M.F.Sc. (Fish Physiology and Biochemistry)

Course Structure – At a Glance

A	**MAJOR COURSES**			**20 Credits**
	A1	**CORE COURSES**		12 Credits
1	FPB 501	Fish Physiology	2+1	
2.	FPB 502	Reproductive Physiology and Endocrinology	2+1	
3	FPB 503	Fish Biochemistry	2+1	
4	FPB 504	Metabolism of Biomolecules	2+1	
	A2	OPTIONAL COURSES		8 Credits
1	FPB 505	Tools and Techniques in Biochemistry	1+1	
2	FPB 506	Cardiovascular System and Respiratory Physiology	2+1	
3	FPB 507	Immunobiology	1+1	
4	FPB 508	Cellular and Molecular Physiology	2+1	
5	FPB 509	Sensory Physiology	1+1	
6	FPB 510	Physiology of Fish Behaviour	1+1	
7	FPB 511	Pharmaco-biology of Aquaculture Drugs	1+1	
8	FPB 512	Physiology of Excretion and Osmoregulation	1+1	
9	FPB 513	Eco-physiology of Fishes	1+1	
10	FPB 514	Enzymology	2+1	
11	FPB 515	Diagnostic Biochemistry	1+1	
12	FPB 516	Fish Nutrigenomics	2+1	
13	FPB 517	Aquatic radioecology	2+1	
B	**MINOR COURSES** (Courses outside major discipline/from other relevant disciplines)			**9 Credits**
C	**SUPPORTING COURSES** (Compulsory)			**5 Credits**
1	FST 501	Research Methodology	1+1	
2	FST 502	Statistical Methods	1+2	
		Total Course Work Credits		**34 Credits**
D	**MASTERS' SEMINAR**			**1 Credits**
1	FPB 591	Masters' Seminar I	0+1	
E	**FIELD TRAINING**			**2 credits**
1	FPB 551	Field Training Phase I	0+2	
F	**MASTERS' RESEARCH**			**20 Credits**
1	FPB 599	Masters' Research (Semester III)	0+10	
2	FPB 599	Masters' Research (Semester IV)	0+10	
	Total M.F.Sc. Program Credit Hours			**57 Credits**

FISH PHYSIOLOGY AND BIOCHEMISTRY

Course Contents

FPB 501	**FISH PHYSIOLOGY**	**2+1**
Objective	To understand the basic physiology of finfish and shellfishes	
Theory		
Unit I	Cell Physiology: Structures, membranes, organelles and functions; cell cycle; Signaling and cell death	
Unit II	Physiology of Digestion: Digestive system; absorption and assimilation of food; digestive enzymes, hormones and regulation; factors affecting digestion.	
Unit III	Physiology of respiration: Gill Morphology, mechanism of Respiratory pigments and their functions; Mechanism of gaseous exchange, CO_2 transport, countercurrent principle, water flow across the gills, respiratory pumps.	
Unit IV	Cardiovascular system: structure and functions of heart, blood circulation, blood pressure, Composition of blood, heart and cardiac output, structure of blood/haemolymph pigments.	
Unit V	Physiology of Osmoregulation and Respiration: Excretory and osmoregulatory organs in fish and shellfish and their functions; Mechanism of osmotic and ionic regulation; Acid base regulation, Mechanism of excretion of nitrogenous waste	
Unit VI	Physiology of Reproduction: Structure and functions of gonads, gametogenesis; vitellogenesis; gonadal steriodgenesis; seasonality of reproduction, and endocrine control of reproduction.	
Practical	Estimation of digestive enzymes: amylases and trypsin, Assay of Na^+-K^+ ATPase activity and estimation of hemoglobin and hematocrit value, Estimation of osmolality in blood/haemolymph samples. Dissection and display of reproductive system, Estimation of hormones.	

FPB 502	**REPRODUCTIVE PHYSIOLOGY AND ENDOCRINOLOGY**	**2+1**
Objective	Basic concepts of reproductive physiology and endocrinology.	
Theory		
Unit I	Modes of reproduction: Sex determination and differentiation; sexual dimorphism; primary and secondary sex characters; bisexual reproduction; inter-sexes; hermaphroditism, Sex reversal.	
Unit II	Pituitary gland: Structure and functions; chemistry and functions of gonadotropins; gonadotropin receptors; gonadotropin releasing hormone; regulation of gonadotropin secretion.	
Unit III	Transport of nutrients: Metabolic changes during gametogenesis; hormonal control of oocyte maturation and ovulation, nutrient regulation of endocrine function.	
Unit IV	Reproductive cycle and breeding patterns: Role of environment (photoperiod, temperature, rainfall), nutrition and genetics; Pheromones and reproductive behaviour, parental care;	
Unit V	Reproductive technology: Hypophysation for Induced spawning, cryopreservation of gametes; artificial fertilization; Neuro-endocrine system in crustacean and its role in the	

	regulation of reproduction.
Unit VI	Peripheral endocrine glands and hormones: Structure and functions: Thyroid, ultimobranchial body, adrenal homologues, corpuscles of Stannius and urophysis, PTH-related peptides, calcitriol, pancreatic hormones.
Practical	Dissection and display of reproductive and endocrine organs. Preparation of pituitary extracts, Assay of hormones-testosterone, estradiol, cortisol, thyroxine; histological examination of different stages of gonads and endocrine glands.

FPB 503	**FISH BIOCHEMISTRY**	**2+1**
Objective	Biochemical functions of different biomolecules.	
Theory		
Unit I	Carbohydrates: Definition, classification and biological significance; Chemical reactions; stereoisomerisms and mutarotation, structure and properties of monosaccharides, disaccharides, polysaccharides and mucopolysaccharides.	
Unit II	Proteins: Definition, classification, biological significance and structure. Amino acids: Structure, classification, zwitter ions and chemical reactions.	
Unit III	Lipids: Definition, classification, biological significance. Fatty acids: PUFA, prostaglandins, saponification and iodine number, peroxide value. Phospholipids and steroids: Structure, properties and functions.	
Unit IV	Nucleic acids: Structure, functions and properties. Structure of purines, pyrimidine; DNA and RNA; different type of DNA and RNA, Watson and Crick model of DNA.	
Unit V	Enzymes: Nomenclature and structure of enzymes, Active site; Concepts of activation energy, Transition state and enzyme-substrate complex , Units of enzyme activity, enzyme kinetics; Factors affecting enzyme activity.	
Unit VI	Vitamins and minerals: Chemical structure, sources, properties of water and fat soluble vitamins, Biological significance of minerals	
Practical	Extraction and purification of tissue proteins and lipids. Isolation, purification and characterization of nucleic acids from tissue extract. Qualitative and quantitative analysis of proteins, lipids, carbohydrates and nucleic acids; Isolation of genomic, DNA, plasmid DNA and RNA; Agarose gel and SDS PAGE; Enzyme assay and kinetics.	

FPB 504	**METABOLISM OF BIOMOLECULES**	**2+1**
Objective	Metabolism of different biomolecules.	
Theory		
Unit I	Carbohydrate metabolism: Glycolysis, TCA cycle; feeder pathways of carbohydrate metabolism: Pentose phosphate pathway and gluconeogenesis; Glycogen metabolism, Regulation of blood glucose level.	
Unit II	Lipid metabolism: Biosynthesis of fatty acids; oxidation of fatty acids; ketone bodies; desaturation and elongation mechanisms; Control of fatty acid metabolism.	
Unit III	Oxidative phosphorylation: Substrate level phosphorylation; Electron Transport Chain; NADH, NADPH, and $FADH_2$. Fo-F1 ATP synthesis.	
Unit IV	Protein and amino acid metabolism: Biosynthesis of protein; degradation of amino acids; transamination and deamination, ammonia carrier and excretion; Biosynthesis of non-essential amino acids.	
Unit V	Nucleic acids metabolism: Purine and pyrimidine metabolism, Biosynthesis of	

	deoxyribonucleotides and ribonucleotides.
Unit VI	Metabolomics: Basic concepts and applications.
Practical	End product estimation of aerobic and anaerobic carbohydrate metabolism (pyruvate and lactate). Enzyme assay for LDH, MDH, Catalase, AST, ALT and nucleases.

FPB 505	**TOOLS AND TECHNIQUES IN BIOCHEMISTRY**	**1+1**
Objective	Different experimental techniques in the fish Biochemistry.	
Theory		
Unit I	Theory and application of spectrophotometry: Beer-Lambert's law; Calibration plot; UV-visual, fluorescent, IR, CD spectroscopy, Atomic mass spectroscopy, RT-PCR and NMR, X-ray crystallography.	
Unit II	Basic principles of chromatography: Theory and applications of paper, affinity, column, thin layer, ion-exchange, size exclusion and gas chromatography. HPLC; Factors affecting chromatographic resolutions, resolving power and retention time.	
Unit III	Radioimmunoassay (RIA) and Enzyme-linked immunosorbent assay (ELISA): Basic principle and application in quantitative estimation of biological analytes.	
Unit IV	Theory and applications of electrophoresis; Gel electrophoresis of proteins and nucleic acids. Determination of molecular weight of proteins and nucleic acids; Principle and uses of ultracentrifugation; Types of rotors and their applications.	
Practical	Quantitative estimation of biomolecules by spectrophotometric methods; Isolation and purification of protein; Estimation of proteins by different methods (Lowry, Biuret, Bradford); Separation of amino acids by paper chromatography; TLC separation of lipid and alkaloids; HPLC analysis of anti-nutritional factor and bioactive compound; Qualitative and quantitative estimation of fatty acids by gas chromatography; Separation of proteins and nucleic acids by gel electrophoresis. Hormone assay by RIA and ELISA.	

FPB 506	**CARDIO-VASCULAR SYSTEM AND RESPIRATORY PHYSIOLOGY**	**1+1**
Objective	Dynamics of cardiovascular system and their respiratory physiology.	
Theory		
Unit I	Types of heart and pacemaker: morphological structure, blood vascular system, cardiac output and blood pressure; accessory heart. Lymph and lymphatic system. Regulation of cardiac activity; Neural and hormonal control of heart.	
Unit II	Definition of respiration, external respiration, internal respiration. Respiratory organs and accessory respiratory organs, Functional morphology of gill structure. Respiratory pigments and their functions.	
Unit III	Respiratory metabolism and energy budget in relation to environmental conditions and stress.	
Unit IV	Metabolic responses to hypoxia; anoxic layers in habitats. Factor influencing oxygen consumption rate.	
Practical	Measurement of heart rate, ECG, study of rate of oxygen consumption in relation to abiotic factors (pH, temperature, salinity). Differential count of blood cells and estimation of haemoglobin concentration, haematocrit value.	

FPB 507	IMMUNOBIOLOGY	1+1
Objective	Different aspects of immunostimulants and their effect on fish immunity, stress and disease resistance.	
Theory		
Unit I	Basic principles of immune system in fishes, Cell and organ involved in immunity,	
Unit II	Mechanism of immunity; Humoral and cell mediated immunity. Cytokines, interferon, lymphokine, chemokines, their role in immune response.	
Unit III	Immunoprophylaxis; toxin, toxoid and vaccines. Immuno-stimulant and immunomodulation.	
Unit IV	Biosynthesis of antibody. Interaction of Endocrine with immune system.	
Unit V	Role of nutraceuticals *viz.,* levan, β-glucan, omega-3 fatty acid, levanisole, nucleotide, alginates and bovine lactoferine on fish/ shellfish immunity and mechanism of their action.	
Unit VI	Principles of stress resistance, stress tolerance. Challenge study.	
Practical	Lysozyme activity. Estimation of NBT. Estimation of CBC. Estimation of prophenol oxidase. Estimation of superoxide dismutase. Estimation of IgM.	

FPB 508	CELLULAR AND MOLECULAR PHYSIOLOGY	2+1
Objective	To understand the cellular signaling cascades and related molecular physiology.	
Theory		
Unit I	Cell signaling: General principles, Mechanism of cell signaling, Intracellular and extracellular receptors (Ion channel linked, G-Protein linked and enzyme linked) mediated signaling pathways, modular binding domains etc.	
Unit II	Cellular trafficking: Endocytic and Exocytic pathways, membrane transport, Protein sorting, vesicular transport etc.	
Unit III	Structure and functions of heat shock proteins; Antifreeze and metallothionene proteins; C-reactive protein.	
Unit IV	Thermogenesis: Biochemical mechanisms. Adaptation mechanism during thermal extremes, starvation and stress.	
Unit V	Gene expression and regulation: mechanism; Gene splicing, duplication and mutation. DNA damage and repair, apoptosis pathways.	
Unit VI	Recombinant DNA technology: cloning, sequencing, molecular probes, blotting and hybridization, molecular markers and fingerprinting	
Practical	PAGE and SDS-PAGE, RNA isolation and CDNA synthesis, PCR, Genomic DNA isolation, Quantitation of HSP by ELISA, DNA barcoding.	

FPB 509	SENSORY PHYSIOLOGY	1+1
Objective	To understand different sensory organs and their functional mechanism in fish.	
Theory		
Unit I	Sense organs and their functions: Electroreceptors, chemoreceptors, baroreceptors, propioreceptors, hydroreceptors and photoreceptors .	
Unit II	Olfactory and auditory organs: Physiological mechanisms.	
Unit III	Sensory neurons: action potential, synapse, neurotransmitters, impulse transmission, Excitation-contraction coupling.	
Unit IV	Chemoluminescence and bioluminescence; chromatophores.	
Practical	Practical on chemoreception using different feeding attractants. Study of reflex action. Effect of spinal nerve transection on melanophore behaviour. Effect of optic nerve transection on melanophore behaviour in response to background colour. Chromatophores response in relation to background colour, light, temperature, etc	

FPB 510	PHYSIOLOGY OF FISH BEHAVIOUR	1+1
Objective	To understand the behavioural physiology of fish.	
Theory		
Unit I	Concept of fish behavior and regulatory mechanism.	
Unit II	Feeding and predation: Predatory avoidance; Feeding behavior	
Unit III	Social and reproductive behavior: Sexual and Parental behavior.	
Unit IV	Adaptation mechanism in altered environment: Migration, schooling and shoaling.	
Practical	Tagging studies. Audio visual recording of behavior in simulated experiment.	

FPB 511	PHARMACO-BIOLOGY OF AQUACULTURE DRUGS	1+1
Objective	To understand aquaculture drugs and their delivery mechanism.	
Theory		
Unit I	Drugs in aquaculture and fish health management: E.O., FDA and ISO standards of levels of drugs.	
Unit II	Pharmacological studies: kinetics and dynamics; detoxification.	
Unit III	Chemotherapeutic agents: antiprotozoal agents, ectoparasiticide, antihelmenthic, anaesthetics.	
Unit IV	Antimicrobial drugs: antibacterial, antifungal, antiviral drugs and their delivery system.	
Practical	Estimation of residual level of different drugs: Minimum Inhibitory Concentration of drugs test, Pharamaco-kinetics.	

FPB 512	PHYSIOLOGY OF EXCRETION AND OSMOREGULATION	1+1
Objective	To understand the physiology of excretion and osmoregulation in fish.	
Theory		
Unit I	Definition and importance of excretion and osmoregulation.	
Unit II	Excretory organs in fish and their functions. Mechanism of excretion (Ultra filtration,	

	reabsorption, and secretion) of nitrogenous waste.
Unit III	Stenohaline and Euryhaline fishes; chloride shift mechanism and ornithine/ammonia cycle.
Unit IV	Mechanism of osmotic and ionic regulation; Osmoregulation in migratory fishes. Endocrine control of osmoregulation.
Practical	Estimation of osmolality in blood samples. Estimation of osmolality in relation to different salinities. Estimation of ammonia in blood and water samples.

FPB 513	**ECOPHYSIOLOGY OF FISHES**	**1+1**
Objective	To understand the physiology of fish in changing ambient environment.	
Theory		
Unit I	Fish habitats: disruption of habitats; pollutants, toxicants and radionuclides emittants	
Unit II	Climate change effectors: impacts on ecology, growth and reproduction; mitigation mechanisms.	
Unit III	Thermal and hypoxic stress: Physiological and metabolic responses; Heat shock protein (HSP); Hypoxia Inducing Factor (HIF); cardiovascular and gill ventillatory systems.	
Unit IV	Occurrence of radioactive substances in water and threat on food chain. Use of radioisotopes in tracer techniques for metabolic studies. International radiological limits for the export and import of aquatic products.	
Practical	Estimate threshold of thermal and hypoxia tolerance. Estimation of LC_{50} of pollutants. Estimation of stress enzymes, isozymes. Estimation of cortisol. Use of isotopes in tracer techniques for metabolic studies. Quantification of Tritium and other radioisotope levels in fish tissues.	

FPB 514	**ENZYMOLOGY**	**1+1**
Objective	To understand enzyme kinetics and regulation.	
Theory		
Unit I	Enzymes: Introduction; enzyme specificity; mode of action; nomenclature, classification and EC numbering; structure of enzymes, active site.	
Unit II	Enzyme kinetics; enzyme equilibrium; Single substrate enzyme kinetics and factors affecting the rates of enzyme catalyzed reactions; Michaelis- Menten equation; K_m and V_{max} values; enzyme efficiency; Lineweaver and Burke Plots;	
Unit III	Enzyme inhibition: reversible and non-reversible, competitive, uncompetitive and non-competitive inhibition; enzyme poisoning.	
Unit IV	Enzyme regulation: allosteric enzymes; Factors affecting enzyme activity, holoenzyme and coenzyme, zymogens, isoenzymes, ribozymes; Immobilized & restriction enzymes.	
Practical	Enzyme extraction and purification, specific activity, enzyme substrate reactions, mode of enzyme kinetics, assay of enzyme activity (alkaline phosphatase, transaminases, amylase, LDH, MDH, G6PD).	

FPB 515	DIAGNOSTIC BIOCHEMISTRY	1+1
Objective	To understand the different aspects of biochemical diagnostic Techniques.	
Theory		
Unit I	OIE (Office of the international epizootics) listed diseases of fish in the world and their approved diagnostic methods.	
Unit II	Enzymes and isoenzymes of clinical significance; Metabolic disorders related to carbohydrate, lipid, protein and nucleic acid metabolism in fishes.	
Unit III	Biochemical markers for EUS, viral haemorrhagic septicaemia, enteritis, spring viraemia in carp and Bacterial kidney diseases (BKD) diagnosis; Biochemical indicators for stress.	
Unit IV	Biochemical techniques for identification of liver diseases, bone disorder and pesticide poisoning. Detoxification mechanisms of gill, liver and kidney.	
Practical	Specimen collection, identification, transport, delivery, preparation and preservation of samples; Estimation of blood glucose, albumin and globulin; Identification of pathogens by PCR and DNA fingerprinting in fish; Disease diagnosis by histopathology, histochemistry and X-ray techniques; Liver and plasma enzyme assay (GOT, GPT, ALP and AChE); Analysis of stress proteins.	

FPB 516	FISH NUTRIGENOMICS	1+1
Objective	To understand the nutrient-gene interactions in fish	
Theory		
Unit I	Functional Genomics: Comparative nutrigenomics to understand the metabolic diversity; nutritional biochemistry and climate change.	
Unit II	Metabolomics: Nutritionally important genes; gene regulation by lipid, carbohydrates; metabolic control analysis; Desaturases, elongases.	
Unit III	Omic Studies: Transcriptomics, proteomics; nutrient-gene interactions and expressions	
Unit IV	Molecular Techniques: RT-PCR, cDNA synthesis; genetic control of metabolic pathways; interfacing with human health; bioinformatics tools.	
Practical	Nutrient-gene expression; glycolytic enzymes expressions in fish liver; studies on fatty acid synthesis; Desaturases and elongases expressions.	

FPB 517	AQUATIC RADIOECOLOGY	1+1
Objective	To understand the impacts of radionuclides in aquatic environment	
Theory		
Unit I	R**adiation ecology**: Definition. Natural and anthropogenic radiation; types of radiation and their sources. Speciation of radiation in the environment.	
Unit II	**Radionuclide ecology**- distribution of radionuclide in different ecosystems. Dynamics of radionuclides in food chain. Identification of radionuclide sensitive organism –external exposure, internal exposure and risk factors.	
Unit III	Impact of radiation: **on phytoplankton, zooplankton, microalgae, benthic microorganism, molluscs, crustaceans and fish. Safety measures for human health.**	
Unit IV	Measurement of radioactivity: counting systems, radiation spectrometry, liquid scintillation counter.	
Practical	Quantification of gamma and alpha radiation in non-human biota. Determination of half life of radioactive nuclides. Estimation of radionuclides in water, rocks and sediments	