Ph.D (Fish Biotechnology)

Course Structure – At a Glance

A. MAJOR COURSES **15 Credits**

1	FBT 601	Advances in Molecular Biology	2+1
2	FBT 602	Advances in Cell Biology	2+1
3	FBT 603	Genetic Engineering of Bacteria and Viruses	2+1
4	FBT 604	Genetic Engineering of Eukaryotes	2+1
5	FBT 605	Genomics and Transcriptomics	2+1
6	FBT 606	Genome Markers in Aquaculture	2+1
7	FBT 607	NGS Platforms and Data Analysis	0+1
8	FBT 608	Proteomics and Metabolomics	1+1
9	FBT 609	Bio-Process Technology	1+0

B. MINOR COURSES (Courses from other relevant disciplines) **8 Credits**

C. SUPPORTING COURSES (Compulsory) **5 Credits**

Course Work Total **28 Credits**

D. SEMINAR **2 Credits**

E. RESEARCH THESIS **45 Credits**

Total **75 Credits**

Detailed syllabus- PhD

FBT601	**ADVANCES IN MOLECULAR BIOLOGY**	**2+1**
Objective	To provide a deeper understanding of the molecular processes involved in the functioning and maintenance of living organisms so as to enable and encourage students to think of novel applications in future.	
Theory		
Unit I	Content of the genome: genome size and complexity, C-value paradox, repetitive and non-repetitive DNA, Cot curve, evolution of interrupted genes, cluster and repeats, gene families, pseudogenes, evolutionary clock.	
Unit II	Mitochondrial genome: structure and organization of genes	
Unit III	Molecular Biology of RNA: RNA types, RNA stability, RNA decay, post-transcriptional gene silencing, RNA editing, short and long non-coding RNA.	
Unit IV	Molecular Biology of Proteins: Post-translational modifications, Protein sorting and transport, Protein trafficking, Protein stability, Protein folding, Protein-Protein Interactions,	
Unit V	Epigenetic modifications and gene regulation: DNA methylation, DNA imprinting, histone modifications, histone code, chromatic remodelling,	
Unit VI	Biology of bacterial adaptive immunity - CRISPR	
Practical	Safe laboratory practices, DNA sequence analysis for identification of cis acting elements – Kozak sequence, intron-exon boundaries, poly A signal, terminators, promoters, transcription factor binding sites, zinc finger motif, , Designing RNAi and CRISPR guide molecules , Promoter analysis, 2D gel electrophoresis.	
Suggested Reading	**1.** Alberts et al. (2014) Molecular Biology of the Cell (6th edition). W. W. Norton & Company, NY, 1464 pp. ISBN-10:0815344325; **2.** Lodish et al. (2016) Molecular Cell Biology (8th edition). W. H. Freeman & Company Publishers. London, UK, 1280 pp ISBN-10: 1464183392; **3.** Edmund W. (1900) The Cell in Development and Inheritance (2nd edition). The Macmillan Company, NY; **4.** Gilbert S. F. & Barresi, M.J.F. (2016) Developmental Biology (11th edition). Sunderland; Sianuer Associates Inc Publishers, GIL: 810 pp. ISBN-10: 1605354708.	

FBT602	**ADVANCES IN CELL BIOLOGY**	**2+1**
Objective	To provide a deeper understanding of the cellular processes involved in the functioning, maintenance and death of living cells so as to enable and encourage students to think of novel applications in future.	
Theory		
Unit I	Cell cycle and growth regulation: cell cycle check points, cyclins, CDKs (Cyclin dependent kinases); Apoptosis: programmed cell death – genetic pathways for PCD, anti and proapoptotic proteins, Ubiquitin pathway for protein degradation,	

	Proteasome.
Unit II	Cell signalling, differentiation and de-differentiation, cell specific markers, FACS and MACS
Unit III	Oncogenesis: Viral and cellular oncogenes, tumour suppressor genes.
Unit IV	Molecular mechanisms of cellular communication, Cell movements, structure and function of cytoskeleton, actin and myosin filaments
Unit V	Signal transduction: Membrane receptors- G-protein coupled, Tyrosine kinase coupled and signalling pathways; Intracellular receptors: Steroid hormone receptors and signalling pathways
Unit VI	Active and passive transport: Carrier proteins - Uniporter/ symporter/antiporter, pumps, ion channels (ligand and voltage gated channels
Practical	Analysis of apoptosis through DNA ladder assay or TUNEL assay; Comet assay; Exposure to FACS and MACs machineries; *In silico* homology modelling; Molecular docking of receptor and signalling molecules. Purification of proteins using size exclusion, ion exchange and affinity chromatography techniques.
Suggested Reading	**1.**Alberts et al. (2014) Molecular Biology of the Cell (6th edition). W. W. Norton & Company, NY, 1464 pp. ISBN-10:0815344325; **2.** Lodish et al. (2016) Molecular Cell Biology (8th edition). W. H. Freeman & Company Publishers. London, UK, 1280 pp ISBN-10: 1464183392; **3.** Edmund W. (1900) The Cell in Development and Inheritance (2nd edition). The Macmillan Company, NY; **4.** Gilbert S. F. & Barresi, M.J.F. (2016) Developmental Biology (11th edition). Sunderland; Sianuer Associates Inc Publishers, GIL: 810 pp. ISBN-10: 1605354708.

FBT603	**GENETIC ENGINEERING OF BACTERIA AND VIRUSES**	**2+1**
Objective	To provide knowledge on various techniques available to produce genetically engineered microbes and their application, design of viral vectors for efficient gene delivery.	
Theory		
Unit I	Recombinant protein expression in Bacteria: Optimization of expression; fusion proteins, purification of recombinant proteins – inclusion bodies, extracellular targeting, engineering of signal sequences, electroporation.	
Unit II	Genetic engineering of Virus: Use of animal viruses like vaccinia, herpes, retrovirus, baculovirus and adenovirus as cloning vectors, design of viral vectors – special features, cis acting regulatory elements; strategies to optimize recombinant protein production, pros and cons of using viral vectors as gene delivery vehicles; vectors based on bacteriophage lambda, P1 and M13, special features and their application in optimizing recombinant protein production.	
Unit III	Scope and application of genetic engineering in virus: Efficient gene delivery	

	strategies, host-pathogen interaction, antigenic proteins, vaccination approaches, DNA vaccines, diagnostics; non-antibiotic selectable markers for live vaccines and gene therapy, methods for detection of viral infection, estimation of viral load by Real Time PCR, etc.
Unit IV	IPR issues in Biotechnology.
Practical	Transformation of bacteria by electroporation, Southern and dot-blot transfer techniques; Restriction mapping of DNA; labelling of DNA probes; PAGE analysis for recombinant proteins. Preparation of primary and secondary monolayer cell culture, use of cell culture in virus cultivation and assay; Viral DNA isolation and restriction analysis; Culture and maintenance of bacteriophages; qRT-PCR. Bacterial mass culture through fermentation technique.
Suggested Reading	**1.** Krebs, J.E., Goldstein, E.S. & Kilpatrick, S.T. (2017) Lewin's Genes XII. Jones & Bartlet Publishers, MA, USA 829 pp. ISBN-10: 1284104494. **2.** Rodney Boyer (2005) Concepts in Biochemistry (3rd Edition). Wiley, NJ, US, 736 pp. ISBN-10: 0471661791. **3.**. Green, M.R. & Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual (4th edition : Vol 1-3.). Cold Spring Harbor, NY, USA 2028 pp. **4**. Brown T.A. (2017) Genomes 4 (4th edition). Garland Science, US, 544 pp.

FBT604	**GENETIC ENGINEERING OF EUKARYOTES**	**2+1**
Objective	To provide in-depth knowledge on the techniques available for genetic engineering of eukaryotes and strategies to optimize recombinant protein production in eukaryotic expression systems.	
Theory		
Unit I	Eukaryotic expression systems: Yeast expression system - host strains, special features, types of vectors (yeast episomal vectors, integrating vectors and YACs), yeast two hybrid system.	
Unit II	Insect cell expression system - special features, types, baculoviral expression vectors, polyhedron promoters.	
Unit III	Mammalian cell expression system - special features, selectable markers; Transfection: principle, types, selection; transduction by viral vectors, construct design (strong and constitutive promoters, inclusion of introns).	
Unit IV	Fish cell expression systems: Tissue specific promoters, constitutive promoters and applications. Strategies for optimizing recombinant gene expression in eukaryotic systems; Downstream processing of recombinant proteins.	
Unit V	Transgenesis: methods of gene transfer, integration and detection techniques, *In situ* hybridization; strategies for gene targeting (homologous sites/cre-lox recombination system); specialized vectors for high efficiency transgenesis – eukaryotic transposon vectors, retroviral vectors, etc., an overview of transgenics developed in fisheries sector; Biosafety regulation.	

Unit VI	Fish as a model organism: Gene function analysis – gene knockouts, gene silencing by RNAi, morpholinos, etc; site directed and transposon mediated mutagenesis. CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) knockout/ knockdown technology.
Practical	Gene transfer experiments (electroporation, microinjection); Western, Southern blotting for confirming integration and expression of transgene; Inverse PCR-Partial RE digestion, designing of primers and interpretation of results; Construction of cDNA library; Screening: Probe design, colony hybridization; Designing of guide RNA for CRISPR vector.
Suggested Reading	**1.** Krebs, J.E., Goldstein, E.S. & Kilpatrick, S.T. (2017) Lewin's Genes XII Jones & Bartlet Publishers, MA, USA 829 pp. ISBN-10: 1284104494. **2.** Rodney Boyer (2005) Concepts in Biochemistry (3rd Edition). Wiley, NJ, US, 736 pp. ISBN-10: 0471661791. **3.** Green, M.R. & Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual (4th edition: Vol 1-3.), Cold Spring Harbor, NY, USA 2028 pp. **4.** Brown T.A. (2017) Genomes 4 (4th edition). Garland Science, US, 544 pp.

FBT 605	**GENOMICS AND TRANSCRIPTOMICS**	**2+1**
Objective	To give an introduction to application of modern techniques for genome and functional genome analysis.	
Theory		
Unit I	Genome size estimation; High throughput sequencing platforms for whole genome sequencing: Principles, applications, limitations. Data analysis; Gap filling and linkage groups; Gene annotation; Genome mining for various applications.	
Unit II	Transcriptome sequencing by RNAseq and NGS data analysis, sequence assembly, annotation, gene ontology assignment, KEGG pathway analysis.	
Unit III	Non-coding RNA: Structure and processing of miRNA and long noncoding RNA	
Unit IV	Global gene expression analysis: DNA Microarray, Subtractive hybridization and differential display for the identification of differentially expressed genes.	
Practical	Processing of high throughput sequence data for assembling contigs, gene annotation and pathway analysis; mining of transcriptome data for protein coding genes, differentially expressed genes, short and long non coding RNA and their target genes; Ensembl genome browser; DNA microarray,	
Suggested Reading	**1.** Schlena, M.(1999) DNA Microarrays: A Practical Approach, Oxford University Press, London, UK, 232 pp.; **2.** Peruski , L.F. & Peruski, A.H.(1997), The Internet and New Biology: Tools for Genomic and Molecular Research. ASM press, WA, USA, 350 pp. **3.** Stephen, H. & Livesey, F. (2000), Functional Genomics: A Practical Approach, Oxford University Press, London, UK, 272 pp.	

FBT 606	GENOME MARKERS IN AQUACULTURE	2+1
Objective	To learn development and application of genomic tools in aquaculture species.	
Theory		
Unit I	Molecular markers in aquaculture and their application. Transcriptome associated markers - Type I markers	
Unit II	DNA marker maps: Radiation hybrid mapping and integrated maps	
Unit III	Genome analysis: Preparation of ordered cosmid libraries, BAC libraries, Shotgun libraries and sequencing, conventional and automated sequencing, Metagenomics, NGS platforms – principles and applications.	
Unit IV	Comparative genomics, Genotype based sequencing, Case studies of linkage maps (Rohu, Tilapia, European seabass, Channel catfish, *Litopenaeus vannamei*).	
Unit V	QTL and Maker assisted selection, genomic selection, DNA chips, phenomics and association studies	
Practical	Microsatellite enriched genomic library construction, screening by colony hybridization, probe labelling techniques, software related to linkage mapping, SNP discovery and analysis.	
Suggested Reading	**1**. Pasteur et al., (1988) Practical Isozyme Genetics. Ellis horwood ltd, England: 215 pp.; **2.** Avise, J.C. (1994). Molecular Markers, Natural History and Evolution, Springer, US, 516 pp. **3**. Caetano-anolles G. and Gresshoff P.M. (1998) DNA Markers: Protocols, Applications and Overviews. Wiley-VCH, NY: 364 pp. **4.** Green, M.R. and Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual (4^{th} edition : Vol 1-3.). Cold Spring Harbor , NY, USA 2028 pp.	

FBT 607	NGS PLATFORMS AND DATA ANALYSIS	0+1
Objective	To understand the basic principles of next generation sequencing technology including data generation, processing and analysis.	
Practical	NGS platforms, genome & transcriptome sequencing, NGS experimental design and planning, NGS data files and formats, introduction to Linux environment; NGS bioinformatics workflow steps following sequence generation, data analysis/quality filtering using FAST-Q screen, variant calling & NGS data assembly tools (reference guided and *de novo*), sequence alignment using BWA, genome and transcriptome annotation, gene ontology (GO) and pathway analysis (KEGG) of transcriptome data, SNP and SSR detection, metagenomics analysis.	
Suggested Reading	**1.** Liu Z. (2010). Next Generation Sequencing and Whole Genome Selection in Aquaculture. Wiley-Blackwell, NJ, USA232 pp. **2.**Naira R.E. et al. (2012) Bioinformatics for High Throughput Sequencing. Springer-Verlag New York,	

	255 pp.

FBT 608	**PROTEOMICS AND METABOLOMICS**	**1+1**
Objective	To introduce modern tools used to study proteomes and metabolomes for deeper understanding of cellular and molecular processes and their modulation in response to various stimuli.	
Theory		
Unit I	Introduction to proteomics, metabolomics and system biology including principles and applications.	
Unit II	1D and 2D–gel electrophoresis, 2-D Difference Gel Electrophoresis (DIGE); Two dimensional liquid chromatography, Isotope-coded affinity tag (ICAT); Isobaric tagging for relative and absolute quantitation (iTRAQ); Stable Isotope labelling by Amino Acid in Cell Culture (SILAC).	
Unit III	Mass Spectrometry: Overview and working of different types of mass spectrometer (LC-MS & GC-MS).	
Unit IV	Functional Proteomics - Protein Microarrays: Protein-protein interactions to understand biological systems; Different types of protein microarrays and their advantages and disadvantages.	
Unit V	Bioinformatics tools used in proteomics: Protein databases and interfaces; Software used for protein identification.	
Practical	Sample preparation, Separation of proteins by two-dimensional gel electrophoresis, Protein purification and quantification, In gel-trypsin digestion, Protein identification using computational tools.	
Suggested Reading	**1.** Schlena, M.(1999) DNA Microarrays: A Practical Approach, Oxford University Press, London, UK, 232 pp.; **2.** Peruski , L.F. & Peruski, A.H.(1997), The Internet and New Biology: Tools for Genomic and Molecular Research. ASM press, WA, USA, 350 pp. **3.** Stephen, H. & Livesey, F. (2000), Functional Genomics: A Practical Approach, Oxford University Press, London, UK, 272 pp.	

FBT 609	**BIOPROCESS TECHNOLOGY**	**1+0**
Objective	To learn the techniques for bulk processing, production and purification of biologicals.	
Theory		
Unit I	Raw materials for bioprocessing, comparison of chemical and biochemical processing based on energetics and environmental issues. Development of inocula, kinetics of enzymatic and microbial processes, optimisation studies, sterilization of media, air and equipment, modes of cell cultivation, general principles of bioreactor design and their operation -Downstream processing,	

	separation and purification techniques, quality assurance testing, representative examples of microbial products, vaccines and vaccine development.
Unit II	Immobilization of cells and enzymes: principles, methodology and applications, disintegration of cells, separation of solid and liquid phases, isolation and purification techniques for proteins and other products based on different physico-chemical properties, eg., precipitation, adsorption, chromatographic separations, bio-affinity based methods - Principles of bioprocess control, bioprocess automation and application of computers in bioprocessing, recombinant products with representative examples,
Suggested Reading	**1.** Ratlidge, C. & Kristiansen, B. (2006) Basic Biotechnology. Cambridge University Press, Cambridge, UK, 679 pp. **2.** Renneberg, R. et al. (2017). Biotechnology for Beginners. Academic Press, MA, USA, 464 pp. **3.** Waites, M.J. et al. (2001) Industrial Microbiology: An Introduction. Wiley-Blackwell, NJ, USA, 304 pp.

List of Journals

1. Animal Biotechnology
2. Applied biochemistry and biotechnology
3. Biochemical Genetics
4. Bioinformatics
5. Biology of the Cell
6. Biotechnology Advances
7. Biotechnology and applied biochemistry
8. Biotechnology and Bioengineering
9. Briefings in Bioinformatics
10. Cell
11. Cell and tissue research
12. Cell Biology International
13. Cell Death and Differentiation
14. Cell Growth and Differentiation
15. Cell Research
16. Conservation Genetics
17. Conservation Genetic Resources
18. Critical Reviews in Biotechnology
19. Current bioinformatics
20. Current Opinion in Biotechnology
21. Current Opinion in Cell Biology
22. Current Stem Cell Research and Therapy
23. European Journal of Immunogenetics
24. Experimental Cell Research
25. Gene Expression Patterns
26. Gene Structure and Expression
27. Genome Research
28. Journal of animal law and ethics
29. Journal of Biochemistry and Molecular Biology
30. Journal of Biotechnology
31. Journal of Cell Biology
32. Journal of Cell Science
33. Journal of Commercial Biotechnology
34. Journal of Computational Biology
35. Journal of Industrial Microbiology and Biotechnology
36. Journal of Marine Biotechnology

37. Journal of Molecular Biology
38. Journal of RNAi and Gene silencing
39. Marine biotechnology
40. Microbial biotechnology
41. Molecular Biology of the Cell
42. Molecular Biotechnology
43. Molecular Cell Research
44. Molecular Ecology
45. Molecular Ecology Resources
46. Molecular Genetics and Genomics
47. Molecular Marine Biology and Biotechnology
48. Molecular Phylogenetics and Evolution
49. Nature Biotechnology
50. Nature Cell Biology
51. Nature Structural and Molecular Biology
52. Nucleic acids research
53. Proteins, structure, function and bioinformatics
54. Recent Patents on Biotechnology
55. Reviews in environmental science and biotechnology
56. Reviews in Molecular Biotechnology
57. Trends in Biotechnology
58. Trends in Cell Biology