Fulekar. (2010). CRC Press.
5. Microbiology. 7th ed. (2008) Prescott, L.M., Harley, J.P., and Klein, D.A. McGraw-Hill Publ. 1088 p.
6. Microbiology, Principles and Exploration. Black, J. G., 6th edition (2005) John Wiley and Sons.
7. Polymicrobial Diseases. Brogden, K. A. and Guthmiller. J. M. (2002) Washington (DC), ASM Press.
8. Bioresources and human environment. Mohanka, R. and Singh, M.P. (2009) APH Publishing Corporation. New Delhi
9. Environmental Microbiology, 2nd ed. (2009) Raina M. Maier, Lan Pepper and Charles P. Gerba. Academic press and Elsevier.

Course No: **IBB. Biotech. 709**
Course Title: **Advances in Agriculture Biotechnology**
Course Rating: **3 Credits**

Course Objectives

To acquaint the student with the technique to develop skills to produce transgenic crops according to specific agricultural problem and requirement.

Course Contents

Introduction, Plant Molecular Markers, Phyto-hormones; types and application in biotechnology, Cell and Tissue Culture, Protoplast Culture, Somaclonal Variation as breeding tool, Somatic Hybridization, Plant Transformation, Chloroplast Transformation, Biofertilizers, Microbial Transformation of Carbon, Nitrogen, Phosphorus and Sulphur, Biological Nitrogen Fixation, Plant Microbe Interaction, Biotic and abiotic stress tolerance, Biosafety and concerns.

Recommended Books

1. Arie Altman and Paul M Hasegawa, 2012. Plant Biotechnology and Agriculture: Prospects for the 21st Century.
2. C. Neal Stewart Jr, 2012. Plant Biotechnology and Genetics: Principles, Techniques and Application.
3. Adrian Slater, Nigel W. Scott, Mark R. Flower, 2008. Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.
4. S. Harding, 2007. Biotechnology and Genetic Engineering Reviews: V. 24, Nottingham University Press.
5. Sheela Srivastava, Alka Narula, S.S. Bhojwani, 2004. Plant Biotechnology and Molecular Markers, Springer.
6. National Biosafety Guidelines Biosafety rules 2005
7. Jane K Setlow, 2003. Genetic Engineering: Principles and Methods, Springer.
8. Peter M. Gresshoff, 1993. Plant Biotechnology and Development, CRC Press

Course No.: **IBB. Biotech. 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. Biotech. 711**
Course Title: **Biotechnology Business and Entrepreneurship**
Course Rating: **3 Credits**

Course Objectives

This course is designed to familiarize the students with the language of business and to imbibe in them the appropriate skills needed for being an effective entrepreneur. All aspects of commercial biotechnology will be addressed through a combination of readings, group discussions, case studies and a team project, designed to expose the student to the tools, concepts and practices of the entrepreneurial world.

Course Contents

Entrepreneurship and economic development. Era of bioenterpreneurship; An empirical analysis of the bioentrepreneurship in developed and developing countries. Developing and maintaining the culture of bioentrepreneurship in Pakistan.

History of the establishment of pioneer biotechnology companies, significance and impact of business models. Starting up or spinning out of a new biotech company; Company formation and organization; Building/hiring of a dream team; Incentivizing innovative business ideas/entrepreneurial plans; Intellectual property protection strategy; Financing the biotech company, fundraising and financing process; Manufacturing process, commercialization and distribution of goods/biotech products; Biomarketing and business strategies, strategic alliances, collaborations, licensing and technology transfer; Regulatory affairs; Roadmap to reimbursement and access; Working towards a successful exit.

In addition to the formal lectures, students will be asked to perform in-depth analysis of a hypothetical biotechnology/pharma company. The analysis shall revolve around goals and objectives of a selected company, its product/s, competitive landscape, risks and opportunities, marketing/sales strategies and organizational structure and future development forecast. Two field trips to pharmaceutical companies or biotech industry shall also be arranged.

Recommended Books

1. Salgaller ML. Biotechnology Entrepreneurship: From Science to Solutions. 2010.
2. Barringer B, Ireland D. Entrepreneurship: Successfully Launching New Ventures, 2nd Edition, Pearson Prentice Hall, Upper Saddle River, NJ. 2008
3. Ernst, Young. Beyond Borders: Global Biotechnology Report. Life Science Practice, 2008.
4. Jogdand SN. Entrepreneurship and Business of Biotechnology, India: Himalaya Publishers, 2008.
5. Cohen B, Winn MI. Market Imperfections, Opportunity and Sustainable Entrepreneurship. Journal of Business Venturing, 2007, 22(1): p29-49
6. Baker T, Nelson RE. Creating Something from Nothing: Resource Construction through Entrepreneurial Bricolage. Administrative Science Quarterly, 2005, 50(3): p329-366.

Course No: **IBB. Biotech. 712**
Course Title: **Biotechnology Lab.**
Course Rating: **3 Credits**

Course Objectives

Objective of this laboratory course is to upgrade the skills of students to independently perform the routine biotechnology techniques, important for their future research projects.

Course contents

Electrophoretic and chromatographic techniques (gel filtration, ion exchange; affinity chromatography, HPLC, GC). Cell and tissue culture techniques (haploid-, single-cell and protoplast culturing); Cell separation and Cell fusion techniques for human therapy. Recombinant DNA cloning and gene transfer techniques; Restriction mapping; PCR and Real-time PCR methodologies; Site-directed mutagenesis; Sequencing techniques; Peptide mass fingerprinting; Blotting techniques (Western, Northern and Southern Blotting). Immunohistochemisty; immunocytochemisty; ELISA; optical and fluorescent microscopy.

Course Impact

After completing this course students will be able to practice advanced techniques in molecular biotechnology and independently use the instruments for their research projects.

Recommended books

1. Laboratory Protocols in Applied Life Sciences, Parkesh Bisen (2014), CRC press, Talyor and Francis group.
2. Methods for protein analysis, R.A. Copeland, (2013), Springer Publishers.
3. Lab. Techniques in Biochemistry and Molecular Biology, P.T. Sharpe, (2012) Elsevier Inc.
4. Molecular Biology Techniques by Susan Carson, 3rd edition (2012), Elsevier Inc.
5. Principles and Techniques of Biochemistry and Molecular Biology edited by Wilson and Walker, 7th edition (2010), Cambridge University Press.

Course No: **IBB. Biotech. 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.