M.F.Sc. (Fish Biotechnology)

Course Structure – At a Glance

A. MAJOR COURSES **23 Credits**

1	FBT 501	Fundamentals of Molecular Biology	2+1
2	FBT 502	Basic Concepts of Cell Biology	2+1
3	FBT 503	Gene Structure and Regulation of Expression	2+1
4	FBT 504	Basic Principles of Genetic Engineering	2+1
5	FBT 505	Molecular Markers	2+1
6	FBT 506	Bioinformatic Tools in Genetic Engineering	1+1
7	FBT 507	Cell Culture and its Applications	1+2
8	FBT 508	Marine Biotechnology	1+1
9	FBT 509	Aquaculture Biotechnology	2+1
10	FBT 510	Molecular Biology Techniques	1+1 (Non FGB students)
11	FBT 511	Molecular Taxonomy and Phylogenetics	2+1

B. MINOR COURSES (Courses from other relevant disciplines) **6 Credits**
C. SUPPORTING COURSES (Compulsory) **5 Credits**
D. OPTIONAL COURSES **3 Credits**

(Course Work Total **37 Credits)**

E. SEMINAR **1 Credits**
F. Skilled training **2 Credits**
G. RESEARCH THESIS **20 Credits**

Total **60 Credits**

Detailed Syllabus – M.F.Sc.

FBT 501	**FUNDAMENTALS OF MOLECULAR BIOLOGY**	**2+1**
Objective	To provide knowledge of basic molecular processes involving nucleic acids and protein structures, synthesis and maintenance within a living cell so as to impart an overall understanding of universality of living processes.	
Theory		
Unit I	Nucleic Acids: Genetic material, Structures of DNA and RNA; Stereochemistry of bases and secondary structures; Alternative forms of DNA structure Organisation of the nucleic acids: Chromatin structure; Telomeres, Physico-chemical properties of DNA: Tm, hyperchromicity, kinetic classes, buoyant density, etc.	
Unit II	DNA replication: Models of DNA replication in prokaryotes, eukaryotes and viruses; Molecular events during DNA replication; The Replisome: *E. coli* and eukaryotes; Structure and function of DNA polymerases	
Unit III	Transcription in prokaryotes: Bacterial RNA polymerases; initiation, elongation and termination, Transcription in eukaryotes – RNA polymerases and mechanism; Post transcriptional modifications; Structure and synthesis of rRNA and tRNA.	
Unit IV	Translation: Genetic code, codon bias, types and structures of ribosomes, tRNA structure, Wobble hypothesis, mechanisms of initiation, elongation, termination, and post-translational modifications in prokaryotes and eukaryotes and the factors involved in various steps, concept of polysomes and protein structure.	
Unit V	DNA recombination: Homologous and site-specific recombination; Crossing over; Holliday junction; Transposition.	
Unit VI	Mutations: Types, Mutagens – nitrous acid, UV, aflatoxin, bleomycin, ethidium bromide.	
Unit VII	DNA Repair: DNA repair enzymes, types and mechanisms.	
Practical	Good Laboratory Practices- Biosafety and disposal of hazardous material; Preparation of buffers, reagents and media; Tissue sampling; Nucleic acid isolation (genomic/plasmid DNA and RNA); Agarose gel electrophoresis; Nucleic acid quantification; Protein purification and separation in polyacrylamide gel electrophoresis (SDS-PAGE)	

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.** Primrose, S.B. (1987) Modern Biotechnology. Blackwell Scientific Pub., London, UK, 184 pp. **4.** Glick R.B., Pasternak, J.J. & Patten, C.L. (2010) Molecular Biotechnology: Principles and Applications of Recombinant DNA (4th edition). ASM Press, WA, USA, 850 pp **5.** Watson, J. D. et al. (2017) Molecular Biology of the Gene (7th edition). Pearson Education, London, UK, 912 pp.

FBT 502	**BASIC CONCEPTS OF CELL BIOLOGY**	**2+1**
Objective	To outline the basic structure, growth and differentiation of prokaryotic and eukaryotic cells, sub-cellular components and their functions so as to impart an overall understanding of cellular organisation and evolutionary changes.	
Theory		
Unit I	Prokaryotic and eukaryotic cell architecture: Cell theory; diversity of cell size and shape.	
Unit II	Organization and function of sub-cellular organelles: Cell membrane; Cytoplasm; Endoplasmic reticulum; Golgi apparatus; Lysosomes; Mitochondria; Nucleolus; Peroxisomes and Sub-nuclear structures.	
Unit III	Principles of membrane transport: Active/passive membrane transport (Case study – Osmoregulation in freshwater and marine fishes) ion channels; carrier proteins; Cell signalling: Signalling molecules, Cell surface receptors, Secondary messengers and Intracellular signal transduction.	
Unit IV	Cell division: Cell cycle and its regulation in *E. coli* and animal cells.	
Unit V	Cell motility: Actin-myosin filaments; Flagella; Cilia.	
Unit VI	Protein sorting: Secretion and targeting; Vesicular traffic; Endocytosis; Exocytosis; Protein translocation and secretary pathways.	
Practical	*E. coli* growth curve; Gram staining; Microscopic techniques - bright field, phase contrast and fluorescent microscopy; Microtomy; Histochemical techniques; Sub-cellular fractionation and functional integrity; Isolation and purification of mitochondrial DNA; Chromosome preparation.	

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, 396 pp.; **4.** Gilbert S. F. & Barresi, M.J.F. (2016) Developmental Biology (11th edition). Sunderland; Sianuer Associates Inc Publishers, GIL: 810 pp. ISBN-10: 1605354708.

FBT 503	**GENE STRUCTURE AND REGULATION OF EXPRESSION**	**2+1**
Objective	To understand the structure of genes in prokaryotes and eukaryotes and the significance of *cis* and trans acting genetic elements in the regulation of gene expression and to discuss the possibilities of manipulating gene function for the good of mankind in general and fisheries in particular.	
Theory		
Unit I	Gene structure: Promoters, UTRs, ORFs, exons, introns, termination signal, mono- and polycistronic genes; Gene clustering; Overlapping genes (Phi X174 virus); Bidirectional promoters.	
Unit II	Regulation of gene expression in prokaryotes: Operon concept, Types of operons, lactose and tryptophan operons, their structure and mode of regulation; SOS response.	
Unit III	Regulation of gene expression in eukaryotes: DNA protein interactions (concept of DNA foot printing, EMSA, Zinc fingers, Leucine zippers, Helix turn helix, Z-DNA); Transcription factors, Promoters, Enhancers, Repressors, Insulators, Attenuators, IRES, Alternative splicing, Histone modification and DNA Methylation.	
Unit IV	RNA in gene regulation: Antisense RNA, MicroRNA, Ribozymes.	
Unit V	Expression profiling: Real time PCR; Overview of Microarray and RNA seq	
Practical	Retrieval of gene information from ensemble and NCBI, BLAST; *In silico* identification and analysis of promoters, transcription factors and other regulatory elements, T/A cloning and blue white selection of recombinant clones, total RNA extraction, cDNA synthesis, RT-PCR, real-time PCR, DNA microarray.	
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.** Primrose, S.B. (1987) Modern Biotechnology. Blackwell	

	Scientific Pub., London, UK, 184 pp.

FBT 504	**BASIC PRINCIPLES OF GENETIC ENGINEERING**	**2+1**
Objective	To detail the basic steps in recombinant DNA technology and its application in optimization of production, health and environment in fisheries and aquaculture.	
Theory		
Unit I	Recombinant DNA technology: Overview; DNA modifying enzymes - types of restriction endonucleases (Type I, II and III), DNA polymerases, reverse transcriptase, alkaline phosphatases, kinases, exonucleases, ligases, terminal transferases; Vectors - plasmids (replication, copy number control and compatibility), phagemids, cosmids, high capacity vectors (eg. BAC), shuttle vectors; Adapters, linkers, ligation, transformation and selection.	
Unit II	Selection Markers: Mode of function and resistance mechanisms of selected antibiotics (Ampicillin, Tetracyclin, Streptomycin, Chloramphenicol, Kanamycin); Auxotrophic markers	
Unit III	Host organisms: Prokaryotic (selected *E. coli* strains) and eukaryotic (yeast strains).	
Unit IV	Principle of DNA amplification by PCR and applications; Optimization, Prevention of mispriming; Hot Start, Touchdown, Gradient PCR; T/A cloning of amplified products; Characteristics and types of thermostable DNA polymerases	
Unit V	Cloning strategies for prokaryotic and eukaryotic constructs; Promoter systems for high expression in *E. coli;* Cloning for *in vitro* transcription; Expression optimization and affinity purification strategies for recombinant proteins.	
Unit VI	Genomic DNA library: Shotgun cloning Construction in high capacity vectors, Screening, and Applications; Chromosome walking.	
Unit VII	cDNA library: Construction and screening; Clone characterization.	
Practical	*In silico* DNA sequence analysis for cloning; PCR primer designing, Insert and vector preparation, ligation, preparation of competent cells, transformation, clone selection techniques (Blue/white selection, horizontal slot lysis/colony PCR); Southern hybridization, probe Labelling methods; Western blotting	
Suggested Reading	**1**. Green, M.R. & Sambrook, J. (2012) Molecular Cloning: A Laboratory Manual (4^{th} edition: Vol 1-3.). Cold Spring Harbor , NY, USA 2028 pp. **2.** Brown T.A., (1998) Molecular Biology LabFax, Volume 1: Recombinant DNA. Academic Press, MA, USA. 255 pp. **3.** Brown T.A. (2017) Genomes 4 (4^{th} edition). Garland Science, US, 544 pp. **4.** Primrose S.B. & Twyman R.M., (2006) Principles of Gene Manipulation and Genomics (7^{th} edition). Blackwell Publishing, Oxford	

	UK., 672 pp.

FBT 505	**MOLECULAR MARKERS**	**2+1**
Objective	To acquaint the students with techniques used to estimate genomic variation among individuals and populations for applications in selective breeding and conservation.	
Theory		
Unit I	Sources and significance of genetic variation; Statistical methods to estimate genetic variation.	
Unit II	Biochemical and molecular markers: Type I and Type II markers; Development and applications of Allozymes, mtDNA markers, RFLP, RAPD, AFLP, Minisatellites, Microsatellites and SNPs.	
Unit III	Sequencing technologies: Chemical sequencing, Chain termination and NGS.	
Unit IV	Whole genome (Nuclear and Mitochondrial) and transcriptome sequencing and their applications in marker development.	
Unit V	Marker Assisted Selection: Overview of linkage maps; FISH, QTL and genomic selection, population genomics.	
Practical	Allozyme variation by PAGE, Transcriptome analysis for various markers (SSR and SNPs). RAPD, PCR-RFLP, Microsatellite development, validation and analyses. Interpretation of gels, data analysis and use of software.	
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. & Gresshoff P.M., (1998) DNA Markers: Protocols, Applications and Overviews. Wiley-VCH, NY: 364 pp.	

FBT 506	**BIOINFORMATIC TOOLS IN GENETIC ENGINEERING**	**1+1**
Objective	To introduce the students to DNA and protein databases, sequence retrieval and analysis and their application in biotechnological research.	
Theory		
Unit I	Overview of bioinformatic resources and applications; Platforms (Linux and Windows) and available software	
Unit II	Sequence Alignment: Dot matrix, PAM, BLOSSUM matrix, Sequence retrieval from online database, simple pairwise alignment (BLAST) and multiple sequence alignment.	

Unit III	Sequence analysis tools: Sequence quality, assembly and annotation of Sanger sequencing reads, identification of *cis* acting regulatory elements, ORF finding, signal sequences in DNA and proteins, data analysis tools for SNP and ESTs.
Unit IV	Phylogeny and evolution: phylogenetic analysis - maximum parsimony, maximum likelihood, Bayesian inference; estimation of divergence time.
Unit V	Protein information resources, primary and secondary protein databases, analysis packages.
Practical	Sequence retrieval, sequence submission to NCBI GenBank/BOLD, BLAST analysis, ClustalW, NCBI ORF finder, primer designing software, restriction site identification, plasmid map drawing, PCR primer design, RNA secondary structure prediction, protein structure prediction software, phylogenetic analysis by MEGA, MrBayes, Phylip and PAUP software.
Suggested Reading	**1.** Rashidi, H. H. & Buehler, L.K. (2005) Bioinformatics Basics: Applications in Biological Science and Medicine (2nd edition). CRC press, FL, USA, 360 pp. **2.** Attwood, T. K. & Parry-Smith D. J. (2001) Introduction to Bioinformatics. Benjamin Cummings, SF, USA, 339 pp. **3.** Mount, D. W. (2004) Bioinformatics: Sequence and Genome Analysis. CSHLP, NY, 692 pp. **4.** Brown S. M. (2000) Bioinformatics: A biologists' Guide to Biocomputing and the Internet. Eaton Pub Co, 188 pp.

FBT 507	**CELL CULTURE AND ITS APPLICATIONS**	**1+2**
Objective	To impart knowledge on cell and tissue culture techniques and their application in health management, gene banking and genetic characterization.	
Theory		
Unit I	Introduction: Structure and Organization of animal cell; biology of cultured cells;	
Unit II	Basic requirements for animal cell culture technology: Equipment, Media and supplements, basic aseptic techniques. –.	
Unit III	Primary culture, establishment and maintenance of cell lines; Organ and histotypic cultures; assessment of contaminants; scaling-up of cell culture; applications of cell culture / lines.	
Unit IV	Overview of methods used for characterization of primary culture / cell lines.	
Unit V	In vitro cytotoxicity and genotoxicity	

Unit VI	Stem cells: Stem cell cultures, embryonic stem cells and their applications; ;; Overview of three dimensional culture and tissue engineering.
Unit VII	Conservation of cell lines, Storage and maintenance of cell lines.
Practical	Preparation of cell culture medium and membrane filtration, preparation of single cell suspension from selected tissue, cell counting and cell viability; trypsinization and sub culturing, cryopreservation and thawing; measurement of doubling time, Characterization of cells using cytogenetic and molecular markers.
Suggested Reading	**1.** Freshney, R. L. (2010) Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th edition). Wiley-Blackwell, NJ, USA, 768 pp. **2.** Masters, J.R.W. (2000) Animal Cell Culture-Practical Approach. Oxford Press, London, UK, 334 pp.; **3**. Baserga, R. (1989) Cell growth and Division: A Practical Approach. Oxford Press, London, UK, 172 pp. **4.** Butler, M. & Dawson, M. (1992) Cell culture Labfax. Academic Press, MA, USA, 274 pp. **5.** Clynes, M. (1998) Animal Cell Culture Techniques. Springer, NY, USA 618 pp.

FBT 508	**MARINE BIOTECHNOLOGY**	**1+1**
Objective	To give the students an overview on the potential marine resources for bioactive compounds, pharmaceuticals and the application of biotechnological tools to combat marine pollution.	
Theory		
Unit I	Introduction: Historical background, overview of the present status of marine biotechnology, commercially important and potential species, micro-and macro-algae their culture.	
Unit II	Marine Resources: biodiversity, marine natural products, valuable chemicals, biomedical, polysaccharides and bioactive compounds from marine organisms, marine organisms as a source of antiviral, anticancer and anti-inflammatory compounds; and commercially important enzymes, Biofuel from micro algae.	
Unit III	Environmental Biotechnology: bio-film and bio-remediation, bio-sensors; genetically engineered microbes for pollution control, biofouling and prevention,	
Unit IV	Metagenomics: bio-prospecting of genes and allele mining for novel proteins.	
Practical	Isolation of marine algae, plankton and its culture method, methods for isolation aerobic and anaerobic microbes from sea; Extraction and screening of selected	

	bioactive compounds from seaweeds, microalgae and sponges;
Suggested Reading	**1.** Fusetani, N. (2000) Drugs from the Sea. Karger Publisher, Switzerland, 158 pp.; **2.** Karl, D.M. (1995) Microbiology of Deep-Sea Hydrothermal Vents. CRC Press FL, USA, 299 pp.; **3.** Omum, S. (1992) The Search for Bioactive Compounds from Microorganisms. Springer-Verlag New York, 336 pp.

FBT 509	**AQUACULTURE BIOTECHNOLOGY**	**2+1**
Objective	To provide an overview of the application of biotechnological tools in fish breeding, nutrition, health, processing and other issues in fisheries.	
Theory		
Unit I	Reproductive biotechnology: Induced breeding hormones and analogues. . Manipulation of primordial germ cells and surrogacy.	
Unit II	Chromosome manipulation: Ploidy manipulation, Sex manipulation, Androgenesis, Gynogenesis and applications.	
Unit III	Transgenesis in fish; GMOs: Biosafety regulations and ethics.	
Unit IV	Nutritional & health biotechnology: Probiotics, Biofilms, Biofloc, Single cell protein, Bio-encapsulated feeds, Nutraceuticals, Nutrigenomics, Disease diagnostic techniques and therapeutics.	
Unit V	Gene Bank and conservation: Cryopreservation of gametes, embryos and stem cells.	
Unit VI	IPR issues in Biotechnology	
Practical	Chromosomal manipulation- Gynogenesis, Triploidy, Disease diagnosis using PCR and ELISA, Spirulina culture, Cryopreservation of milt, Patent search.	
Suggested Reading	**1.** Dunham, R. A., (2004) Aquaculture and Fisheries Biotechnology: Genetic Approaches. CABI Publishing, Cambridge, USA. 385 pp. **2.** Borowitzka, M.A. & Borowitzka, L.J. (1988) Micro-algal Biotechnology. Cambridge University Press, London, UK, 488 pp. **3.** Chen, F. &Jiang, Y. (2001) Algae and their Biotechnological Potential. Springer Netherlands, 306 pp. **4.** Gordon R. & Seckbach J. (2012) The Science of Algal Fuels**.** Springer Netherlands, 506 pp. **5.** Lakra. W.S (2004) "Fisheries Biotechnology" Narendra Publishing House, New Delhi, 240 pp.	

FBT 510	MOLECULAR BIOLOGY TECHNIQUES	1+1
Objective	To provide basic knowledge on theoretical and practical aspects of molecular biology to students of other disciplines applying molecular approaches in their research work.	
Theory		
Unit I	Introduction to molecular biology, Structure of nucleic acids (DNA & RNA), Physico-chemical properties of nucleic acids, Nucleic acid quantification	
Unit II	Overview of DNA replication, DNA amplification by PCR, PCR variants and minimizing mispriming, DNA sequencing by chain termination method	
Unit III	Overview of transcription, Structure of eukaryotic gene, gene expression studies	
Unit IV	Overview of recombinant technology, Cloning of PCR products	
Unit V	Molecular markers: Principles and application of mitochondrial and nuclear markers	
Unit VI	Introduction to bioinformatics – I, Introduction to bioinformatics – II	
Practical	Do's and Don'ts in molecular biology lab, Isolation of genomic DNA, Nucleic acid quantification, Agarose gel electrophoresis, Gel documentation and analysis by software, PCR primer design, DNA amplification by PCR, Gel elution of PCR products, TA cloning, Ligation, Competent cell preparation, Transformation, Screening for recombinant clones by colony PCR / slot lysis electrophoretic analysis, Isolation of plasmid DNA , Isolation of total RNA, cDNA synthesis, RT-PCR, Real time PCR, Analysis of DNA sequence chromatograms, RAPD and RFLP.	
Suggested Reading	**1.**Dale, J.W. & M. von Schantz (2007) From Genes to Genomes: Concepts and Applications of DNA Technology. Wiley –Blackwell, NJ, USA, 360 pp; **2.** Lodge, J., Lund P. & Minchin S. (2007) Gene Cloning. Taylor and Francis, UK, ISBN 0748765344, 462 pp. ; **3.** Reece, R. J. (2004) Analysis of Genes and Genome. Wiley –Blackwell, NJ, USA, 490 pp; **4.** Starkey, M. & Elaswarapu, R. (2011) Genomics. John Wiley and Sons Ltd., ISBN 978-0-470-71157-6, 333p; **5.** Beaumont, A.R. & Hoare K. (2003) Biotechnology and Genetics in Fisheries and Aquaculture. Wiley –Blackwell, NJ, USA 158p; **6.** Z. (John) Liu (2007) Aquaculture Genome Technologies. Wiley –Blackwell, NJ, USA 551p.	

FBT 511	MOLECULAR TAXONOMY AND PHYLOGENETICS	2+1
Objective	To acquaint the students with techniques used to delimit species using DNA / Protein sequence data for application in molecular taxonomy and conservation.	
Unit I	Molecular Basis of Evolution: Overview of genome structure; Sources of genetic variation (Recombination, Mutations, Indels, Gene duplication); fast and slow-evolving sequences; Homologous, Paralogous and Orthologous genes. Concept of Neutral theory of molecular evolution.	
Unit II	Evolution and Speciation: Allopatric, Sympatric and Parapatric speciation. Factors responsible for speciation Phylogenetic species concept, Phylogenetic trees, Concept of monophyly, paraphyly and polyphyly. Gene trees and species trees DNA barcoding: Principle, Methodology, Application and limitations.	
Unit III	Genetic distances: observed and expected distances, Phylogenetic reconstruction using distance-based methods (UPGMA, Neighbour-Joining), Principle, methodology, interpretation of results and limitations.	
Unit IV	Phylogenetic reconstruction using character-based methods, Maximum Parsimony, Maximum Likelihood and Bayesian Inferences	
Practical	DNA sequence analysis, Genomic databases, Genbank search and dataset download. Sequence alignment, and editing, Data partition, Selection of the best substitution model. Use of Neighbour-Joining, Maximum Likelihood and Bayesian inference. Re-analysis and interpretation of reference data. Bioinformatic tools (Phylip, PAUP, Mr. Bayes) for phylogenetic tree reconstruction.	
Suggested Reading	**1.**Avise J.C. (1994) Molecular Markers, Natural History and Evolution. Springer, US, 516 pp. **2** Nei, M. & Kumar, S. (2000) Molecular Evolution and Phylogenetics. Oxford University Press, NY, 348 pp. ; Lemey, P., Salemi, M & Vananmme, A-M. (2009). The Phylogenetic Hand book: A Practical Approach to Phylogenetic Analysis and Hypothesis Testing. Cambridge University Press.UK, 749 pp.	