Ph.D (Fish Physiology and Biochemistry)

Course Structure – At a Glance

Revised

A	**MAJOR COURSES**			**17 Credits**
	A1	**CORE COURSES**		9 Credits
1	FPB 601	Advances in Fish Biochemistry	2+1	
2	FPB 602	Advances in Fish Physiology	2+1	
3	FPB 605	Intermediary Metabolism	2+1	
	A2	**OPTIONAL COURSES**		8 Credits
1	FPB 603	Climate change and adaptive physiology	2+1	
2	FPB 604	Analytical Biochemistry And Instrumentation	1+2	
3	FPB 606	Fish Neuroendocrinology	1+1	
4	FPB 607	Metabolomics	1+1	
5	FPB 608	Endocrinology	2+1	
6	FPB 609	Advances in Aquatic Radioecology	1+1	
B	**MINOR COURSES** (Courses outside major discipline / from other relevant disciplines)			**8 Credits**
C	**SUPPORTING COURSES** (Compulsory)			**5 Credits**
1	FST 601	Advanced Statistical Methods	2+1	
2	FST 602	Software for Fisheries Data Analysis and Management	0+2	
		Total Course Work Credits		**28 Credits**
D	**DOCTORAL SEMINAR**			**2 Credits**
1	FPB 691	Doctoral Seminar I	0+1	
2	FPB 692	Doctoral Seminar II	0+1	
E	**DOCTORAL RESEARCH**			**45 Credits**
	FPB 699	Doctoral Research (Semester III)	0+11	
	FPB 699	Doctoral Research (Semester IV)	0+11	
	FPB 699	Doctoral Research (Semester V)	0+11	
	FPB 699	Doctoral Research (Semester VI)	0+12	
		Total PhD Program Credit Hours		**75 Credits**

FISH PHYSIOLOGY AND BIOCHEMISTRY

Course Contents

FPB 601	**ADVANCES IN FISH BIOCHEMISTRY**	**2+1**
Objective	To understand advanced biochemistry of fish.	
Theory		
Unit I	Saccharide chemistry: classification; significance of monosaccharides; amino sugars, acidic sugars, glycosides, sulfonated sugars; oligosaccharides; mannan oligosaccharide, fructose oligosaccharide, galactose oligosaccharide, polysaccharides; glycans, glycogen, mannan, levan, alginates, chitin, heparin, keratin sulphate, chitosan and hyaluronic acid. Carbohydrates of clinical significance.	
Unit II	Lipid chemistry: Simple and complex lipids; classification; significance of fatty acid derivatives, prostaglandins, thromboxanes, leukotrienes; plasmalogen, gangliosides, sphingomyelin, cerebrosides, Liposomes, glycero-phospholipid metabolism. Lipids of clinical significance.	
Unit III	Protein chemistry: classification; significance of glycoproteins, lipoproteins, protein folding, trafficking and protein sequencing, bioactive peptides; chaperones, heat shock proteins; antifreeze proteins, cytochrome P450, metallothionenes, Immunoglobulins. Clinical proteomics. Proteins of clinical significance.	
Unit IV	Nucleic acid chemistry: classification; types of DNA and RNA, metabolic functions of nucleotides. Sense and antisense RNA, RNA interference; Cistron, operon and transposon.	
Unit V	Enzyme chemistry: classification, types of enzymes, mechanisms of enzyme action, enzyme kinetics, units of enzyme activity, coenzymes, co-factors and prosthetic groups, enzymes of clinical significance.	
Unit VI	Vitamin and mineral chemistry: classification, active forms of vitamins, types of vitamins and essential minerals; deficiency syndromes of vitamins and minerals; clinical significance of vitamins and essential minerals.	
Practical	Extraction, purification and quantification of specific proteins by SDS-PAGE; Estimation of phytic acid, Estimation of fatty acids by GC-MS; Assay of metabolic enzymes. DNA & RNA isolation, Restriction digestion, amplification of DNA by PCR, analysis of amino acids and steroids. Assays of vitamins A and C.	

FPB 602	**ADVANCES IN FISH PHYSIOLOGY**	**2+1**
Objective	To understand the current status of fish Physiology	
Theory		
Unit I	Cardiovascular System: cardiac anatomy, ultra-structure of cardiocytes; physiology of cardiac pumping, coronary circulation, ECG, Cardiac plasticity in fish.	
Unit II	Physiology of bimodal gas exchange: Hemoglobin – structural and functional variations in fish, oxygen transport by haemoglobin. Gill and accessory respiratory organs for gas exchanges, oxygen sensing, cardiac energy metabolism. Respiratory control.	
Unit III	Physiology of ion transport and excretion: Functional morphology of branchial ionocytes; mechanism of ion transport and water balance, osmo-sensing, role of gut and kidney in osmoregulation. Nitrogen excretion.	
Unit IV	Understanding growth in fish: Myogenic cells and growth; Muscle satellite cells; muscle fibre dynamics, Genetic and environmental factors regulating muscle growth; Diversity and plasticity in muscle fiber.	

Unit V	Reproduction and Fertility: germ cell migration, differentiation and formation of mature gametes. Vitellogenin: structure, synthesis and transportation to oocytes, Gamete activation and fertilization in fish. Sex determination and differentiation; sex reversal. Hypothalamo-hypophyseal-gonadal axis, endocrine disruption.
Unit VI	Reproductive biotechnology: cryopreservation of gametes, Trans-sex, application of surrogate brooders, evolution of fish genomes, global gene expression profiling, growth hormone over expression.
Practical	Measurement of heart rate, ECG; Measurement of Osmolality of plasma and muscle, Techniques for examining of channel proteins under environmental conditions. Assay of reproductive steroids; Examination of progress of gonad maturity in fish; DNA/RNA ratio measurement as an indicator of growth parameter.

FPB 603	**CLIMATE CHANGE AND PHYSIOLOGY OF ADAPTATION**	**2+**
Objective	To understand environmental factors affecting fish physiology leading to adaptation.	
Theory		
Unit I	Basic concepts of global warming and climate change.	
Unit II	Interaction of climate change with multiple stressors (Pesticides, salinity, starvation, hypoxia, disease, pH, water hardness, turbidity) and its impacts on fish.	
Unit III	Stress responses: Primary, Secondary and tertiary stress responses; General Adaptive Syndrome. Genetically based adaptation. Modulation of intermediary metabolic pathways.	
Unit IV	Thermal adaptation mechanisms: Types of heat shock proteins, anti-freeze proteins and their roles. Enzyme variants (Isozymes). Thermal limits; Thermal optima; Mechanism of thermal adaptations.	
Unit V	Global warming impacts: Habitat, reproductive performance; embryonic and larval development; growth; Osmoregulation; Cardiovascular functions.	
Unit VI	Mitigation strategies: Cross protection through behavioural, adaptational, nutritional and genetic intervention.	
Practical	Evaluation of stress markers: plasma cortisol level, glucose, HSP expression, HIF expression; Determination of oxygen consumption rates; Determination of temperature, salinity and hypoxia tolerance in fish.	

FPB 604	**ANALYTICAL BIOCHEMISTRY AND INSTRUMENTATION**	**1+2**
Objective	To understand the principles and application of analytical instruments.	
Theory		
Unit I	Spectrophotometry: UV-visual, Infra red, mass spectroscopy.	
Unit II	Electrophoresis: Capillary, vertical slab and horizontal electrophoresis, Immuno-electrophoresis	
Unit III	Chromatography: Paper, TLC, ion exchange, molecular sieving, affinity, FPLC, HPLC and gas chromatography, Centrifugation techniques.	
Unit IV	Molecular techniques: Blotting (Southern, Northern, Western) techniques; Plasmid isolation and cloning; qRT-PCR.	

Practical	Quantitative estimation of metabolites and enzyes, purification of proteins from tissue samples, chromatographic separation and fractionation of proteins, characterization of proteins by Native PAGE, SDS- PAGE and 2D electrophoresis, Spectrophotometric estimation of fish protein, nucleic acids and glycogen; Enzyme assay from fish tissues; Molecular weight determination of fish protein by PAGE; Isolation of plasmid and genomic DNA, and amplification by PCR, cloning of gene in vectors, selection of recombinant and non –recombinant clones, Agarose gel electrophoresis; Southern and dot blotting; Fatty acid analysis by GCMS.

FPB 605	**INTERMEDIARY METABOLISM**	**2+1**
Objective	To understand the intermediary metabolism of biomolecules.	
Theory		
Unit I	Scope and significance: Integration and regulation of lipid, carbohydrate and protein metabolism in fishes.	
Unit II	Lipid metabolism: Oxidation of fatty acids (SFA, MUFA, PUFA, HUFA); biosynthesis of n-3 and n-6 fatty acids; desaturases and elongases in freshwater fish; biosynthesis of triglycerides, phospholipids, sphingolipids and cholesterol.	
Unit III	Carbohydrate metabolism: Coordinated regulation of glycogen synthesis and breakdown; enzymatic control of glycolysis; Feeder pathways for glycolysis; TCA cycle; Gluconeogenesis; pentose phosphate pathway; Electron transport chain.	
Unit IV	Protein metabolism: Oxidative degradation of amino acids; Transamination and deamination; Biosynthesis of amino acids.	
Unit V	Nucleic acid metabolism: Synthesis of deoxy and ribonucleotides; Uric acid production; Derivation of nucleotide groups of CoA, NAD, FAD from ATP;	
Unit VI	Metabolomics: functional transcriptomics; interactions of nutrients and genes; gene expression of metabolic enzymes; environmental metabolomics.	
Practical	Assay of mitochondrial and cytoplasmic enzymes (GK/HK, G6PD, LDH, pyruvate kinase, MDH, AST/ALT, SOD), quantification of genes of metabolic pathways.	

FPB 606	**FISH NEUROENDOCRINOLOGY**	**1+1**
Objective	To study the neuroendocrine mechanisms.	
Theory		
Unit I	Neuroendocrine systems: functional morphology of pituitary, pineal organ and urophysis.	
Unit II	Hypothalamic neurohormones: chemical structure and distribution of GnRH, CRH, somatostatin, TRH, neuropeptide Y, arginine vasotocin, isotocin, 5-HT, dopamine, epinephrine, nor-epinephrine, GABA, KISS peptins and nitric oxide.	
Unit III	Hormone regulation and functions: growth hormone, prolactin, ACTH, gonadotropins, TSH, somatolactin and MSH.	
Unit IV	Neuroendocrine and immune interaction in fish.	
Practicals	Study of neuroendocrine systems through histology. Expression study of growth	

	hormone and Insulin in fish, Isolation of GnRH by HPLC, prolactin assay.

FPB 607	**METABOLOMICS**	**1+1**
Objective	To understand the emerging field of metabolomics.	
Theory		
Unit I	Introduction to Metabolomics: functional transcriptomics; metabolic pathways.	
Unit II	Analytical methods: separation and detection methods: 2D-electrophoresis, mass spectrometry, microarrays, EST, SAGE.	
Unit III	Experimental and computational methods: databases, Genevestigator and OncoMine – browsing microarray-derived gene expression profiles.	
Unit IV	Environmental Metabolomics: Nutrigenomics and metabolic health; future challenges.	
Practicals	Gene expression study of metabolic pathways, Cross feeding mechanism, 2D-electrophoresis, mass spectrometry, EST, microarrays, bio-informatics tools.	

FPB 608	**ENDOCRINOLOGY**	**2+1**
Objective	To understand the endocrine mechanisms in fish.	
Theory		
Unit I	Endocrine glands: Structure and functions of pituitary, pineal, thyroid, ultimobranchial body, corpuscles of Stannius, gonads, kidney, adrenals, urophysis.	
Unit II	Mechanism of hormone action: Hormone receptors and signaling pathways.	
Unit III	Hormones in calcium and Phosphorus homeostasis: calcitonin, stanniocalcin, calcitriol, PTH- related peptide. Mechanism and interaction of PTH, calcitonin and vitamin-D on Ca++ metabolism.	
Unit IV	Hormones: In growth, digestion and colour change.	
Unit V	Role of hormones in osmotic, ionic regulation and adaptation.The Renin: angitensin system	
Unit VI	Reproductive hormones: Gonadal steroids, Prostaglandins, hormones of HPG axis etc.	
Practical	Histological study of endocrine glands; *in vivo* demonstration of endocrine glands; estimation of vitamin D3; assay of steroid hormones; quantification of vitellogenin by ELISA.	

FPB 609	**Advances in Aquatic Radioecology**	**1+1**
Objective	**To understand the impact of radiation on aquatic organisms**	
Theory		
Unit I	Radiochemistry: radio analytical techniques. Dissymmetry - internal and external dissymmetry, lifespan and time frame of radionuclides. Nuclear fuel cycle; sources of radionuclides in the environment	
Unit II	Impact of radiation: Radiation quality and relative biological effectiveness. External exposure, internal exposure and risk factors; Identification of radioecologically sensitive organism; accumulation of radionuclides in the aquatic organisms from background radiation. Potential health hazards.	
Unit III	Radionuclides and aquatic organisms:. Bioaccumulation of radionuclides in food chain. Effects of radionuclides on planktons, benthos, invertebrates. Dosages and effects on	

	growth, reproduction and embryonic development of fish
Unit IV	Radio isotopes: tracer techniques for metabolic and hormonal study
Practical	Use of radioisotopes as tracer for metabolic studies; Quantification of tritium from organisms exposed to tritiated water. Steroid assay