Institutional Quality Assurance Cell

TEMPLATE OF OUTCOME-BASED CURRICULUM 2022

(for Masters program)

Institutional Quality Assurance Cell (IQAC)

Khulna University, Khulna 9208

Bangladesh

Outcome-based Curriculum of
Master of Science in Fish Genetic and Biotechnology

Fisheries and Marine Resource Technology Discipline
Khulna University
Date: June 2022

01. Title of the Academic Program

Master of Science in Fish Genetics and Biotechnology

Program Overview	
Degree	Master of Science in Fish Genetics and Biotechnology
Abbreviated form of the Degree	MS in Fish Genetics and Biotechnology
Discipline/Program Offering Entity (POE)	Fisheries and Marine Resource Technology Discipline
School	Life Science School
Awarding Institution	Khulna University
Location	Khulna, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	9
International Standard Classification of Education (ISCED) Code	0831
Mode of Study	Full time
Language of Study	English
Applicable Session	2022-23 and onwards

02. Name of the University

Khulna University

03. Vision of the University

Khulna University strives to create a knowledge-based just society through accelerating inclusive and transformative growth of Khulna, Bangladesh and the world. The university aims to achieve this vision through cross-cutting research, scholarly enquiry and development of new knowledge.

04. Mission of the University

UM1	To explore human potential to its fullest extent and produce self-motivated, aspiring leaders to work for the betterment of the humankind.
UM2	To create a transformative educational experience for students focusing on poverty eradication, food and nutritional security, environmental sustainability, socio-economic well-being and climate resilient development through judicious management of natural resources of the country.
UM3	To foster creative learning, entrepreneurship and inquisitiveness among students based on moral values, professional ethics, and social responsibilities.
UM4	To ensure a quality educational experience that enables graduates to

	make demonstrable economic and social impacts through translating knowledge and innovation into practice.
UM5	To nurture an enabling environment that produces human resource inspired by wisdom, freethinking, creativity and unhindered intellectual exercises.

UM = University Mission

05. Name of the Discipline/Program Offering Entity (POE)

Fisheries and Marine Resource Technology Discipline

06. Vision of the Discipline/POE

To be a globally recognized center of excellence in education, research, entrepreneurs for sustainable fisheries and marine resource development

07. Mission of the Discipline/POE

M1	To generate pioneer scholars through quality education in all aspects of fisheries sciences.
M2	To conduct innovative research for the improvement of fisheries sector.
M3	To establish an effective collaboration with reputed institutions of home and abroad for strengthening institutional capacity.
M4	To promote a culture of continuous learning to build up a knowledge-based community, dynamic leadership, and competent civil services.

M = Mission of the Discipline/POE

08. Objectives of the Discipline/POE

O1	To provide quality education and to maintain the highest academic standard in all aspects of fisheries and marine science in line with the international standard of education;
O2	To build up high level analytical and critical thinking skills for solving emerging problems in the field of fisheries and marine science;
O3	To undertake fundamental and applied research in order to endow developed knowledge and experience to students;
O4	To enhance communication skills, leadership capacity, adaptability, and social interactions;
O5	To impart technology based and need oriented higher education befitting the age;
O6	To generate skilled manpower in order to fulfill the global demands by equitable participation.

O = Objective of the Discipline/POE

09. Name of the Degree

Master of Science in Fish Genetics and Biotechnology

10. Description of the Program

Fisheries & Marine Resources Technology (FMRT) Discipline is one of the important disciplines under the Life Science School of Khulna University, which started its journey in 1992, the second year of establishment of Khulna University. Master Program in Fish Genetics and Biotechnology was started in 2008, though MS in Fisheries was commenced in 1997 under FMRT Discipline. FMRT Discipline commits itself to continuously improving the quality of fisheries education; competence of its faculty to meet the changing needs of fisheries education, research and extension services. The vision of Master Program in Fish Genetics and Biotechnology is generating forerunner scholars who take challenges for intellectual property protection, sustainable utilization and posterity through quality assessment, improvement and conservation of fish genetic resources. This Branch is oriented toward fisheries biologists, fisheries decision-makers, professionals in the aquaculture industry, and students whose goals are to work in fisheries-related professional fields. The Branch will provide a broad topical overview of genetic/genomic aspects of aquaculture, fisheries management and related topics.

11. Graduate Attributes

GA1	Comprehensive knowledge in research	[*fundamental domain*]
GA2	Critical thinking, problem solving and decision making skills	[*thinking domain*]
GA3	Competency in information and communication technology	[*fundamental domain*]
GA4	Integrity and professionalism	[*personal domain*]
GA5	Leadership and communication skills	[*social domain]*
GA6	Competence in Ethics and morality	[*social domain*]
GA7	Lifelong learning skills and self-awareness	[*personal domain*]

GA = Graduate Attributes

12. Program Educational Objectives (PEOs)

PEO1	To intellectualize the advanced knowledge, theories and procedures in the area of fish genetics and biotechnology.
PEO2	To reveal high level analytical and critical thinking skills to solve emerging problems through the application of fundamental principles.
PEO3	To improve skill to demonstrate safe and acceptable skills in field and laboratory works and independent research.
PEO4	To enrich the communication skill in written, oral and interactive presentation.
PEO5	To expedite enthusiasm in making scientific investigation and realizing the roles of graduates on industrial, environmental, social and economic aspects nationally and globally.
PEO6	To flourish moral and ethical values in all spheres of life.

PEO = Program Educational Objective

13. Program Learning Outcomes (PLOs)

After successful completion of the degree, the learner will be able to:

A. Fundamental Skills	
PLO1	Master the knowledge behind the genetic modifications and improvements of fish.
PLO2	Understand the genetic and genomic approaches to fisheries management and conservation.
PLO3	Explore the genetic basis for qualitative and quantitative traits, biotechnology and engineering.
B. Social Skills	
PLO4	Demonstrate social values and practice professional ethics in the conduct of science.
PLO5	Communicate and interact effectively for social, academic and professional purposes.
C. Thinking Skills	
PLO6	Evaluate the veracity and value of scientific outcomes related to fisheries and marine bioscience.
D. Personal Skills	
PLO7	Demonstrate the ability to incorporate entrepreneurial and managerial skills in planning daily activities.
PLO8	Apply ICT skills for information management in daily and professional life.

PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs

Missions / PEOs	UM1	UM2	UM3	UM4	UM5
PEO1	2	1	3	3	2
PEO2	2	3	2	2	3
PEO3	3	2	3	1	2
PEO4	2	1	2	2	1
PEO5	3	2	3	2	2
PEO6	3	2	3	2	1

Level of Correlation: 3=High, 2=Medium, 1=Low

15. Mapping PLOs with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)					
		PEO1	PEO2	PEO3	PEO4	PEO5	PEO6
A. Fundamental Domain	PLO1	*	*	*			
	PLO2	*	*	*	*		

	PLO3		*	*			
B. Social Domain	PLO4					*	*
	PLO5				*		
C. Thinking Domain	PLO6		*	*			
D. Personal Domain	PLO7					*	*
	PLO8					*	*

16. Mapping Courses with PLOs

Course Code and Course Title		PLOs							
		Fundamental Domain			Social Domain		Thinking Domain	Personal Domain	
		PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8
First Year First Term									
Core Course									
0831 06 FGB 5101	Fish Genetics and Breeding	X	X	X	X		X		X
0511 06 FGB 5103	Molecular Biology	X	X	X			X		
0111 06 RES 5102	Seminar–I: Research Methodology	X	X	X		X	X	X	X
Optional Course									
0831 06 FGB 5105	Aquatic Animal Physiology	X	X		X		X	X	X
0831 06 FGB 5107	Biology of Fishes	X		X			X		X
0831 06 FGB 5109	Endocrinology of Aquatic Animals	X	X				X	X	X
0831 06 FGB 5111	Advanced Fish Biochemistry	X	X	X			X		X
0831 06 FGB 5113	Developmental Biology						X		X
First Year Second Term									
Core Course									
0831 06 FGB 5201	Population and Evolutionary Genetics	X	X		X			X	
0831 06 FGB 5203	Genomics of Aquatic Animals	X	X		X		X		X
0111 06 RES 5202	Seminar–II: Data analysis and management	X	X	X		X		X	X
0831 06 FGB 5204	Dissertation Part -I								X
Optional Course									
0831 06 FGB 5205	Aquatic Biotechnology	X	X	X	X			X	
0831 06 FGB 5207	Bioinformatics	X	X	X	X	X	X	X	
0831 06 FGB 5209	Cytogenetics	X	X	X	X			X	
0831 06 FGB 5211	Principles of Microbial Biotechnology	X	X	X	X		X		
0831 06 FGB 5213	Genetics and Breeding of Shellfish	X	X	X					
Second Year First Term									
Core Course									
0111 06 FGB 6102	Seminar-III	X	X		X	X		X	X
0831 06 FGB 6204	Dissertation Part -II	X	X		X	X		X	X

17. Structure of the Curriculum

a) Duration of the Program	1.5 years	3 terms
b) Admission Requirements	Candidates seeking admission into a Master's program must possess a Bachelor of Science in Fisheries or equivalent degree from a recognized university (home and abroad) with 16 years schooling and a minimum CGPA/class/division of 3.00 will be eligible for admission into this program. Other terms and conditions are set or revised periodically by the appropriate authority subject to the approval of EC, BOAS, and AC.	
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program	Total minimum 40 credits of Mixed mode (Dissertation)	
c2) Available Credits	Total 64 credits including 34 of core and 30 of optional	
d) Total Class Weeks in a Term*	14	
e) Minimum CGPA Requirements for Graduation	3.00	
f) Maximum Academic Years of Completion	5 years	

* Term Duration				
Teaching and Learning	Preparatory Leave	Term Final Examination	Term Break	Total
14 Weeks	2 Weeks	4 Weeks	2 Weeks	22 Weeks

g1) Area-wise Credit Distribution

Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GED) Courses**	Theory	01	03	09
	Sessional	03	06	
Core/Compulsory Courses	Theory	03	09	09
	Sessional			
Optional/Elective Courses	Theory	10	30	30
	Sessional			
Capstone Courses***	Sessional	02	16	16
Total		19	64	64

** 11% from GED courses

*** Thesis, project, internship etc. courses

g2) Category of Courses

Area	Course Type	Course Title	Credits
General Education (GED) Courses	**Theory**	1. Molecular Biology	03
	Sessional	1. Seminar–I: Research Methodology 2. Seminar–II: Data analysis and management 3. Seminar–III	06

Core/ Compulsory Courses	**Theory**	1. Fish Genetics and Breeding 2. Population and Evolutionary Genetics 3. Genomics of Aquatic Animals	09
	Sessional		
Optional/ Elective Courses	**Theory**	1. Aquatic Animal Physiology 2. Biology of Fishes 3. Endocrinology of Aquatic Animals 4. Advanced Fish Biochemistry 5. Developmental Biology 6. Aquatic Biotechnology 7. Bioinformatics 8. Cytogenetics 9. Principles of Microbial Biotechnology 10. Genetics and Breeding of Shellfish	30
	Sessional		
Capstone Courses	**Sessional**	01. Dissertation Part - I 02. Dissertation Part - II	16
Total			**64**

18. Year/Term-wise Distribution of Courses

First Year First Term						
Course code	**Course Title**	**Course status**	**Contact hours/week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0831 06 FGB 5101	Fish Genetics and Breeding	Core	3		3	None
0511 06 FGB 5103	Molecular Biology	Core	3		3	None
0111 06 RES 5102	Seminar–I: Research Methodology	Core		3	2	None
Optional Course						
0831 06 FGB 5105	Aquatic Animal Physiology	Optional	3		3	None
0831 06 FGB 5107	Biology of Fishes	Optional	3		3	None
0831 06 FGB 5109	Endocrinology of Aquatic Animals	Optional	3		3	None
0831 06 FGB 5111	Advanced Fish Biochemistry	Optional	3		3	None
0831 06 FGB 5113	Developmental Biology	Optional	3		3	None
Total	Core: Theory - 02; Sessional – 01, Optional: Theory - 05		21	3	23	
First Year 2nd Term						
Course Code	**Course Title**	**Course status**	**Contact hours/week**		**Credits**	**Prerequisites**
Core Course						
0831 06 FGB 5201	Population and Evolutionary Genetics	Core	3		3	None
0831 06 FGB 5203	Genomics of Aquatic Animals	Core	3		3	None
0111 06 RES 5202	Seminar–II: Data analysis and management	Core		3	2	None
0831 06 FGB 5204	Dissertation Part - I	Core		8	4	None
Optional Course						
0831 06 FGB 5205	Aquatic Biotechnology	Optional	3		3	None
0831 06 FGB 5207	Bioinformatics	Optional	3		3	None
0831 06 FGB 5209	Cytogenetics	Optional	3		3	None
0831 06 FGB 5211	Principles of Microbial Biotechnology	Optional	3		3	None
0831 06 FGB 5213	Genetics and Breeding of Shellfish	Optional	3		3	None
Total	Core: Theory - 04; Sessional – 03, Optional: Theory - 05		21	11	27	

Second Year First Term						
Course code	**Course Title**	**Course status**	**Contact hours/week**		**Credits**	**Prerequisites**
Core Course			Theory	Sessional		
0111 06 FGB 6102	Seminar-III	Core		3	2	None
0831 06 FGB 6204	Dissertation Part - II	Core		24	12	None
Total	Core Sessional Course - 02			27	14	None

19. Course Description

First Year First Term

Course Code: 0831 06 FGB 5101	**Year:** First	**Term:** First
Course Title: Fish Genetics and Breeding		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		
Rationale	A broad understanding of the basic principles of genetics and breeding of fish is useful in application to fisheries management and aquaculture. The erosion of genetic diversity and the reduced effectiveness of selection in small populations can limit opportunities for adaptation to changing conditions. Knowledge on brood stock management, quantitative phenotypes, selective breeding and chromosome set manipulation can address the fitness consequences of inbreeding in natural and hatchery populations and their implications for species conservation.	

Course Contents		CLOs
Section A		
1	**Breeding and Brood Stock Management:** Endemic and exotic fishes used for artificial breeding, brood stock management scenario in hatcheries in Bangladesh, domestication of animals, genetic improvement and permanent gains, selective breeding programs in aquaculture	1
2	**Genetics of Quantitative Phenotypes:** Qualitative vs. quantitative phenotypes, environmental effect, types of quantitative characteristics, polygenic inheritance, statistical methods of analyzing quantitative characteristics, heritability, QTLs mapping	2, 3
3	**Inheritance of Quantitative Traits:** Heritability, quantifying heritability, interpreting and applying heritability estimates, quantitative trait loci (QTL) analysis, genome wide association study (GWAS), candidate gene approach to study trait heritability	2, 3
4	**Epigenetics:** Basic epigenetic principles, role of epigenetic modification in gene expression, application of epigenetics in aquaculture, regulation of gene expression, gene expression in response to environmental change, role of mutation in gene expression	3
Section B		**CLOs**
5	**Inbreeding, cross breeding and pure-breeding:** Concept of inbreeding and relatedness, calculating coefficients of kinship, uses of inbreeding; consequences of inbreeding; relationship between effective population size and inbreeding rate, factors affecting allele frequencies, management of genetic variation in fish breeding schemes	1, 2
6	**Designing breeding programs:** Base population, maintenance of additive genetic variance, mating design, selection, breeding goal, selection and mating, physical tags versus DNA-markers for parental assignment, small and large scale breeding program (breeding nucleus, test animals, selection, multiplier units, measuring response to selection)	1, 2, 3
7	**Success Story of Selective Breeding in Aquaculture:** Carps, tilapia, channel catfish, sea bream, shrimp, oyster, salmon, rainbow trout, and genetic improvement in aquatic species compared to terrestrial livestock species	1, 2, 3
8	**Chromosome manipulation:** Gynogenesis, androgenesis, polyploidization, Sex-reversal, production of mono-sex population, Production of YY stocks, hybridization, application of hybridization, hybrid vigor, estimating	2, 3

	heterosis effect	

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Acquire sound knowledge in the use of traditional and modern fish breeding methods, as well as some major aquaculture breeding programs.	PLO1, PLO2, PLO3
	CLO2	Gain skills in the evaluation of various breeding strategies.	PLO3, PLO4, PLO7
	CLO3	Understand quantitative genetics, epigenetics and chromosomes set manipulation of fish.	PLO3, PLO4, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. Douglas Tave; Genetic for Fish Hatchery Management (3rd edition), 2. Trygve Gjedrem: Selection and Breeding Programs in Aquaculture (editor),Springer, 2005 3. Mackay, Trudy F. C.; Falconer, D. S. An introduction to Quantitative Genetics published by Pearson, Prentice Hall, 2009 4. John B. Gratzek, Paul V. Loiselle, Joanne Norton. Contributor Joanne Norton Fish Breeding and Genetics: Fish Breeding and Genetics published by Tetra Press, 1992.

Course Code: 0511 06 FGB 5103	**Year:** First	**Term:** First
Course Title: Molecular Biology		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		
Rationale	The application of molecular methods has spread to virtually all fields of modern biology, including ecology, conservation, breeding and natural resource management, leading to the establishment of a new discipline, Molecular Ecology. With the expansion of the application of molecular tools, it has become crucial that all biologists have a basic understanding of genetics and molecular biology, and the application of molecular tools to the detection of kin, the identification of populations, the reconstruction of phylogenetic relationships, and more recently, to the understanding of local adaptation and evolution.	

Course Contents		CLOs
Section A		
1	**The structure of genetic material:** The nature of genetic material, the chemical composition of DNA and RNA	1, 2
2	**The organization of DNA in chromosome:** Structural characteristics of	1, 2

	bacterial, viral and eukaryotic chromosomes, unique sequence and DNA and repetitive sequence DNA in eukaryotic chromosome	
3	**DNA replication and recombination:** DNA replication in prokaryotes and eukaryotes, DNA recombination	1, 2
4	**The genetic code and the translation of the genetic message:** Protein structure, the nature of the genetic code, translation of genetic message; protein sorting in the cell	2, 3
5	**Transcription, RNA molecules and RNA processing:** The transcription process; transcription of protein coding gene, transcription of other gene	6
Section B		**CLOs**
6	**Biomembranes and cell architecture:** Cell theory, fluid mosaic model, membrane lipids, membrane proteins, functions of membrane proteins, cytoplasmic organelles	4
7	**Microbial genetics:** Genomes of virus and bacteria, genetic material transfer in virus and bacteria	4
8	**Regulation of gene expression:** Regulation in bacteria, genes and regulatory elements, DNA-binding proteins, constitutive (housekeeping) genes, controllable genes, negative inducible operon, negative repressible operon, regulation in eukaryotes, gene regulatory network	4, 5
9	**Integration of signals and gene controls:** Integration of multiple second messengers regulates glycogenolysis, oxygen deprivation induces a program of cellular responses, control of cell fates by graded amounts of regulators	4, 5
10	**Changes in DNA:** Mutation of DNA replication, mutation of base modifications, DNA polymorphism, recombination, transposition, trinucleotide repeat expansion, DNA repair	5, 6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	State the organization of DNA in chromosome.	PLO1, PLO2, PLO3
	CLO2	Explain the mechanisms of transcription and processing of RNA.	PLO3, PLO4, PLO7
	CLO3	Explain the regulation of gene expression in bacteria and bacteriophages.	PLO3, PLO4, PLO7
	CLO4	Compare and contrast the catabolic and biosynthetic operons of Escherichia coli.	PLO3, PLO4, PLO8
	CLO5	Demonstrate the regulation of gene expression in lytic and lysogenic bacteriophages.	PLO5, PLO6, PLO8
	CLO6	Examine the levels of gene expression regulation in eukaryotes.	PLO6, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test
CLO4	Lecture, demonstration, discussion	Class test
CLO5	Lecture, demonstration, discussion	Class test
CLO6	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. Bruce Alberts Alexander D JohnsonJulian Lewis Martin Raff Keith Roberts Molecular Biology of the Cell 2. Harvey Lodish, Arnold Berk, Paul Matsudaira, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Lawrence Zipursky, James Darnell - Molecular Cell Biology (2008, W. H. Freeman) - libgen.lc 3. Author(s): James D. Watson, Tania A. Baker, Stephen P. Bell, Alexander Gann, Michael Levine, Richard Losick; Molecular Biology of the Gene (International Ed.) Pearson, 2004 4. Biochemistry, V edition, by J.M.Berg, J.L. Tymocz Ko and L. Stryer. 6. Genes, VII, International Edition, 2004 By Benjamin Lewin

Course Code: 0111 06 RES 5102	**Year:** First	**Term:** First
Course Title: Seminar–I: Research Methodology		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge on practical aspects of research methodology, processing of research problems and planning, sampling and research design and writing and presentation of research results, so that students can identify the problems, realize the way of doing scientific research, plan and design a research, and ultimately write a report/ thesis in a systematic way.	

	Course Contents	**CLOs**
1	**General Aspects of Oral Presentation:** Scientific papers presented at a level that is appropriate to the audience; clear and informative visual aids (simple, sufficient time).	1, 2, 3
2	**Introduction:** Overview of problem area provided; unfamiliar terms introduced; appropriate literature abstracted and presented clearly; research hypothesis of the study identified.	4
3	**Methods:** Brief overview of the equipment and materials used, and how obtained; brief overview of the experimental design used and any other parts of the methods employed; materials and/or equipment described; procedures followed to conduct the experiment presented.	5
4	**Results:** Anticipated and actual results reported; statistics clearly presented.	2, 6
5	**Discussion:** Implications if the hypothesis is supported clearly stated; implications if the hypothesis is not supported clearly stated; limitations of your study discussed; future research addressed.	2, 6
6	**Questions:** Demonstrated knowledge of the material; poised and confident, but no bluffing; answered the question(s) asked (asked for clarification or restatement of the question).	2

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Communicate science in a 30-40 minute oral scientific presentation.	PLO1, PLO2, PLO3
	CLO2	Understand and critique scientific presentations	PLO3, PLO4, PLO7

	CLO3	Create and implement a career plan to prepare for their identified career goals.	PLO3, PLO4, PLO7
	CLO4	Identify actions to take in areas of fisheries science education, including research, and internship / experiential learning.	PLO1, PLO3, PLO7
	CLO5	Understand workplace expectations, communicate professionally, and identify and solve workplace conflicts.	PLO1, PLO3, PLO7
	CLO6	Understand the different types of interview questions and craft focused answers in response.	PLO1, PLO3, PLO7
	CLO7	Construct a professional network.	PLO1, PLO3, PLO6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Group discussions, short lectures, strong student involvement	Presentation
CLO2	Group discussions, guest panelists, strong student involvement	Presentation
CLO3	Group discussions, guest panelists, strong student involvement	Presentation
CLO4	Group discussions, guest panelists, strong student involvement	Presentation
CLO5	Group discussions, guest panelists, strong student involvement	Presentation
CLO6	Group discussions, guest panelists, strong student involvement	Presentation
CLO7	Group discussions, guest panelists, strong student involvement	Presentation

Learning Materials

Recommended Readings	1. Bennett, B. 2001. The three P's of scientific talks: Preparation, practice, and presentation. Society for Economic Botany Newsletter. 15: 6-9. 2. Jan Recker. Scientific Research in Information Systems. A Beginner's Guide. Springer International Publishing. 2013. P.164. ISBN 978-3-642-30048-6. 3. David Hitchcock. Patent searching made easy: how to do patent searches on the internet & in the library. 4. Sixth edition. Berkeley, CA: Nolo, April 2013 p.257. ISBNs: 9781413318722, 141331872X, 9781413318739. 5. Yvonne N. Bui. How to Write a Master′s Thesis. Third Edition. SAGE publications, Inc. 2020. P.298. ISBN-13: 978-1506336091, ISBN-10: 1506336094.

Course Code: 0831 06 FGB 5105	**Year:** First	**Term:** First
Course Title: Aquatic Animal Physiology		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		

Rationale	This course is designed to provide information regarding the function of animals and their constituent parts. The focus of the course is to deliver several lectures in order to teach the students about different.

	Course Contents	**CLOs**
	Section A	
1	**Introduction:** Importance of fish physiology, the diversity of fishes, implication of salt tolerance in freshwater fish, importance of phylogenetic information for comparative fish physiological studies, superlative fishes	1, 2
2	**Fish Growth:** General aspects of fish growth, measuring fish growth, factors affecting fish growth, fish growth in tropical vs. temperate fish, biochemical changes during fish growth, role of hormone in regulating fish growth and metabolism, general biology of neuropeptides, role of neuropeptides in fish and crustacean growth	3
3	**Feeding and Digestion:** Feeding behavior, territoriality, group foraging, feeding migration, digestion mechanisms and digestive enzymes, nutrient absorption in fish, role of gut microflora and symbiotic organisms, energy metabolism and energetics, neuropeptides in controlling food intake, fish foraging impact on ecosystem	4
4	**Circulatory Systems:** Tissue fluids and blood passing organs, mechanism of blood circulation in fish, control of body temperature	4
5	**Physiology of stresses**: Temperature, light, salinity, dissolved gases, improper pH, intentional pollution, nitrogenous and other metabolic wastes	4
	Section B	**CLOs**
6	**Membranes, channels and transports:** Cell membranes, transmembrane transport, passive transmembrane movements, active transmembrane transport, endocytosis and exocytosis, carbohydrate protein and lipid transport	5
7	**Ionic and osmotic balance:** Problems of osmoregulation, osmoregulation in water breathing vertebrates, osmoregulatory organs, physiological adaptations in migrating fish, ATPase, Na^{+},K^{+}, Ca^{2+}, anion)-Dependent ATPase, branchial ion transport	5
8	**Gas exchange:** Gas exchange organ and other adaptation, structure and function of gills, gas transport, steps of respiration, gas transfer in water, regulation of gas transfer, structure of hemoglobin, inhibiting factors, oxygen and carbon dioxide transport, transfer of gases at the tissues	6
9	**Reproductive physiology:** Reproductive system in fish, pituitary hormones and analogues, sex determination, role of hormones in sexual behavior of fish, control of reproduction by environmental factors	6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	State what is growth, why it is different in fishes than mammals, how to measure and influencing variables, growth hormones and their functions, etc.	PLO1, PLO2, PLO3
	CLO2	Develop knowledge on digestion, absorption and assimilation, digestive system in fishes, digestive organs involved in fish digestion, digestive enzymes and their roles.	PLO3, PLO4, PLO7
	CLO3	Explain blood, blood cells, blood circulation systems, and micro-circulation,	PLO3, PLO4, PLO7

		how body temperature and gas exchange are regulated, etc.	
	CLO4	Acquire knowledge on osmoregulation and other associated biological functions, types of osmoregulators depending on migrations, and osmoregulation controlling hormones in fishes	PLO4, PLO6, PLO7
	CLO5	Discuss about structure and functions of fish gills, its involvement in gas exchange and blood circulation.	PLO6, PLO7, PLO8
	CLO6	Develop knowledge on hormonal control of the physiological activities of fishes.	PLO6, PLO7, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test
CLO4	Lecture, demonstration, discussion	Class test
CLO5	Lecture, demonstration, discussion	Class test
CLO6	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. David Hudson Evans. The Physiology of Fishes. Contributor David Hudson Evans Published by CRC Press, 1997 2. Lynwood S. Smith. Introduction to Fish Physiology. Published by T.F.H., 1982 3. Barbara A Block, E Donald Stevens, William Stewart Hoar. Fish Physiology. Published by Academic Press, 2001.

Course Code: 0831 06 FGB 5107	**Year:** First	**Term:** First
Course Title: Biology of Fishes		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	Ichthyology encompasses the study of fishes, including major groups such as the jawless, cartilaginous and bony fishes. Lecture material will include the systematics, physiology, behavior, ecology and evolution of this diverse group of vertebrates.	

Course Contents		CLOs
Section A		
1	**Introduction:** Phylogeny of fishes, evolutionary changes in bony fishes	1, 2
2	**Interrelationships of the major groups of fishes:** Early chondrichthyans, living elasmobranchs, acanthodians	3
3	**Types of fish:** Crossopterygians, coelaeanthiforms, osteoglossomorphs, clueomorphs and euteleosteans fishes	3
4	**Swimming and locomotion:** Means of fish locomotion, classification of fish swimming, body shape and fish locomotion	4

Section B		CLOs
5	**Fish anatomy:** skin, scales, coloration, fins, muscles, body shapes, and mouth	4
6	**Muscular features:** Major kinds of muscles, skeletal musculature of trunk, head region and fin of fishes	4, 5
7	**Skeletal features:** Exo-skeleton, endo-skeleton, axial firm skeleton, appendicular firm skeleton	4, 5
8	**Zoogeography of fishes:** Zoogeography of freshwater and marine water fishes, clues of geographical history of fishes, distribution, causes and factors	4, 5
9	**Behavior and communication/interaction:** Mechanosensory signaling of social interactions; signal modalities including visual, auditory, tactile, chemical and electrical signals; electrocommunication; multimodal communication; prey and predator interaction; mutualistic symbiotic interaction	4, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Define the main taxonomic and phylogenetic relationships among the fishes.	PLO1, PLO2, PLO3
	CLO2	Recognize the main characters used to define the main branches of fish taxonomy.	PLO3, PLO4, PLO7
	CLO3	Provide an explanation and examples of morphological, behavioral, and physiological adaptations in fishes.	PLO3, PLO4, PLO7
	CLO4	Describe and explain how scientific studies provide evidence to test hypotheses about phylogenetic relationships, as well as morphological, behavioral, and physiological adaptations.	PLO4, PLO7, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test
CLO4	Lecture, demonstration, discussion	Class test
CLO5	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. Quentin Bone and Richard Moore, Biology of Fishes, Published by Taylor & Francis, 2008 2. Devendra Nath Saksena. Ichthyology: Recent Research Advances. Published by Science Publishers, 1999 3. Lagler, K. F. Lagler, etc., J.E. Bardach, R.R. Miller, D.R. May Passino. Ichthyology. 4. Daniel Pauly. Darwin's Fishes: An Encyclopedia of Ichthyology, Ecology, and Evolution. Published by Cambridge University Press, 2004

Course Code: 0831 06 FGB 5109	**Year:** First	**Term:** First
Course Title: Endocrinology of Aquatic Animals		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	Endocrinology is the study of hormones and hormone producing tissues, both their normal physiology and their pathophysiology. A comprehensive study of the endocrine system will allow the student to integrate and better understand the functions of the other systems of the body. The relationship of the nervous system to the endocrine system is explored in the context of signaling within a multicellular organism. Also, the pathological conditions and diagnostic procedures associated with endocrine imbalance are investigated.	

Course Contents		**CLOs**
Section A		
1	**General concept of endocrinology**: Scope and position of endocrinology, historical background with special emphasis on fish	1, 2, 3
2	**Hormones and glands:** Modern concepts of hormones, types of hormone, role of hormones, endocrine glands. Anatomy, functions and secretions of the thyroid gland, the adrenal gland, the endocrine pancreas, the urophysis, the corpuscles of stannius and the ultimobranchial gland, the pineal gland	4
3	**Hormone-nutrition interaction:** Hormones involved in food intake, major appetite regulating factors, major peripheral factors, Hypothalamus-pituitary-thyroid axis (HPT axis), reproductive hypothalamus-pituitary-gonad (HPG) axis, CRF and the hypothalamus-pituitary-interrenal (HPI) axis, "novel" appetite-regulating peptides	5
Section B		**CLOs**
4	**Endocrinology of the testis:** Histology of testis, chemistry of androgens, regulation of testicular functions, biology of spermatozoa, environment and sexual periodicity	7
5	**Endocrinology of the ovary:** Histology of ovary, biochemistry of the ovarian hormones, endocrine control of ovary, vitellogenesis of the eggs, hormonal profiles of egg maturation process	7
6	**Hormones in aquaculture:** The use of hormones in fish farming, sex reversal hormones including androgens, estrogens and nonsteroidal agents, artificial reproduction for induce maturation and spawning, impact of the hormone on the environment and consumer health, methods of analysis for determination of hormone residues in several matrices	8

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Explain the general principles hormone action.	PLO1, PLO2, PLO3
	CLO2	Discuss the functions and control of endocrine glands.	PLO3, PLO4, PLO7
	CLO3	Assess endocrine glands and functions of the productive system.	PLO3, PLO7, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. Manfred Reinecke, Giacomo Zaccone, B. G. Kapoor. Fish Endocrinology.Published by Science Publishers, 2006 2. Matty. Fish Endocrinology. Published by Taylor & Francis, 1985. 3. Grace E Pickford. Fish Endocrinology. Published by Kraus Reprint, 1976 4. Yadav, B N Yadev B.. Fish Endocrinology. Published by Daya Publishing House, 1995.

Course Code: 0831 06 FGB 5111	**Year:** First	**Term:** First
Course Title: Advanced Fish Biochemistry		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed to give thorough understanding to students on the biochemistry of principal nutrients in fish diet and tissues. The composition of fish and fish value will be discussed. The biochemical processes that occur to these nutrients in fish cells will be deliberated. Also, the biochemistry of Fish organs, tissues and cells, structure of these organs, tissues, cells and organelles related to their functions will as well be dealt with.	

Course Contents		CLOs
Section A		
1	**Biochemical Composition of fish:** Principal molecules of fish and its nutritional values, health benefit of fish biomolecules, factors affecting the composition	1
2	**Amino acid metabolism in fish:** The nature of amino acids, formation of polypeptides protein structure and functions, protein metabolism, loss of protein structure	2
3	**Glycerophospholipid metabolism:** Definition and classification of lipid, fatty acids classification, properties of saturated and unsaturated fatty acids, essential fatty acids, functions of EFA	2
4	**Protein synthesis in fish:** The measurement of protein synthesis rates in body organs and tissues, the integration of organ metabolism into whole animal physiology, the flux of an amino acid or nitrogen	3
Section B		**CLOs**
6	**Nutrition fluxes and regulation in fish intestine:** Mechanism of nutrient fluxes and regulation in the fish intestine, cellular mechanisms, underlie adaptive changes in nutrient absorption, adaptations to diet and hormonal regulation	2
7	**Exercise metabolism of fish:** Estimation of the potential contribution of specific fuels, depots, and pathways in exercise, a tissue-mass, exercise and recovery metabolism in fish	2
8	**Fasting and starvation:** Specific effects of starvation, the preferential tissues of metabolic stores, distinct routes of mobilization, the mobilization of carbohydrate, proteins, and lipids	3

9	**Origin of luciferins:** The ecology of bioluminescence in marine fishes, enzyme-catalyzed light production and bioluminescence, the properties of fish bioluminescence	4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Know various values fish have and their compositions.	PLO1, PLO2, PLO3
	CLO2	Explain chemical composition, structure and classes of proteins carbohydrate and proteins and its metabolisms in the cells.	PLO3, PLO4, PLO7
	CLO3	Describe the roles of enzymes in fish, functions of antibodies and membranes system and its influence on fish life.	PLO3, PLO4, PLO7
	CLO4	Identify some fish organs and explain the function of the identified organs.	PLO5, PLO7, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test
CLO4	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. P.W. Hochachka and T.P. Mommsen Biochemistry and Molecular Biology of Fishes, 4: Metabolic Biochemistry: Fish biochemistry, Published by Pergamon Press, 1982 2. Experimental Techniques in Biochemistry by J. M. Moyle Biochemistry and Molecular Biology of Fishes by Hochachka

Course Code: 0831 06 FGB 5113	**Year:** First	**Term:** First
Course Title: Advanced Fish Biochemistry		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide the knowledge on basic biology of multicellular organisms for understanding animal developmental pattern, morphogenesis, origin of life via reproduction, and role of genetics in life formation and early development.organs, tissues, cells and organelles related to their functions will as well be dealt with.	

Course Contents		CLOs
Section A		
1	**Introduction to Developmental Biology:** Principles and questions of developmental biology, anatomical approaches, epigenesist and preformation, developmental modeling, evo-devo	1
2	**Life Cycles and Developmental Patterns:** Stages of animal development,	2

	role of nucleus in morphogenesis, origins of multicellularity and reproduction, evolution of differentiation, life cycles and developmental pattern	
3	**Experimental Embryology:** Environmental sex determination, adaptation to heterogeneous environments, developmental mechanics of cell specification, morphogenesis and cell adhesion	2
4	**Genes and Development:** role of nucleus and cytoplasm on heredity, developmental genetics, genomic equivalence, differential gene expression, RNA localization techniques, functional roles of developmental genes	3
Section B		**CLOs**
5	**Cellular Communication in Development:** Cascades of interactions, paracrine factors, receptors and signal transduction pathways	3
6	**Early Embryonic Development:** Fertilization to beginning of a new organism, gamete recognition, gamete fusion and prevention of ploypermy, activation of egg metabolism, fusion of genetic materials, rearrangement of egg cytoplasm	4
7	**Development of Vertebrates:** Cleavage in fish eggs, gastrulation and axis formation in fish embryos, formation of the central nervous system, development of eye	4
8	**Environmental Regulation of Animal development:** Environmental regulation of normal development, phenotypic plasticity, adaptive nervous system, environmental disruptions of normal development	5
9	**Model fishes:** Developmental biology of tilapia, zebra, guppy, medaka, common carp, catfish	5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Name, describe and order the main stages of development common to most multicellular organisms.	PLO1, PLO2, PLO3
	CLO2	Describe the main anatomical changes that occur during development.	PLO3, PLO4, PLO7
	CLO3	Identify the cellular behaviors that lead to morphological change during development.	PLO3, PLO4, PLO7
	CLO4	Understand how gene activation plays a role in differentiation and development.	PLO3, PLO4, PLO8
	CLO5	Describe the main signaling pathways that play important roles in development.	PLO5, PLO6, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, discussion	Class test
CLO2	Lecture, demonstration, discussion	Class test
CLO3	Lecture, demonstration, discussion	Class test
CLO4	Lecture, demonstration, discussion	Class test
CLO5	Lecture, demonstration, discussion	Class test

Learning Materials

Recommended Readings	1. Gilbert, S. F., 2000. Developmental Biology (6^{th} edition) 2. Jonathan M. W. Essential Developmental Biology, Slack Publisher Wiley-Blackwell, 2006

First Year Second Term

Course Code: 0831 06 FGB 5201	**Year:** First	**Term:** Second
Course Title: Population and Evolutionary Genetics		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide students with a general introduction to population genetics, which examines the interaction of basic evolutionary processes in determining the genetic composition and evolutionary trajectories of natural populations. An understanding of the mechanisms shaping genetic variation within and between populations is critical to understanding the course of adaptive evolution and is increasingly being recognized as a critical component of fisheries research and the development of effective treatments for disease.	

	Course Contents	**CLOs**
	Section A	
1	**Introduction:** A Darwinian view of life, descent with modification, uniformitarianism, Lamarck's hypothesis of evolution, historical context of Darwin's life and ideas, Darwin's research, adaptation, artificial selection, natural selection and its action	1, 2
2	**The evolution of population:** Modern evolutionary thought – macro and microevolution, types of evolution – convergent and divergent evolution, allele frequency change, raw material for evolutionary change	2, 3
3	**Gene polymorphism:** Types of polymorphisms, causes of genetic polymorphism, effects of genetic polymorphism in a population, phenylthiocarbamide (PTC) - bitter compound, step of evolution process, techniques used in studying genetic polymorphism	3
4	**Hardy-Weinberg Principle:** Hardy-Weinberg equilibrium, assumptions and results, application of Hardy - Weinberg equation, microevolution of species, modes of natural selection, variations in populations, linkage disequilibrium	3, 4
5	**Molecular markers:** Types, detection, mapping of genetic markers, markers in fish breeding; markers in fish population	2, 5
6	**Computational Phylogenetics:** Phylogenetic analysis, phylogeny tree basics, types of tree, computational process, rooted and unrooted trees, parsimony methods, maximum likelihood methods, minimum evolution methods, clustering methods – UPGMA & N-J methods	2, 5
	Section B	**CLOs**
7	**Population Structure:** Stock, estimating allelic frequency, relationship between alleles and genotypes, changes in allelic frequency, estimating population structure, problems associated with population genetic analysis, mixed stock analysis (MSA), cryptic and panmactic population	1, 2, 8
8	**Finite and Structured Populations:** The neutral theory of molecular evolution, mitochondrial DNA, applications of neutral evolution, migration and differentiation between populations, the establishment of a new favorable	3, 7, 8

	mutation, molecular clock and estimation species divergence	
9	**Natural Selection:** The basis and basics of natural selection, Darwinian fitness, natural selection and adaptive evolution, adaptation, difficulties in understanding natural selection	5, 7, 8
10	**Evolution of Eukaryotic Genome:** Genome, evolutionary gene, evolutionary genome, pseudogenes, origin of new genes and pseudogenes, fate of new genes and pseudogenes, evolution by gene expression, evolution by gene and genome duplication, divergent and convergent evolution, genetic causes of convergent evolution	5, 7, 8

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Describe population structure in terms of genetic variation.	PLO1, PLO2, PLO5,
	CLO2	Evaluate the principles to describe the genetics profile of populations as specified by HardyWeinberg.	PLO1, PLO3, PLO4
	CLO3	Evaluate mechanisms that change gene frequencies in populations.	PLO1, PLO6, PLO8
	CLO4	Describe genetic and environmental processes leading to speciation.	PLO1, PLO2, PLO7
	CLO5	Compare and contrast the effects of discrete and continuous traits.	PLO5, PLO7
	CLO6	Differentiate organismal and molecular evolution.	PLO1, PLO3, PLO5
	CLO7	Describe how mutation and genetic recombination influence evolutionary adaptation.	PLO1, PLO2, PLO4
	CLO8	Assess the role of genetics in conservation biology.	PLO1, PLO2, PLO3, PLO4, PLO6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, Group Discussion	Class test, Assignment
CLO2	Lecture, Case Study	Presentation, Quiz
CLO3	Lecture	Class Test
CLO4	Lecture, Group Discussion	Assignment, Presentation
CLO5	Lecture, Case Study	Assignment, Quiz
CLO6	Group Discussion, Case Study	Class Test, Presentation
CLO7	Lecture, Group Discussion	Quiz
CLO8	Lecture, Group Discussion	Final Exam

Learning Materials

Recommended Readings	1. Francisco José Ayala. Population and Evolutionary Genetics: A Primer. Published by Benjamin/Cummings Pub. Co., 1982 2. James Franklin Crow. Basic Concepts in Population, Quantitative, and Evolutionary Genetics. Published by W.H. Freeman, 1986

	3. Richard C. Lewontin, R. S. Singh, Costas B. Krimbas, Kōstas V. KrimpasContributor R. S. Singh, Costas B. Krimbas. Evolutionary Genetics: From Molecules to Morphology. Published by Cambridge University Press 4. Volker Loeschcke, Jürgen Tomiuk, Subodh K. Jain. Conservation Genetics. Published by Birkhäuser, 1994

Course Code: 0831 06 FGB 5203	**Year:** First	**Term:** Second
Course Title: Genomics of Aquatic Animals		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		
Rationale	This course is designed to provide the knowledge on state of the art genomics principles and techniques and their applied aspects important in improving aquaculture production and also fisheries management and conservation.	

	Course Contents	**CLOs**
	Section A	
1	**Introduction to Genomics:** Gene, genome and genomics, introduction to OMICS, application of genomics in aquaculture and fisheries management, introduction next generation sequencing (NGS) for genomics studies, introduction to genomics tools and techniques	1, 2
2	**Mitochondrial genomes:** definition, functional roles of mitochondrial (mt) genomes, applications of mt genomes, mt genomics of aquatic animals, drawbacks of mt genomes	1, 2
3	**Transcriptomics:** definition, importance, application of transcriptomics in aquatulture, principles of transcriptomics, cDNA library preparation, challenges and solutions in RNA sequencing, micro-array vs transcriptome, gene expression and regulation	1, 3
4	**Genotyping-by-sequencing (GBS):** Introduction to GBS, principles of GBS studies, applications of GBS in aquaculture and fisheries management, GBS based marker discovery, genome wide association mapping, GBS in evolutionary studies	1, 2, 3
	Section B	**CLOs**
5	**Complete Genome Sequencing:** Considerations in genome sequencing, genome size estimation, application of complete genomes, genome assembly and annotation	1, 2, 3
6	**Epigenetics:** applications of epigenetics in aquaculture, epigenetic mechanisms, epigenetic principles, environmental effects on epigenetic modifications, role of epigenetic modification in gene expression	1, 3
7	**Proteomics:** History of proteomics, areas and types of proteomics, proteomic techniques, modeling protein structure, applications of proteomics	1, 2, 3
8	**Meta-genomics:** Introduction to meta-genomics, applications of meta-genomics, microbial diversity and species richness, The Binning Strategy, Functional meta-genomics, comparative meta-genomics, pitfalls in meta-genomics	1, 2, 3
9	**Phylogenomics:** important terminologies, phylogenetics vs phylogenomics, phylogenomic principles, opportunities and pitfalls, road map for phylogenomic workflow, crucial steps in phylogenomics, phylogenomics in	1, 2, 3

	evolutionary studies, phylogenomic estimations, phylogenomic topologies for biodiversity	

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Describe recent advances in genomics, transcriptomics, proteomics and metabolomics.	PLO1, PLO2, PLO3, PLO5, PLO7
	CLO2	Explain some of the current genomics technologies and illustrate how these can be used to study gene function	PLO1, PLO2, PLO3, PLO6, PLO7, PLO8
	CLO3	Obtain and analyse information and data relating to specific genes using general and fish-specific databases, proteomics and metabolomics online portals, next generation sequencing tools and next generation mapping portals	PLO1, PLO2, PLO3, PLO4, PLO5, PLO6, PLO7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, Group Discussion	Quiz, Class Test
CLO2	Lecture, Case Study	Assignment, Presentation
CLO3	Lecture	Final Exam

Learning Materials

Recommended Readings	1. Auwera, G. A. V. and O'Connor, B. D., 2020. Genomics in the Cloud. 2. Marshall, C., 2019. Bioinformatics and Functional Genomics. 3. Rajora, O. P., 2019. Population Genomics: Concepts, Approaches and Principles. 4. Maclean, D., 2019. Bioinformatics Cookbook.

Course Code: 0111 06 RES 5202	**Year:** First	**Term:** Second
Course Title: Seminar–II: Data analysis and management		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course intends to provide students advance knowledge and hand-on experience on assembling, analysis and presentation of data obtained from the primary research and secondary studies.	

	Course Contents	CLOs
1	**Introduction:** Statistics in coastal and marine science, types of data, data sources, accuracy, precision, errors and their sources, error minimization and	1, 2

	separation;	
2	**Sampling:** Sample size estimation, types of sampling and its uses, sampling distribution;	1, 2
3	**Studies and experimental units:** coastal and marine sciences;	1, 2
4	**Processing and presentation:** Array Formation, Frequency Distribution/ Table, Graphic representation;	3
5	**Data analysis:** analysis of collected data regarding coastal and marine science.	2

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	explain different types of data	PLO1, PLO2, PLO4, PLO8
	CLO2	determine sample size and suitable sampling strategies;	PLO1, PLO2, PLO8, PLO11
	CLO3	design survey and experimental research works;	PLO1, PLO2, PLO8, PLO11
	CLO4	analyze and present data	PLO8, PLO11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Seminar, group discussion, video tape	Presentation
CLO2	Seminar, problem based learning	Presentation
CLO3	Seminar, problem based learning	Presentation

Learning Materials

Recommended Readings	1. Bhujel, R.C., 2009. Statistics for aquaculture. John Wiley & Sons. 2. Kothari, C.R., 2004. Research Methodology: Methods and techniques. New Age International. 3. Bhamrah, H.S., Sandhu, G.S. and Gupta, K.C., 2006. Research Techniques in Biological Science. Dominant Publishers. 4. Pillay, T.V.R., 1990. Aquaculture Principles and Practices (pp.575). Fishing News Books, University Press.

Course Code: 0831 06 FGB 5204	**Year:** First	**Term:** Second
Course Title: Dissertation Part - I		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	This course is designed to provide the students an opportunity to conduct and write their thesis proposal.	

	Course Contents	**CLOs**
1	This course serves as an introductory course in the dissertation methodology writing process. The focus of the course is to develop the MS student's dissertation proposal. The core objective of this course is to provide guidance	1

	and motivation to the MS students for their comprehensive understanding on the problem identification, literature review and methodology.	

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Construct a research question that can be empirically addressed during experiment.	PLO1, PLO3, PLO7, PLO8
	CLO2	Design and execute a meaningful research project that demonstrates spatial thinking using knowledge and skills.	PLO7, PLO8
	CLO3	Undertake the research process and be aware of research obligations and pitfalls.	PLO10
	CLO4	Articulate research or project objectives clearly, situate research within an academic or scholarly context; state claims and evidence clearly, assess validity of claims, evidence, outcomes, and results.	PLO2, PLO9, PLO10,
	CLO5	Utilize the relevant software and bibliographic reference manager competently and efficientlyto produce documents that meet MS in CMS program requirements.	PLO9, PLO11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Demonstration, project, modular, group discussion, seminar, workshop,	Presentation and viva

Course Code: 0831 06 FGB 5205	**Year:** First	**Term:** Second
Course Title: Aquatic Biotechnology		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	Fish Biotechnology is important to identify and combine traits in fish and shellfish to improve quality and increase productivity. Fish is also used as a model organism in developmental biology; recombinant DNA technology or genetic engineering, and gene cloning enable scientists to study the regulation of individual genes, even to understand the aberration in gene activity in human diseases such as cancer. The technology enabled biologists to find out new applications in agriculture, medicine and biotechnology.	

Course Contents		CLOs
Section A		
1	**Introduction:** History, role, implications of biotechnology and genetic engineering in aquaculture and fisheries, current and potential application of biotechnology and genetic engineering in A&F, limitation and ethical issues	1, 2
2	**Gene cloning:** Restriction enzymes, vectors, cloning from mRNA, cloning	1, 2, 3

	from genomic DNA, advanced cloning strategies	
3	**Recombinant DNA:** Genetic selection and screening methods, screening using nucleic acid hybridization, analysis of cloned gene, applications of gene cloning and DNA analysis in research and biotechnology	1, 2, 3
4	**Gene-transfer Technology:** Gene-transfer technique in fish Promoters, integration, transmission of transgenes, transgene expression of growth-hormone and reporter genes	1, 3
5	**Genome editing:** Gene targeting, TALEN, CRISPR, nucleobase modification multiplex automated genomic engineering, targeted gene modification in animals gene therapy, eradicating diseases prospects and limitations	1, 2, 3
Section B		**CLOs**
6	**Genetic engineering in action:** Analysis of gene structure and function, making proteins, transgenic animals, spin-off technologies	1, 2, 3
7	**Industrial Biotechnology:** Renewable raw materials, bioprocesses life cycle, assessment, a check list for sustainability	2, 3
8	**Environmental implications of transgenic fish:** Potential risks, mitigation strategy (sterilization; quarantine etc) international guidelines, labeling	1, 3
9	**Biosafety of GMOs:** Principles of transgenic technology and transgenic production and its application to fisheries risk assessment; GMOs and biosafety regulations; gene therapy, and designer ornamental fish strains; ethical issues in GMOs: cartagena protocol, national regulations on GMOs; impact assessment of GMOs; transgenic containment	1, 2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Elucidate the mechanism of cloning strategies from mRNA and genomic DNA	PLO1, PLO2, PLO5
	CLO2	Understand the basic techniques of gene cloning and producing transgenic animals, its analysis and application in research and biotechnology	PLO3, PLO4, PLO5, PLO6, PLO7, PLO8
	CLO3	Explain the molecular tools used in understanding gene expression	PLO1, PLO2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture	Quiz, Class Test
CLO2	Lecture, Group Discussion, video tape	Assignment, Presentation
CLO3	Lecture and Group Discussion	Final exam

Learning Materials

Recommended Readings	1. Sambrook J., Fritsch E. F. and Maniatis T. 1989. Molecular Cloning: A laboratory manual. New York: Cold Spring- Harbor Laboratory, Cold Spring Harbor, Vol 1- 3. 2. Rex A. Dunham. Aquaculture and Fisheries Biotechnology: Genetic Approaches. Published by CABI, 2004 3. 4. Sherlock, John D. Morrey. Ethical Issues in Biotechnology. Contributor Richard Sherlock, John D. Morrey. Published by Rowman & Littlefield, 2002.

	4. W B Vasantha Kandasamy; Florentin Smarandache: Methods in industrial biotechnology for chemical engineers, Infolearnquest, 2008

Course Code: 0831 06 FGB 5207	**Year:** First	**Term:** Second
Course Title: Bioinformatics		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		

Rationale	Bioinformatics has been defined as the science of examining the structure and function of genes and proteins through the use of computational analysis, statistics, and pattern recognition. The approaches to the discipline of bioinformatics incorporate expertise from the biological sciences, computer science and mathematics. The major in bioinformatics is designed for students interested in molecular biology and genetics, information technologies and computer science. Bioinformaticists are involved in the analysis of the genome of organisms, identification of targets for drug discovery, development of new algorithms and analysis methods, the study of structural and functional relationships, and molecular evolution.

Course Contents		**CLOs**
Section A		
1	**Introduction to bioinformatics:** history, definition, scope and applications; Fields related to bioinformatics	1, 2
2	**Database:** Mining tools, submission of DNA sequences; Sequence alignment and database searching, similarity search, FASTA, BLAST	1, 2
3	**Information networks:** Internet; genbank sequence database, EBI-net; NCBI, genome net	1, 2, 3
4	**Genomics:** Genome diagnostics, genome projects, genome analysis	1, 2, 4
Section B		**CLOs**
5	**Proteomics:** protein information resources, primary and secondary protein data bases, analysis packages, predictive methods, ESTs	1, 2, 4
6	**Computational genetics:** Phylogenetic analysis; comparative genome analysis; microarray bioinformatics	2, 3, 4
7	**Practical Internet search:** retrieving information from different database like NCBI, protein information sources; Preparation of data base	2, 3, 4
8	**Use of genome analysis packages:** genetics data base; Searching by similarity; Phylogenetic analysis; Accessing and submission to genebanks; BLAST, sequence alignments, comparisons	1, 2, 3, 4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Locate and use the main databases at the NCBI and EBI resources.	PLO1, PLO2, PLO7, PLO9
	CLO2	Know the difference between databases, tools, repositories and be able to use each one to extract specific information.	PLO1, PLO2 PLO3, PLO4
	CLO3	Extract data from specific databases using accessions numbers, gene names etc.	PLO1, PLO2 PLO5, PLO6
	CLO4	Use selected tools at NCBI and EBI to run simple analyses on genomic sequences.	PLO1, PLO2 PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Group discussion	Quiz
CLO2	Lecture, Group discussion and video tape	Assignment
CLO3	Lecture and Group discussion	Class test, Presentation
CLO4	Lecture and Group discussion	Final Exam

Learning Materials

Recommended Readings	1. Discovering Genomics, Proteomics, and Bioinformatics: Malcolm Campbell, A. 2. Introduction to Bioinformatics : Arthur M. Lesk 3. Bioinformatics Basics: Applications in Biological Sciences and Medicine by Rashidi, H.H. and Buehler, L.K. 4. Bioinformatics, A Practical Guide to the Analysis of Genes and Proteins, A.D. Baxevanis and B.F. Ouellettee 5. Bioinformatics: A Biologist's Guide to Biocomputing and the Internet Stuart M. Brown

Course Code: 0831 06 FGB 5209	**Year:** First	**Term:** Second
Course Title: Cytogenetics		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	A study of different aspects of the cell affects inheritance. The purpose of the course is to provide a working knowledge of cytogenetics, the preparation of materials for study, and the importance of chromosomal variations in structure and number in such fields as plant and animal breeding, population genetics, evolutionary genetics, taxonomy, and the medical sciences. The student will be able to recognize, describe and discuss in detail the different aspects of chromosomal structure, number, and behavior, and their effects at the organismal, population and species levels. They will describe and discuss this material in detail on two essay lecture exams, demonstrating their mastery of the material.	

Course Contents		CLOs
Section A		
1	**Introduction:** Historical background, importance, improved cytogenetic techniques	1
2	**Chromosome theory of inheritance:** Chromosomal models and their ultra-structure; Chromosomal movements and position effect	1, 2
3	**Sex determination and differentiation:** Sex chromatin and Lyon's hypothesis; Chromosome numbers in fish and karyotyping	1, 3
Section B		**CLOs**
4	**Chromosomal aberrations:** Genetic and evolutionary implications; Chromosome banding techniques; FISH	1, 2, 3
5	**Cytogenetics and evolution:** Genotoxicity assays (single cell electrophoresis, MNT, SCE).	1, 2, 4
6	**Practical Preparation of chromosome spreads:** Karyotyping; banding techniques; MNT, SCE, comet assay.	1, 2, 3, 4

	At the end of the course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Evolution of various chromosomal aberrations (structural and numerical), their applications in alien gene transfer and hybrid seed development	PLO1, PLO2, PLO3, PLO4, PLO6
	CLO2	Culture in haploid development and development of diploid inbreds or hybrids or doubled isogenic lines from haploids that has got important applications in plant breeding	PLO1, PLO2, PLO5 PLO6, PLO7
	CLO3	Cytogenetic tools such as FISH and GISH (Genomic *In Situ* Hybridization) techniques	PLO1, PLO2, PLO6, PLO8
	CLO4	Application of fish cytogenetics in validation of physical maps	PLO1, PLO3, PLO5, PLO6, PLO7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Group Discussion	Quiz, Class Test
CLO2	Lecture, Video Tape and Seminar	Assignment, Presentation
CLO3	Lecture, Video Tape and Group Discussion	Class test
CLO4	Lecture, Video Tape and Enquiry based learning	Final Exam

Learning Materials

Recommended Readings	1. Fish Cytogenetics : Pisano, 2. Fish Genetics and Biotechnology: W.S.Lakra; 3. Fish Genetics and Biotechnology - ICAR Publication (Eds. Ayyappan, Thumpy, Reddy, Krishna)

Course Code: 0831 06 FGB 5211	**Year:** First	**Term:** Second
Course Title: Microbial Biotechnology		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	Microbial biotechnology overlaps with the recently developing field of designer bacteria, the so-called 'synthetic microbiology', where large sections of a microbial genome are engineered in order to optimize the metabolism for specific purposes. This complements the previous field of (natural) strain development. The advent of genome sequencing, proteomics and metabolomics now allow comprehensive insights into microbial physiology and coupled with the ability to synthesize long stretches of DNA, enables genome engineering on a grand scale, with many new possibilities. Bioinformatics is an important tool in this process.	

Course Contents		CLOs
Section A		
1	**Introduction:** Historical background, importance, development pace of	1, 2, 3

	microbial biotechnology, development of industrial microorganisms	
2	**Microbial Genetics:** Domains of life, nature of virus, phenotypic and genetic changes of virus, viral genomes, bacterial genome, vertical inheritance, horizontal inheritance, genetic mapping in bacteria by transduction	1, 2, 3, 4
3	**Recombinant microbial biotechnology products:** Production of antibodies, small biological molecules, vaccine, antibiotics, biopolymers	2, 3, 4, 5
	Section B	**CLOs**
4	**Microbes in the food industry:** Use of microorganisms in the production of food and food ingredients	1, 2, 5
5	**Microalgae:** Biofuel production, long chain hydrocarbon synthesis, chemical race of hydrocarbon, pathways of hydrocarbon synthesis	3, 4, 5
6	**Pharmaceutical microbiology:** Use of microorganisms in the production of antibiotics, steroid hormones and health related products	1, 6
7	**Microbes in Aquaculture:** Screening, identification of probiotics, pathogenic microbes and insecticides, bioherbicides related microbes, application in aquaculture	5, 6

	At the end of the course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Critically evaluate the role of micro-organisms in specific biotechnological processes	PLO1, PLO2, PLO5, PLO7
	CLO2	Explain the complex processes behind the development of genetically manipulated organisms	PLO1, PLO2, PLO4, PLO6, PLO8
	CLO3	Demonstrate a clear understanding of how biochemical pathways relate to biotechnological applications	PLO3, PLO4, PLO5, PLO7, PLO8
	CLO4	Conduct a comprehensive search for original research literature pertinent to a selected area of microbiology and biotechnology	PLO1, PLO5, PLO6, PLO7, PLO8
	CLO5	Judge the relative support for different perspectives in potentially controversial issues based on a critical and objective analysis of published research	PLO1, PLO2, PLO5, PLO7
	CLO6	Communicate complex scientific principles and ideas effectively	PLO1, PLO5, PLO6, PLO7, PLO8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture	Quiz
CLO2	Lecture and Group Discussion	Assignment
CLO3	Lecture, Video Tape and Group Discussion	Class test
CLO4	Lecture and Enquiry based learning	Quiz, Presentation
CLO5	Lecture, Video Tape and Co-operative Learning	Written Exam
CLO6	Lecture and Case Study	Final Exam

Learning Materials

Recommended Readings	1. Waites, Morgan, Rockey and Higton: Industrial Microbiology: An Introduction, Blackwell Science (2001) 2. Madigan,Michael and Martinko,John: Brock biology of microorganism, 11th edition, By, (2005) 3. Lee, Y.K. (ed.) Microbial Biotechnology, 2nd edition, World Scientific, 2006

Course Code: 0831 06 FGB 5213	**Year:** First	**Term:** Second
Course Title: Genetics and Breeding of Shellfish		
Course Status: Optional		
Credit: 3.0		
Prerequisite(s): None		
Rationale	A broad understanding of the basic principles of genetics and breeding of shellfishes is useful in application to wild aquatic resource management and aquaculture improvement. Reduced genetic variation (genetic drift and inbreeding) in wild and farmed population can deteriorate production performance and also can put the organisms at the risk of extinction due to reduced population size. Basic knowledge and understandings on wild population genetic structure, brood stock development and domestication, quantitative phenotypes, selective breeding and di-allele cross can address the fitness consequences of inbreeding in natural and hatchery populations and their implications for species conservation.	

Course Contents		**CLOs**
Section A		
1	**Introduction:** Economic and ecological importance of major shellfishes, historical development of shellfish breeding and domestication, shellfish breeding and aquaculture vs fish breeding and aquaculture	1
2	**Breeding and Conservation of Freshwater Prawn:** Breeding technique of giant freshwater prawn, domestication and brood stock development, conservation techniques of wild populations of prawn	1, 2, 3
3	**Domestication and Conservation of Marine Shrimp:** Breeding technique of tiger shrimp, domestication and brood stock development of tiger shrimp, selective breeding, individual and family selection strategies of shrimp	1, 2, 3
4	**Mud Crab:** Biology and development pattern of mud crab, breeding technique, brood stock management, management and conservation of wild populations	1, 2
Section B		**CLOs**
5	**Breeding Biology of Crayfish:** Biology of commercially important crayfishes, breeding technique, brood stock development and maintenance	1, 2
6	**Biology and Genetics of Lobster:** Biology of lobster, economic and ecological importance, challenges in lobster breeding, rearing technique of lobster, developmental pattern of lobster	1, 2
7	**Breeding and Genetics of Mollusks:** Biology and role of mollusks (snail, oyster, mussel, cuttlefish and squid), breeding and farming techniques of mollusks	1, 3
8	**Genetic Improvement of Commercially Important Crustacean:** Success stories of some model species (*Litopenaeus vannamei*, *Eriocher chinensis*	1, 2, 3

	and *Procambarus clarkii*), advances in the field of genetics	

Course Learning Outcomes (CLOs)	At the end of the course the students will be able to:		**Mapping with PLOs**
	CLO1	Acquire sound knowledge in the use of traditional and modern shellfish (crustacean and mollusk) breeding methods, as well as some major aquaculture breeding programs.	PLO1, PLO2, PLO3, PLO4, PLO5, PLO7, PLO8
	CLO2	Gain skills in the evaluation of various breeding strategies.	PLO1, PLO2, PLO6, PLO7
	CLO3	Understand quantitative genetics, epigenetics and hybridization of shellfish.	PLO1, PLO2 PLO3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, Class Test
CLO2	Lecture and Group Discussion	Assignment, Presentation
CLO3	Lecture, Video Tape and Group Discussion	Final Exam

Learning Materials

Recommended Readings	1. Subramonium T., 2017. Sexual Biology and Reproduction in Crustaceans (1st edition) 2. Wickins J. F. and Lee D. O'C., 2002. Crustacean Farming: Ranching and Culture (2nd edition) 3. Spencer B., 2002. Molluscan Shellfish Farming (1st edition)

Course Code: 0831 06 FGB 5204	**Year:** First	**Term:** Second
Course Title: Dissertation Part - I		
Course Status: Core		
Credit: 4.0		
Prerequisite(s): None		
Rationale	This course is designed to provide the students an opportunity to conduct and write their thesis based on the knowledge of Project Work-1 and Research Methodology.	

	Course Contents	CLOs
1.	This course serves as an introductory course in the dissertation methodology writing process. The focus of the course is the further development of the student's dissertation proposal of MS. The core objective of this course is to provide guidance and motivation to the MS student so those students have comprehensive understanding on the literature review and methodology.	1

Course Learning	Upon completion of this course the students will be able to:	**Mapping with PLOs**

Outcomes (CLOs)	CLO1	Understand the clear concepts about their thesis.	PLO1, PLO2, PLO3, PLO4, PLO5, PLO7, PLO8
	CLO2	Design and execute a meaningful research project that demonstrates spatial thinking and uses the knowledge and skills.	
	CLO3	Undertake the research process and be aware of research obligations and pitfalls.	
	CLO4	Articulate research or project objectives clearly, situate research within an academic or scholarly context; state claims and evidence clearly, assess validity of claims, evidence, outcomes, and results.	
	CLO5	Utilize the relevant software and bibliographic reference manager competently and efficiently to produce documents that meet M.S. in FGB program requirements	

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Demonstration, project, modular, group discussion, seminar, workshop,	Presentation and viva

Second Year First Term

Course Code: 0111 06 RES 6102	**Year:** Second	**Term:** First
Course Title: Seminar–III		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course is designed to have insights into practical aspects of review and research works relate to their thesis works.	

	Course Contents	CLOs
1	**Oral Presentation:** Scientific papers presented at a level that is appropriate to the audience; clear and informative visual aids (simple, sufficient time).	1, 2, 3
2	**Introduction:** Overview of problem area provided; unfamiliar terms introduced; appropriate literature abstracted and presented clearly; research hypothesis of the study identified.	4
3	**Methods:** Brief overview of the equipment and materials used, and how obtained; brief overview of the experimental design used and any other parts of the methods employed; materials and/or equipment described; procedures followed to conduct the experiment presented.	5
4	**Results:** Anticipated and actual results reported; statistics clearly presented.	6
5	**Discussion:** Implications if the hypothesis is supported clearly stated;	4,7

	implications if the hypothesis is not supported clearly stated; limitations of your study discussed; future research addressed.	
6	**Questions:** Demonstrated knowledge of the material; poised and confident, but no bluffing; answered the question(s) asked (asked for clarification or restatement of the question).	6, 7

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Communicate science in a 30-40 minute oral scientific presentation.	PLO1, PLO2, PLO3
	CLO2	Understand and critique scientific presentations	PLO3, PLO4, PLO5
	CLO3	Create and implement a career plan to prepare for their identified career goals.	PLO3, PLO4
	CLO4	Identify actions to take in areas of fisheries science education, including research, and internship / experiential learning.	PLO1, PLO2, PLO3
	CLO5	Understand workplace expectations, communicate professionally, and identify and solve workplace conflicts.	PLO3, PLO4, PLO5, PLO9, PLO10
	CLO6	Understand the different types of interview questions and craft focused answers in response.	PLO3, PLO4
	CLO7	Construct a professional network.	PLO3, PLO9, PLO10, PLO11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Group discussions, short lectures, strong student involvement	Presentation
CLO2	Group discussions, guest panelists, strong student involvement	Presentation
CLO3	Group discussions, guest panelists, strong student involvement	Presentation
CLO4	Group discussions, guest panelists, strong student involvement	Presentation
CLO5	Group discussions, guest panelists, strong student involvement	Presentation
CLO6	Group discussions, guest panelists, strong student involvement	Presentation
CLO7	Group discussions, guest panelists, strong student involvement	Presentation

Learning Materials

Recommended Readings	1. Kothari, C.R., 2004. *Research Methodology: Methods and techniques*. New Age International. 2. Bhamrah, H.S., Sandhu, G.S. and Gupta, K.C., 2006. *Research Techniques in Biological Science*. Dominant Publishers. 3. Yvonne N. Bui. How to Write a Master's Thesis. Third Edition. SAGE publications, Inc. 2020. P.298. ISBN-13: 978-1506336091, ISBN-10: 1506336094.

Course Code: 0831 06 FGB 6104	**Year:** Second	**Term:** Second
Course Title: Dissertation-II		
Course Status: Core		
Credit: 12.0		
Prerequisite(s): None		
Rationale	This course is designed for MS students to build on their research competencies. The purpose of this course is to get MS students going on their dissertation writing and become competent in basic research designs, which entails making judgments about matching research designs to particular research problems.	

	Course Contents	**CLO**
1	Possible methodological means of investigation around research topic.	1
2	Writing the dissertation	2, 3, 4
3	Presentation of the research work	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Conduct research work (field arrangement, sample collection, data analysis) independently	PLO3, PLO4, PLO7, PLO8, PLO9, PLO10, PLO11
	CLO2	Articulate research objectives clearly, situate research within an academic or scholarly context; state claims and evidence clearly, assess validity of claims, evidence, outcomes, and results.	PLO7, PLO8, PLO9, PLO10, PLO11
	CLO3	Narrate the research process clearly in the form of a formal multi-chapter master's thesis manuscript, structured according to the approved MS thesis style in Khulna University.	PLO3, PLO4, PLO7, PLO8, PLO9, PLO10, PLO11
	CLO4	Describe research clearly and succinctly, in written and oral forms, to faculty, mentors, and potential sponsors.	PLO3, PLO4, PLO7, PLO8, PLO9, PLO10, PLO11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Instruction and guide.	Report and Presentation
CLO2	Instruction and guide.	Report and Presentation
CLO3	Instruction and guide.	Report and Presentation
CLO4	Instruction and guide.	Presentation, viva, Final dissertation report

20. Grading and Evaluation

20.1.1 Grading Scale

Letter Grades and corresponding Grade Points will be awarded following provisions shown below:

Numerical Grade	Letter Grade	Grade Point
80% or above	A+ (A plus)	4.00
75 to less than 80%	A (A regular)	3.75
70 to less than 75%	A- (A minus)	3.50
65 to less than 70%	B+ (B plus)	3.25
60 to less than 65%	B (B regular)	3.00
55 to less than 60%	B- (B minus)	2.75
50 to less than 55%	C+ (C plus)	2.50
45 to less than 50%	C (regular)	2.25
40 to less than 45%	D	2.00
Less than 40%	F	00
Incomplete	I	
Withdrawn	W	
Continuation (for project, thesis design, etc. course)	X	

20.1.2 Cumulative Grade Point Average (CGPA)

GPA will be calculated as per the standard practices at the undergraduate level of Khulna University. A student's performance will be evaluated in terms of three indices, viz. Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average (CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated up to date by the total completed credits. Thus a student who has earned 275 grade points in attempting 100 credits of courses would have an overall CGPA of 2.75. The students will be awarded the Degree with Distinction, if their CGPA is 3.75 or above.

20.1.3 Evaluation of Theory Courses

All theory courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Continuous Assessments:	30-40 Marks
Term Final:	50-60 Marks
Total:	**100 Marks**

20.1.4 Evaluation of Sessional Courses

All sessional courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Sessional Assessments:	60 Marks
Viva voce:	30 Marks
Total:	**100 Marks**

(a) For both theory and sessional courses, attendance shall carry 10 marks and the basis for awarding marks will be as follows:

Attendance (%)	Marks
≥ 90	10
85 to < 90	9
80 to < 85	8
75 to < 80	7
70 to < 75	6
65 to < 70	5
60 to < 65	4
< 60	0

(b) The continuous assessments (30 to 40 marks) for theory courses may be conducted in the form of written class examinations, assignments, home-works, presentations, quizzes, viva voce, mid-term, etc. For any theoretical course, there shall be at least four assessments. Section best (A & B) assessments shall be counted. A mid-term Examination may be taken if a Discipline/POE opts for it. The concerned Discipline will allocate marks for mid-term and continuous other evaluations in such a case. The course teachers must submit the continuous assessment and sessional assessment mark sheets to the Chair of the Examination Committee before the starting of the Term final examination.

(c) The remaining 50 to 60 marks will be allocated for the term final examination.

(d) A student who fails in any course(s) in the Term final examinations or who registered for the course(s) but did not sit for the examination, the concerned course(s) will be considered as retake course(s).

(e) A student retaking theory course(s) for clearing/passing or improvement must appear at the mid-term (if any) and Term final examinations. A student may attend continuous assessments also on the written approval of the Discipline Head; otherwise, the marks of continuous assessments will be maintained from the student's previous records. The marks of attendance will be carried forward from earlier Term. The obtained grade will be downgraded in case of retaking course(s).

(f) Examination procedure related other guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.1.5 Evaluation of Viva Voce

A Discipline may include Viva Voce of 01/02 credit(s) at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

20.1.6 Dissertation under Mixed-mode

i) There will be two components of the Dissertation, namely Dissertation Part-I in one Term for proposal development, and Dissertation Part-II in another term for completing the Dissertation. The total credit for the Dissertation will be 16 credits. The credit allocation for proposal development and dissertation parts will be 4 credits and 12 credits, respectively.

ii) A Dissertation (both proposal and Dissertation) will be evaluated out of 100 marks.

Marks distribution of Dissertation Part-I will be as follows:

a)	Assessment of Supervisor	30 marks
b)	Proposal Presentation	70 marks

Marks distribution for Dissertation Part-II will be as follows:

a)	Assessment of Supervisor	20 marks
b)	Dissertation Evaluation	50 marks
c)	Defense (Oral examination)	30 marks

iii) Dissertation Part-I will usually commence in the Master's first-year second-term and Dissertation Part-II in the second-year first-term (final Term).

iv) The final evaluation of the Dissertation Part-II will be made at the end of the final Term. However, the evaluation of the Dissertation Part-I will be done in the corresponding Term.

v) A student registered for Dissertation will undertake research work under the guidance of a supervisor and a co-supervisor (if necessary).

vi) The research needs to be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

vii) There shall generally be one Supervisor for each student, but a co-supervisor may also be appointed if needed. A teacher not below the rank of Assistant Professor will act as supervisor/co-supervisor. However, a Lecturer with MPhil/ Master's by Research/ Ph.D. degree is eligible to supervise/co-supervise a student. Co-supervision may also be allowed from other Disciplines of Khulna University/other universities or research institutes.

viii) If a student has any grievance about a Supervisor, or if a Supervisor has any complaint against a student, s/he may inform the Discipline Head about the issue in writing. The Discipline will decide such matters.

ix) Pursuant to the leave rules of Khulna University, a Supervisor can remain absent from Khulna University (not more than six months) while continuing as a Supervisor. The online defense may be arranged in such cases if deemed necessary. Otherwise, the Co-supervisor (if any) or any other competent person will act as the Supervisor as per the guideline of the concerned Examination Committee. This will be applicable for projects and internships also.

x) Every student submitting a dissertation in partial fulfillment of the requirements of a degree will be required to appear at proposal presentation for Dissertation Part-I and defense board of Dissertation Part-II respectively on the dates fixed by the Discipline Head in consultation with the Supervisor(s). Such presentation and defense may be arranged online if deemed necessary to the concerned authority. A student must satisfy the examiners that s/he is capable of undertaking independent work and affording evidence of satisfactory knowledge related to the theory and techniques used in his/her research work.

xi) A student must submit the required number of printed and soft copies of Dissertation Part-II in the approved format through the Supervisors to the Discipline Head by a date to be fixed by the Discipline. The Dissertation will not usually be considered for evaluation if the plagiarism detection system yields a similarity index of more than 25% (excluding bibliography/references, quotes, and small sources with source exclusion threshold of ten-word counts). This will be applicable to the dissertations written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

xii) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

xiii) If any change is required in the title/supervisor/co-supervisor/examiner/etc., the Discipline Head will send it to the BOAS through EC.

20.1.10 Credit Requirement and Duration of the Program

The required credits and duration for Master's Programs are mentioned below.

Program type	Credit Requirement				Program Duration			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Total (Min.)	Term (Min.)	Year (Min.)	Term (Max.)	Year (Max.)
Coursework	40	-	-	40	02	1.0	06	3.0
Mixed-mode (Dissertation)	20	15	20	40	03	1.5	06	3.0
Mixed-mode (Project)	20	3	6	40	03	1.5	06	3.0
Mixed-mode (Internship)	20	3	6	40	03	1.5	06	3.0
Research	-	45	60	45	04	2.0	06	3.0

The details of each Term Duration will be as follows:

Item	Duration
Teaching and continuous assessment/ Contact with Supervisor	14 weeks
Preparatory leave before: Final Examination/ Seminar/ Defense	02 weeks
Final Examination/ Seminar/ Defense	(Maximum) 04 weeks
Term Break	02 weeks
Total	**22 weeks**

20.1.11 Course Types

The courses included in the Master's curriculum may be divided into three groups as follows:

(i) **Core Courses:** Core courses are obligatory for a degree.

(ii) **Optional Courses:** Any other courses students may undertake to earn the Degree.

(iii) **Major Courses:** A Discipline may offer courses from one or more major areas (if any), and after completing a certain number of credits from that area (as reported in the following table), a student can achieve a Master's degree with a major in a specified field, and that will be mentioned in the Transcript, e.g., MS in Agrotechnology (Horticulture). The curriculum of the concerned program will provide a detailed description of such cases.

Credit Requirements for Offering Major

Program type	Min. credit requirement from major area*			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Min. from Major Area
Coursework	20	-	-	20
Mixed-mode (Dissertation)	9	15	20	20
Mixed-mode (Project)	15	3	6	20
Mixed-mode (Internship)	15	3	6	20
Research	-	45	60	45

* For achieving a Master's degree with a major in a specified field under a mixed-mode or 'Master's by Research' scheme, the concerned dissertation must be directly linked with the 'major area' under consideration.

(iv) **Viva Voce:** A Discipline may include Viva Voce of 01/02 credit(s) at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

(v) **Assignment of Credit:**

Theory Courses: For theory courses, one-hour face-to-face learning (e.g., lecture, tutorial, seminar) per week will be equivalent to one credit.

Sessional Courses: For sessional courses, 1.5-hour face-to-face learning (e.g., lab work, studio, fieldwork, or clinical work) per week is equivalent to 1.0 credit. For industrial/ workplace learning, 2-hour learning per week is equivalent to 1.0 credit.

In addition to face-to-face and other means of learning, online teaching-learning might be exercised if deemed necessary to the Discipline/POE.

20.1.12 Course Registration

(i) Each student will get oneself registered with the University. S/he will fill in the course registration form in consultation with the Program Coordinator under the guidance of the Discipline Head. The Program Coordinator will verify the form and submit it to the Discipline Head for forwarding it to the Registrar's office. Such submission might be made online, when and where applicable. The Registrar's office will be responsible for its distribution to relevant authorities (Disciplines and the Controller of Examinations). Course registration will be permitted within five working days at the beginning of each Term. Late registration will be permitted up to the next five working days on payment of a late fee. Student(s) having outstanding dues to the University shall not be permitted to register.

(ii) A student has to register for the backlog/retake/re-retake core courses first followed by the fresh courses offered by the Discipline for the term s/he is going to enroll subject to the compliance with: (i) completion of prerequisite courses (if any) and (ii) maximum credit registration limit per Term. However, s/he may not choose to register the optional backlog/retake/re-retake courses first.

(iii) A student may be allowed to register for advance course(s) in a term subject to: (i) his/her all backlog/retake/re-retake and offered core courses are either clear or registered, (ii) his/her current terms' offered all core courses are registered, (iii) completion of corresponding prerequisite courses (if any), (iv) compliance with maximum credit registration limit per Term, and (v) the desired advance courses are offered by the Discipline/POE in the current Term. However, such an advance course registration option will not be applicable for capstone courses like Thesis/ Project/ Internship/ and so on.

(iv) A student retaking/re-retaking the course will be awarded the immediate lower grade he/she obtains, and this grade will be shown and maintained on the Transcript.

(v) A Discipline/POE will not continue an optional course if less than 30 percent of students (of total seats for that batch) register for that course within ten working days from the beginning of classes. The situation will be solved by dropping that optional course through applying article 10.3 of MS Ordinance by the next five working days. The Coordinator will maintain such records and act accordingly. However, the concerned Discipline/POE might relax this clause for only final term/year optional courses if it is deemed necessary (for example, the studentship will be toward termination or the student will have to wait for additional term/year if the considered optional course(s) are not offered).

20.1.13 Limits on the Credits to be taken in a Term

Discipline Head may allow a student to register up to a maximum of 25 credits if recommended by the Program Coordinator. However, there is no minimum credit limit per Term in Master's level study.

20.1.14 Course Adjustment Procedure

A student will have the option to add or drop course(s) from his/her registration list within fifteen working days from the beginning of classes. This can be done with the advice of the concerned Program Coordinator and consent of the Discipline Head. Adjustment of initially registered courses in any Term can be made by duly filling in the Adjustment Form. The Registrar's office will do the needful.

20.1.15 Withdrawal from a Term

If any student cannot complete the Term Final Examination due to severe illness or serious accident, he/she may apply to the Dean through the Head for total withdrawal from the Term within eight working days after the end of the Term Final Examination. However, s/he may choose not to withdraw from any sessional courses if the grade obtained in such a course is 'C' or better. A medical certificate endorsed by the Chief Medical Officer of the University must support the application. The Dean of the concerned school will decide on such an application and inform the Registrar. If a student is allowed to withdraw from a Term, he/she will have to register as fresh for the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.1.16 Absence in a Term

A student may be absent from continuous assessments (quizzes/class test/field works, etc.) during the Term. Such absences will naturally reduce points/marks, which count towards the final grade. Absence in the Mid Term (if any) and the Term Final Examination will result in 'F' grade. A student who has been absent for short periods, up to a maximum of three weeks due to illness, should request the Course Teacher or Program Coordinator to makeup continuous assessments immediately on returning to the class. A medical certificate should support such request from the Chief Medical Officer of Khulna University. The medical certificate issued by registered medical practitioners (with the registration number shown explicitly on the certificates) and endorsed by the Chief Medical officer of the University will also be acceptable only in those cases where the student has valid reasons for his absence from the University.

20.1.17 Special Term

Students having any retake/re-retake course(s) may apply for a special Term to complete the total required course (maximum 09 credits) in that Term. The special Term will be offered for the final term students who have retake/re-retake courses. The examination will start four (04) weeks after publication of the result and will continue not more than 2 (two) weeks. The marks of both attendance and continuous assessments will be carried over from the previous record.

20.1.18 Registration for Improvement

If any student gets a 'D' to 'C+' grade in any course, s/he may be allowed to repeat that course to improve the grade. The previous grade will be replaced from the grade sheet in such a case.

20.1.19 Backlog

If a student obtains an 'F' grade in any Core course in any term, this 'F' grade will not be counted for Grade Point Average (GPA) but will be shown on the grade sheet, and in such case, he/she will have to retake the course to complete the Degree. If a student does not register for an offered Theory or Sessional course in his/her applicable Term (for example, '0541 12 Math 5101' course in his/her Master's first year first term, '0541 12 Math 5203' course in his/her Master's first year second term, '0541 12 Math 6104' course in his/her Master's second year first term), that course will be considered as a 'Backlog' course for that student in the subsequent terms. If a student gets an 'F' grade in an Optional course, he/she may, subject to availability, choose to take an optional substitute course. In such a case, that substitute course will be deemed as a fresh course. In case of registering for a Backlog Theory or Sessional course, a student has to face/appear/attend 100 marks evaluation, like a fresh course.

20.1.20 Credit Transfer/ Credit Waiver

This ordinance permits credit transfer to facilitate educational mobility. That transfer of credit(s) may be inward or outward. In the case of outward credit transfer, a student of Khulna University has to apply to the Registrar through the Head of the Discipline/POE for getting a credit transfer certificate. The application must be supported by necessary documents, including a copy of the grade sheet(s). Accordingly, the Registrar will issue a credit transfer certificate mentioning the number of credits already completed at Khulna University.

In case of inward credit transfer, students from other Universities/ Institutions may apply to the Registrar of Khulna University for credit transfer. The application must be supported by necessary documents, including a copy of grade sheet(s) and curriculum. The Registrar's office will forward the application to the concerned Discipline/POE. A three-member committee headed by the Discipline Head and two senior most teachers will assess the application and recommend for approval to the Registrar. The maximum limit of credit transfer from other Universities/ Institutions will be less than or equal to 50 percent of the total credits required to complete the concerned Degree. The final transcript of such students will show only the number of credits transferred.

The same process may be applied for handling the credit waiver related applications. However, the maximum limit of inward credit waiver from other Universities/ Institutions should be less than or equal to 20 percent of the total credits required to complete the concerned Degree.

20.2 Grades

Grade related issues are reported in section 20.1.

20.3 Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA)

a) Grade Point Average (GPA) is the weighted average of Grade Points obtained in all the courses passed/completed by a student. For example, if a student has passed/completed five courses in a term having credits of C1, C2, C3, C4, and C5 and his/her points in these courses are G1, G2, G3, G4, and G5, respectively, then,

$GPA = \sum CiGi/\sum Ci$

b) A Numerical Example: Suppose a student has completed five courses in a term and obtained the following grades:

COURSE	CREDIT	GRADE	GRADE POINT
A	3	A+	4.00
B	3	C+	3.00
C	3	A	3.75
D	2	B	3.25
E	1	B+	3.50

Then his/her GPA for the term will be computed as follows:

GPA= 3(4.0) + 3(3.0) + 3(3.75) + 2(3.25) + 1(3.5) / (3 + 3 + 3 + 2 + 1) = 3.52

c) A student's performance will be evaluated in terms of three indices- Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average (CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated till date by the total completed credits. Thus a student who has earned 275 grad points in attempting 100 credits of courses would have an overall CGPA of 2.75.

20.4 Course Withdrawal

a) 'W' is the corresponding grade for withdrawn of a course, as mentioned in section 20.1.1.

b) If any student cannot complete the Term Final Examination due to severe illness or serious accident, he/she may apply to the Dean through the Head of the concerned Discipline for total withdrawal from the Term within eight working days after the Term Final Examination. However, he/she may choose not to withdraw from any sessional course if the grade obtained in such a course is C or better. A medical certificate endorsed by the Chief Medical Officer of the University must support the application. The Dean of the concerned School will decide on such an application and inform the Academic Council. If a student is allowed to withdraw from a Term, he/she will have to register as fresh from the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.5 Incomplete (I) Courses

'I' is the corresponding grade for an incomplete course, as mentioned in section 20.1.1.

20.6 Retake

Retake related issues are reported in section 20.1.

20.7 Grade Improvement

Grade improvement related issues are reported in section 20.1.

20.8 Dropout/Cancellation of Studentship

Dropout/Studentship cancellation related guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.9 Publication of Results

(i) The Controller of Examinations will publish the result and preserve all the records for one year after the Degree is awarded. The result will be published subject to completing the required number of credits and fulfilling other requirements (for example, article/paper for 'Master's by Research' mode students) within the stipulated time limit, as applicable.

(ii) A student can have his/her results re-examined by applying to the Controller of Examinations within 30 working days from the date of publication of results. However, s/he has to pay a re-examination fee fixed by the concerned authorities. The Controller of Examinations will take necessary measures regarding the matter in consultation with the Chairman of the Examination Committee. Answer script re-scrutiny and result re-examination related rules of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs also.

20.10 Subsequent Ordinances

For related/relevant issues, which are not covered (or not cleared) here, provisions of the latest 'Ordinance for Undergraduate Program' and 'Ordinance for Undergraduate Examination' of Khulna University may be consulted and applied, if not conflicting with this Ordinance.