




Bangladesh Open University

 SARD SCHOOL OF AGRICULTURE AND RURAL DEVELOPMENT কৃষি ও পল্লী উন্নয়ন স্কুল	School of Agriculture and Rural Development (SARD)
	Master of Science (MS) in Fisheries Biology and Genetics

Curriculum layout for the degree of Master of Science (MS) in Fisheries Biology and Genetics

1. Requirement for registration: Bachelor of Science in Fisheries (Hon's) or related disciplines from any recognized University
2. Duration: One and a half ($1\frac{1}{2}$) years (Registration valid for three consecutive years)
3. Semester: Three Semesters (Valid up to consecutive six semesters), two semesters in a year each of six (6) months:
4. No. of courses = 12
5. No. of credits = 40
6. Total Marks = 2000

Distribution of courses, credits and marks

MS in Fisheries Biology and Genetics shall be offered with 40 credits in 3 semesters each of six months duration. The courses worth 24 credits of which 12 credits shall be offered during the first semester and the other 12 credits during the 2nd semester respectively for the students. Another 16 credits shall be reserved for the research (thesis and thesis defense). The students have to start their research work for thesis (equivalent to 6 courses) under the guidance and supervision of his/her Research Supervisors after the completion of one semester and the same shall be carried through to the last semester when it will be evaluated. After the evaluation of thesis the students have to face thesis defense (equivalent to 2 courses). The distribution of courses, credits and marks are shown below:

Course Type		No. of Courses	Credits	Marks
Course (compulsory)		12	24	1200
Research	a) Thesis	equivalent to 6 courses	12	600
	b) Thesis defense	equivalent to 2 courses	4	200
Total			40	2000

N.B. 1 course = 2 credits = 100 marks; Thesis = 12 credits = 600 marks, Thesis defense (4 credits) = 200 marks: Each course will carry 80 marks for theoretical examination and 10 marks for one course assignment and 10 marks for class attendance.


Course layout for MS in Fisheries Biology and Genetics

1st Semester

Sl.	Courses Title	Course code	Credit hrs.	Marks
1	Biology of Fish	MSFBG 1201	2	100
2	Advanced Fish Physiology	MSFBG 1202	2	100
3	Conservation Genetics of Fish	MSFBG 1203	2	100
4	Molecular Genetics	MSFBG 1204	2	100
5	Biodiversity of Aquatic Fauna	MSFBG 1205	2	100
6	Fishery Systematics and Evolution	MSFBG 1206	2	100
Total 6 courses			12	600



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2nd Semester

Sl.	Courses Title	Course code	Credit hrs.	Marks
1	Breeding and Stock Improvement of Fish	MSFBG 2201	2	100
2	Endocrinology of Aquatic Animals	MSFBG 2202	2	100
3	Fish Genetic Engineering and Biotechnology	MSFBG 2203	2	100
4	Biology of Shellfish and Non-piscine Aquatic Vertebrates	MSFBG 2204	2	100
5	Embryology of Aquatic Animals	MSFBG 2205	2	100
6	Reproductive Biology and Behaviour of Fish	MSFBG 2206	2	100
Total 6 courses			12	600

3rd Semester

Title	Credit	Mark
a. Thesis (equivalent to 6 courses)	12	600
b. Thesis defense (equivalent to 2 courses)	4	200
Thesis + Thesis defense	16	800
Grand Total	[(12×2)+16] = 40 (Forty)	2000

Syllabus for MS in Fisheries Biology and Genetics

Course Title: Biology of Fish

Credit hours: 2

Course Code: MSFBG 1201

Unit	Title
1	Introduction: Effects of environmental factors on the biology of fish
2	Adaptation of fish to different environmental conditions: (I) Salinity (II) pH (III) Dissolved gases
3	Fish Migration: Types of migration, preconditions for migration, migration of anadromous and catadromous fishes
4	Biology with particular emphasis on the life history, food and feeding habits, age and growth, sexuality and reproduction and breeding behaviour of the following native and foreign fishes (a) <i>Labeo rohita</i> (b) <i>Hypophthalmichthys molitrix</i> (c) <i>Hilsa ilisha</i> (d) <i>Clarias batrachus</i> (e) <i>Pangassius sutchi</i> (f) <i>Anabas testudineus</i> (g) <i>Puntius gonionotus</i> (h) <i>Oreochromis niloticus</i>

Recommended Textbooks


1. Bone, Q.N.B. Marshall and J.H.S. Blaxter (1995) Biology of Fishes. Blackie Academic and Professional, Wester Cleddens Road, Bishopbridge, Glasgow UK. 332p.
2. Lagler, K.F.J.E. Bardach, R.R. Miller and D.R.M. Passino (1977) Ichthyology (2nd Edition). John Wiley and Sons Inc, New York. 506p.
3. Bemis, W.E.W. Burggren and N.E. Kemp. 1987. The Biology and Evolution of Lungfishes. Alan R. Liss Inc. New York 383p.
4. Marshall, N.B. 1965. The Life of Fishes. Weidenfield and Nicolson, London, 402p.

Supplementary Textbooks

5. Wodyanitskii, V.A. (ed) 1969. Function and Gross Morphology in Fish. Israel Program for Scientific Translation, Zerusalem 228p.
6. Harden, J.F.R. 1970. Fish Migration. Edward Arnold (Publishers) Ltd. London. 325 p.
7. McKeown, B.A. 1984. Fish Migration. Cromm helm. London, Sydney. 324p.
8. Shultz, L.P. and E.M. Stern. 1984. The Ways of Fishes. Van Nostard, New York. 675 p.
9. Takeo, I, (ed) 1977. Aquaculture in Shallow Seas : Progress in Shallow sea culture. Academic Publishing Company Pvt. Ltd. New Delhi. 615p.



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	Master of Science (MS) in Fisheries Biology and Genetics

Course Title: Advanced Fish Physiology

Credit hours: 2

Course Code: MSFBG 1202

Unit	Title	Lesson
1	Introduction to Fish Physiology	Metabolism, types of metabolism and metabolic rate, measurement of energy metabolism
2	Circulatory System	Phagocytosis and susceptibility of blood, mechanism of circulation blood as a gas carrying substance
3	Stress Physiology	Nature of stress, external and internal changes, direction of changes, blood parameters, hormone levels, control stress
4	Anaesthesia and Sedation	Meaning and nature, effects of the process and negative effects, inhaled and injectable anaesthesia, use in fisheries science and in fish transportation
5	Homonal Control of Reproduction	Pituitary hormones and analogues, seasonal pattern of gonadal maturity, control of reproduction by environment: light regimes, out of season egg management

Recommended Textbooks

1. Hoar, W.S. and Randall, J.H. (eds). Fish Physiology Vols. I (1969), III (1969), IV (1970), V (1971), VI (1971), VII (1978), VIII (1979), IX-A & B (1983), X-A & B (1984) and Vol XI (1988). Academic Press, New York.
2. Brown, M.E. 1957. The Physiology of Fishes. Vol. 1 & 2. Academic Press.
3. Smith, T. 1982. Introduction to Fish Physiology.
4. Rastogi, S.C. 1988. Essentials of Animal Physiology (2nd edition). Wiley Eastern Limited, India.

Supplementary Textbooks

5. Potts, G.W. and Wootton, R.S. (Editors) 1984, Fish Reproduction: Strategies and Tactics. Academic Press.
6. Roberts, M.B.V. 1995. Biology - a Functional Approach. Chapman and Hall.
7. Schreck, C. and Moyle, P. (eds) 1990. Methods for Fish Biology. American Fisheries Society.
8. Shepherd, C.J. and Bromage, N.R. (Editors) 1992. Intensive Fish Farming. Blackwell Science Publications, Oxford. UK.

Course Title: Conservation Genetics of Fish

Credit hours: 2

Course Code: MSFBG 1203


Unit	Title	Lesson
1	Genetic Constitution of a Population	Hardy weinberg equilibrium, factors altering gene and genotype frequencies, genetic variation within a subdivided population: quantitative measures of differentiation: genetic distance
2	Interpreting Genetic Variation Detected by Electrophoresis	Basic principles, genotypic data from electrophoresis, strengths and limitations of electrophoretic data for studying protein loci
3	Natural Hybridization and Gene Introgression in Fishes	Methods of detection, genetic interpretation of hybridized population
4		Roles of molecular markers in fisheries and aquaculture
5	DNA Fingerprinting	Multilocus DNA fingerprinting, applications of DNA fingerprinting: genome mapping, gynogenesis, aquaculture genetics and fisheries
6	Mitochondrial DNA and Analysis of Fish Population Structures	The mitochondrial genome, restriction endonuclease analysis of mitochondrial DNA, genetic variation in stocks, applications of mitochondrial DNA variability
7	Genetic Drift	Finite population size and genetic drift, the effect of genetic drift, the founder effects and bottlenecks, effective population size: separate sexes, variation in number of gametes, inbreeding, variation in time, age structure, neighbourhood size, genetic aspects of endangered populations
8	Natural Organization and Fish Population	Stock transfer relative to natural organization, management and conservation of fish population, genetical conservation of exploited fishes

Recommended Textbooks

1. Ryman, N. and Utter, F (editors) 1987 Population Genetics and Fishery Management. Washington Sea Grant Program, University of Washington Press, Seattle and London.
2. Falconer, D.S. and Mackay, T.F.C., 1996. Introduction to quantitative Genetics (4rd Edition) Longman, UK.



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	Master of Science (MS) in Fisheries Biology and Genetics

- Crow, J.F. and Kimura, M., 1970. An Introduction to Population Genetics Theory. Harper and Row Publishers, New York.
- Hartl, D.L. and Clark, A.G., 1989. Principles of Population Genetics (2nd edition). Sinauer Associates, Sunderland, MA.

Supplementary Textbooks

- Chapman, B. (Editor), 1985. General and Quantitative Genetics. Elsevier Science Publishers, B.V. Amsterdam-Oxford-New York-Tokyo.
- Kirby, L.T., 1990. DNA Fingerprinting: An Introduction. W.H. Freeman and Co. Saltlake City, UT.
- Roberts, D.F. and De Stefano, G.F. (Editor), 1986. Genetic Variation and its Maintenance. Cambridge University Press.
- Soule, M.E. (Editor), Viable Populations for Conservation. Cambridge University Press.
- Tumer, B.J. (Editor). 1984. Evolutionary Genetics of Fishes. Plenum press.
- Whitmore D.H. (Editor) 1990. Electrophoretic and isoelectric Focusing Techniques in Fisheries Management. CRC Press.

Course Title: Molecular Genetics

Credit hours: 2

Course Code: MSFBG 1204

Unit	Title	Lesson
1	The Genetic Material	Physical and chemical structure of DNA; DNA replication, repair and recombination mechanisms: the geometry and enzymology of DNA replication, the polymerization process and error correction.
2	Gene Expression	Synthesis of RNA and protein, transcription: synthesis of mRNA, RNA polymerase-structure and function, splicing-processing of RNA molecules-mechanism and control, translation : the genetic code, codons and features, transfer RNA and aminoacyl synthetases, polypeptide synthesis, ribosomes
3	Control of Gene Expression	Strategies of gene control, controlling the start of transcription, post transcriptional controls
4	Molecular Organization of Chromosomes	Chromosome proteins: histones, nonhistones, nucleosome: morphology and function, chromatin organization: chromatin fibre, chromatin loops, chromosome band, chromosome condensation, heterochromatin
5	Gene Mapping in Fish: Status, Examples From Different Groups of Fishes; Gene Mapping Techniques	Genetic linkage analysis, centromere mapping, cytogenetics and physical mapping, DNA based technologies and physical mapping, prospects
6	Mutagenesis, Mutations and Mutants	Types and notations, biochemical basis of mutants, mutagenesis, mutation hot-spots
7	Molecular Biology of Fish Immune System	Introduction, major histocompatibility complex in fishes, uses of MHC polymorphisms, MHC and disease resistance, microglobulin-fish endogenous and exogenous antigens, immunoglobulins-fish antibodies and immunoglobulin genes

Recommended Textbooks


- Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., and Watson, J.D., 1994. Molecular Biology of the Cell. (3rd Edition). Garland Publishing Inc. New York and London.
- Freifelder, D., 1987. Molecular Biology (2nd Edition). Jones and Bartlett Publishers, Inc. Boston, Portola Valley.
- Lewin, B., 1997. GENES VI. Oxford University Press. Oxford, England.
- Kumar, H.D., 1998. Molecular Biology. Vikas Publishing House Pvt. Ltd., New Delhi, India.

Supplementary Textbooks

- Carvalho, G.R. and Pitcher, T.J. (Editors), 1995. Molecular Genetics in Fisheries. Chapman and Hall, London.
- Darnel Jr, J., Lodish, H. and Baltimore D., 1995. Molecular Cell Biology. W.H. Freeman and Co., New York.
- Hochachka, P.W. and Mommsen, T.P. (Editors), 1993. Biochemistry and Molecular Biology of fishes. Vol. 2. Elsevier Science Amsterdam-London-New York-Toronto.
- Stryer, L., 1988. Biochemistry (3rd) W.H. Freeman and Co., New York.
- Truner, B.J. (Editor), 1984. Evolutionary Genetics of fishes. Plenum, New York.
- Watson, J.D., Hopkins, N.H., Roberts, J.N., Steitz, J.A. and Weiner, A.M. 1987. Molecular Biology of



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Course Title: Biodiversity of Aquatic Fauna

Credit hours: 2

Course Code: MSFBG 1205

Unit	Title
1	Biodiversity: Introduction, the nature and value of biodiversity, biodiversity at global and country level
2	Causes for the Loss of Biodiversity: Effects of species introduction in the aquatic environments, impact of aquaculture and hatcheries on wild fish
3	Biodiversity Convention and Conservation: Goals and principles, strategies, guidelines and methods of biodiversity conservation, conservation in context of biodiversity convention at global and country level
4	Protection of aquatic biodiversity throughout the human environment
5	Conserving species, population and genetic diversity

Recommended Textbooks

1. Agawal, K.C., 1999. Biodiversity. Pub. Agro Botanica, New Delhi.
2. David, P.P., Epifanio, J.M., Marsden, J.E. and Claussen, J.E., 1995. Protection of Aquatic Biodiversity, Oxford and IBH Pub. Co. New Delhi.
3. Kotwal, P.C. and Banerjee, S., 1998. Biodiversity Conservation. Pub. Agro. Botanica, New Delhi.
4. Shama, B.D., 1999. Indian Wildlife Resources Ecology and Development. Daya Pub. House, New Delhi.

Supplementary Textbooks

5. Anonymous, 1992. Global Biodiversity Strategy. World Resource Institute (WRI), The World Conservation Union (IUCN), United Nations Environment Program (UNEP).
6. Hosetti, B.B. 1997. Concepts in Wildlife Management. Daya Pub. House, New Delhi.
7. Shama, B.D., 1999. Indian Wildlife Resources Ecology and Development. Daya Pub. House, New Delhi.
8. Thorpe, J., Gall, G., Lannan, J., and Nas., C. (Editors) Conservation of Fish and Shellfish Resources Managing Diversity. Academic Press.

Course Title: Fishery Systematic and Evolution

Credit hours: 2

Course Code: MSFBG 1206

Unit	Title	Lesson
1	Principles of Zoological Classification	The species category, the polytypic species concept, population systematic and intra-specific categories, the hierarchy of categories and the higher taxa
2	Methods of Classification	Taxonomic collections and the process of identification, taxonomic characters of fishes, taxonomic decisions on the species level, the procedure of classifying
3	Principle and Application of Zoological Nomenclatures	The rules of zoological nomenclatures, international code of zoological nomenclature, interpretation of the rules of zoological nomenclature
4	Evolution	Theories of organic evolution, the process and patterns of evolution in fishes, evolution at the molecular level
5	Speciation	Nature, modes and types, allopatric and sympatric speciation
6	Strategies of Taxonomic Research	Introduction of biochemical techniques such as protein and DNA analysis (DNA fingerprinting) for identification of species, taxonomic publications

Recommended Textbooks


1. Kapoor, V.C., 1983. Theory and Practice of Animal Taxonomy. Oxford and IBH Pub. Co. New Delhi.
2. Mayr, E., 1969. Principles of Systematic Zoology. McGraw Hill, New York.
3. Jordan, D.S., 1963. The Genera of Fishes and Classification of Fishes. Stanford University Press, Standord.
4. Simpson, G.G., 1961. Principles of animal Taxonomy, Columbia University Press. New York.

Supplementary Textbooks

5. Kitching, I.J., Forey, C.J., and humphris, C.J. and Williams, D.M., 1998. Cladistics (2nd Edition). The Theory and Practice of Parsimony Analysis. Oxford University Press).



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6. Bandyopadhyaya, A. 1991. Matsyo Srenibinnayas. Bangla Academy, Dhaka.
7. Hillis, D.M. Morizot, C., and Mable, B.I. (Editors) 1996. Molecular Systematics. Sinauer Associates, Inc.
8. Mayr E., 1966. Animal Species and Evolution.
9. Rahman, A.K.A., 1989. Freshwater Fishes of Bangladesh. The Zoological Society of Bangladesh, Dhaka.
10. Shafi, M. and M.M.K. Kuddus, 1982. Bangladesher Matsya Sampad (Bangla) Bangla Academy, Dhaka.
11. Talwar, P.K. and A.G. Jhingran, 1991. inland Fishes of India and Adjacent Countries Vol. 1 and 2. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
12. Weber, M. and L.F. De Beaufort, 1965. The Fishes of the Indo Australian Archipelago. E.J. Brill, Leiden.
13. Young. J.Z., 1962. The Life of Vertebrates. The Clarendon Press, Oxford.

Course Title: Breeding and Stock Improvement of Fish

Credit hours: 2

Course Code: MSFBG 2201

Unit	Title	Lesson
1	Artificial Breeding of Commercially Important Fishes in Hatcheries	Background information on different species of endemic and exotic fishes used for artificial breeding
2	Genetic Management of Brood Stocks	Brood stock management scenario in the hatcheries in Bangladesh, problems identified with existing fish stocks and hatchery operations, short and long term plans for brood stock development in hatcheries
3	Inbreeding	Identify by descent, calculating inbreeding from pedigrees, inbreeding and population size, effective breeding number, effects of inbreeding, breeding plans to avoid inbreeding depression
4	Selective Breeding	Selective breeding for qualitative traits, selective breeding for quantitative traits, prediction and measurement of response to selection, selection index theory, correlated response to selection, effects of artificial selection on gene frequency and variance, heritability: characteristics, estimation and uses, suitable model of selective breeding for major and minor carp species
5	Hybridization	Planning cross-breeding programs, heterosis a hybrid vigor, effects of unplanned hybridization, current trends in hybridization in fish hatcheries of Bangladesh
6	Sex-determination	Sex-reversal and sex determination, hybridization and sex determination, gynogenesis and sex determination, cytology of sex chromosomes

Recommended Textbooks


1. Tave, D., 1993. Genetics for Fish hatchery Managers (2nd Edition) Van Nostrand Reinhold. New York.
2. Purdom, C.E., 1992. Genetics and Fish Breeding. Chapman and Hall, London-New York-Tokyo-Melbourne-Madras.
3. Bromage, N.R. and R.J. Roberts (eds) 1995. Broodstock Management and Egg and Larval Quality. Blackwell Science.
4. Chonder, S.L., 1994. Induced Carp Breeding, CBS Publication and Distributors, New Delhi, India.

Supplementary Textbooks

5. Hussain, M.G. and Mazid, M.A. 2000. Breeding Plans, Stock Improvement and Conservation of Carp Genetic Resources in Bangladesh. CLARM, Dhaka.
6. Doyle et al. (Editors), 1996. Genetics in Aquaculture-V. Elsevier Science Publishers.
7. Gall et al (Editors), 1993. Genetics in Aquaculture IV. Elsevier Science publishers.
8. Gall, G. and C. Busack (Editors) 1986 Genetics in Aquaculture II. Elsevier Science Publishers.
9. Gjedrem, T. (Editor) 1990. Genetics in Aquaculture III. Elsevier Science Publishers.
10. Jhingran, V.G. and R.S.V. Pandian, 1988. A Hatchery Manual for the Common, Chinese and Indian Major Carps.
11. Kirpichnikov, V.S. 1981. Genetic Bases of Fish Selection, Springer-Verlag, Berlin-Heidelberg-New York.
12. Reddy, P.V.G.K., 1999. Genetic Resources of Indian Major Carps. FAO Fisheries Technical Paper No. 387. Rome Italy.
13. Tave, D. 1995. Selective Breeding Programs for Medium Sized Fish Farms. FAO Fisheries Technical Paper 352. Rome Italy.
14. Tave, D., 1999. Inbreeding and Broodstock Management. FAO Fisheries Technical Paper No. 392. Rome Italy.



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Course Title: Endocrinology of Aquatic Animals

Credit hours: 2

Course Code: MSFBG 2202

Unit	Title	Lesson
1	General concept of endocrinology	Scope and position of endocrinology with special emphasis on fish
2	Organization of the endocrine system	Methods of study, the assay of hormones, hormone synthesis, release and transport, receptor mechanisms, hormone action mechanisms, hormonal interrelations
3	Neuroendocrinology	Concept of neurosecretion, control of endocrine system, hormonal actions of the brain
4	Pituitary gland	Anatomy and histophysiology, secretions, functions and mechanisms
5	Endocrinology of the testis	Histology of testis, chemistry of androgens, regulation of the testicular functions, biology of spermatozoa, environment and sexual periodicity
6	Endocrinology of the ovary	Histology of the fish ovary, biochemistry of the ovarian hormones, endocrine control of ovary, vitellogenesis of the eggs, hormonal profiles of egg maturation process
7	Hormones	Modern concept of hormones, roles of the hormones on the life processes and breeding processes of fish and its impact on aquaculture

Recommended Textbooks

1. Barrington, E.J.W. 1963. Introduction to General and Comparative Endocrinology. Clarendon Press, Oxford.
2. Matty, A.J. 1985. Fish Endocrinology. Croom Helm Ltd. London and Sydney.
3. Hoar, W.S. and Randal, D.J. 1969. Fish Physiology Vol. III. Academic Press, New York.

Supplementary Textbooks

4. Turner, C.D. and Bagnara, J.T. 1976. General Endocrinology (6th edition). W.B. Saunders Company, London and Toronto.
5. Barrington, E.J. and Jorgensen, C.B. (eds). Perspectives in Endocrinology. Academic Press, London and New York.
6. Bentley, P.J. 1982. Comparative Vertebrate Endocrinology (2nd edition), Cambridge University press, Cambridge, London, New York, Rochelle, Melbourne and Sydney.

Course Title: Fish Genetic Engineering and Biotechnology

Credit hours: 2

Course Code: MSFBG 2203

Unit	Title	Lesson
1	Introduction	Prospects for genetic engineering in fishes, fish as model animal for genetic engineering and biotechnology, an overview of genes cloned from fishes
2	General Plan of a Eukaryotic Gene	Genetic regulatory elements-promoters, enhancers, silencers, constructing chimeric DNA, DNA synthesis from mRNA, isolating individual gene from the genome
3	Gene Cloning	Constructing cDNA/genomic DNA library, library screening, isolation of a particular gene/cDNA, Cloning vectors, Plasmids: isolation, general properties and types
4	Basic Techniques	Isolation of nucleic acids, quantification, labeling, restriction digestion: restriction endonucleases-properties, restriction mapping, southern, northern and western blotting, in situ hybridization, DNA sequencing
5	Polymerase Chain Reaction	Theory, techniques and applications
6	Recombinant DNA and Genetic Engineering: Restriction and Ligation of DNA Molecules	Ligation with homopolymer, blunt-end and synthetic linker, insertion of a particular DNA molecule into a vector cDNA and the use of reverse transcriptase, detection of recombinant molecules, reporter genes: characteristics types and uses
7	CREATION of Genetically Engineered Fish	Methods of gene transfer: Individual and mass techniques, fate of injected DNA, expression of foreign genes: Transient, integrated, studies of expression, northern blotting, in situ hybridization and immunocytochemistry, integration of foreign gene into the genome:



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8 Chromosome Manipulation Techniques

Mechanisms and studies: Southern blot analysis, germ line transmission, applications: Growth enhancement, cold tolerance, disease resistance, transgenic markers, ethics and containment
Background and prospects, Polyploidy, gynogenesis, androgenesis, production of monosex and sterile fish population

Recommended Textbooks

1. Kingsman, S.M., and kingsman, A.J., 1989. Genetic Engineering. Blackwell Scientific Publications, Oxford, London. Edinburgh.
2. Tave, D., 1996. Genetics for Fish Hatchery managers (3rd Edition) Van Nostrand Reinhold. New York
3. Brown, T.A., 1995. Gene Cloning: An Introduction (3rd Edition). Chapman and Hall London.
4. Meyers, R.A. (Editor), 1995. Molecular Biology and Biotechnology. VCH Publishers, New York.

Supplementary Textbooks

5. Watson, J.D., Gilman, M., Witkowski, J. and Zoller, M., 1992. Recombinant DNA (2nd edition). Scientific American Books. Distributed by W.H. Freeman and Co. New York.
6. Ennion, S.G. and Goldspink, G (Editors), 1996. Gene Expression and Manipulation in Aquatic Organisms, Cambridge University Press.
7. Glick, B.R. and Pasternak, J.J., 1994. Molecular Biotechnology: Principle and Applications of Recombinant DNA. ASM Press.
8. Harris, N. and Wilkinson, D.G., 1990. In Situ hybridization: Application to Development Biology and Medicine. Cambridge University Press.
9. Hew, C.L. and Fletcher, G.L. (Editors), 1992. Transgenic Fish. World Scientific, Singapore-New Jersey-London-Hong Kong.
10. Horton, R.M. and Tait, R.C. (Editors), 1998. Genetic Engineering with PCR. Horizon scientific Press, Norfolk, England.
11. Newton, C.R. and Graham, A., 1997. PCR (2nd Edition). Bios Scientific Publishers, Oxford, England.
12. Old, R.W. and Primrose, S.B., 1989. Principles of Gene manipulation: An Introduction to Genetic Engineering (2nd Edition). Blackwell Scientific Publications.

Course Title: Biology of Shellfish and Non-piscine Aquatic Vertebrates

Credit hours: 2

Course Code: MSFBG 2204

Unit	Title
1	Major groups of non-piscine aquatic vertebrates in Bangladesh and in the world and their economic importance: (I) Biology of shrimps, lobsters, crabs, oysters, mussels with particular emphasis on life history, food and feeding, digestion, reproduction and its control mechanisms (II) Biology of whale, crocodile, turtles & tortoises, dolphin with particular emphasis on life history, food and feeding, digestion, reproduction and its control mechanisms
2	Environmental adaptation to food and feeding, respiration, reproduction, osmoregulation and mechanisms of pearl formation in shellfishes
3	Adaptation of non-piscine aquatic vertebrates to different environments: Adaptation to changes in temperature and adaptation to drought conditions, relationship between environment and gonad maturation, distribution and abundance

Recommended Textbooks


1. Bliss, D.E. and L.H. Mantel, 1985. Biology of Crustacea, Vol. 9. integument, pigments and hormonal processes, Academic Press Inc. Orlando, Florida 550p.
2. Kotpal, R.L., Mollusca. Rastogi Publications, Shinagi Rd. Meerut, India.
3. Parker, T.J. and Haswell, W.A., 1974. Text Book of Zoology-Invertebrates. The Macmillan press Limited, London.
4. Angell, C.L., 1986. The Biology and Culture of Tropical Oysters. ICLARM, Manila Philippines. 42p.

Supplementary Textbooks

5. Alderton, D., 1988. Turtles and Tortoises of the World. Facts on file publications 191pp.
6. Anderson, H.T., 1969. The Biology of Marine Mammals. Academic Press Inc. (London) Ltd. 510pp.
7. Mantel, L.H., 1983. The biology of Crustacea vol.5. Internal anatomy and physiological regulation, Academic Press inc. 111th avenue, New York. 471p.
8. Morton, J.E., 1967. Mollusca. Hutchinson University, London.
9. Provenano, A.J., 1985. The Biology of Crustacea, Vol. 10. Economic Aspects, Fisheries and Culture. Academic Press Inc. orlando, Florida 331p.
10. Purchon, R.D., 1968. Biology of the Mollusca. pergamon Press, Oxford.
11. Vemberg, F.J. and W.B. Vemberg, 1983. The Biology of Crustacea vol.8. Environmental Adapatation. Academic Press. 111th Avenue, New York. 383p.



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	Master of Science (MS) in Fisheries Biology and Genetics

- Wilber, K.M. and Yonge, C.M. (Editors), 1966. Physiology of Mollusca Vol.I and II. Academic Press.
- Matchell, E., 1975. Porpoises, Dolphins and small Whale Fisheries of the World: Status and Problems. International Union for Conservation of Nature and Natural resources. Morges, Switzerland.

Course Title: Embryology of Aquatic Animals

Credit hours: 2

Course Code: MSFBG 2205

Unit	Title	Lesson
1	Introduction	Gametogenesis, structure of the gametes
2	Fertilization in Fishes	Mechanism of sperm-egg interactions, hypotheses of egg activation, interaction and fusion of gametes, prevention of polyspermy, fusion of the genetic materials formation, hardening and break down of egg envelop
3	Embryonic Development	Cleavage, blastulation, gastrulation, fate of cells, organogenesis, hatching, yolk sac absorption mechanisms, embryonic and larval development from representative fish groups such as carps, catfish, tilapia, zebrafish etc
4	Control of Embryonic Development	Physico-chemical parameters, hormonal control gene activity in the early stages, control of development at the molecular level
5	Care of the Developing Embryos	Post larval development

Recommended Textbooks

- Balinsky, B.J., 1975. An Introduction to Embryology (4th edition). W.B. Saunders Company 648p.
- Nelson, O.E., 1953. Comparative Embryology of Vertebrates. McGraw-Hill Book Company, Inc. 982p.
- Belon, E.K. (Editor), 1985. Early life history of fishes. Dr. W. Junk Publisher. 280p.
- Nuccitelli, R., 1991. in Current Topics in Development Biology Vol. 25. Academic Press.

Supplementary Textbooks

- Gilbert, S.F., 1991. Development Biology (3rd edition). Sinauer associates, Inc. Publishers Sunderland, Massachusetts, 891p.
- Davison, E.h., 1968. Gene activity in early development. Academic Press. 375p.
- International Review of Cytology Vols. 121 & 136.

Course Title: Reproductive Biology and Behaviour of Fish

Credit hours: 2

Course Code: MSFBG 2206

Unit	Title
1	Introduction: Principles of response formation in fish, factors responsible for fish behaviour
2	Appetite (feeding) behaviour and consumatory act, aggregation as defense against predator, cannibalism in fishes
3	Reproductive Behaviour: Response of fishes to gonadal changes and maturation
4	Breeding behaviour of cultivable species, courtship, pairing and parental care
5	Behaviour of diseased fish, factors causing abnormal behaviour
6	Hormonal control of fish behaviour
7	Behaviour as a tool of fish catching

Recommended Textbooks

- Hoar, W.S., Randall D.J. and Brett, J.R. (Editors). Fish Physiology Vol. VIII (1979)
- Hoar, W.S. and D.J. Randall (eds) Fish Physiology Vols. I (1969), II (1969), V (1971), VI (1971) and VII (1978).
- Pitcher, T.J., 1993. Behaviour of Teleost Fishes (2nd Edition) Chapman and Hall.

Supplementary Textbooks

- Brown, M.E., 1957. The Physiology of Fishes Vols. I & II. Academic Press New York.
- Chavin, W., 1973. Responses of Fish to Environmental changes.
- Munro, A.D., A.P. Scott, and Lam, T.J. (Editors), 1990. Reproductive Seasonality in teleosts: environmental influences. CRC Press, Boca Raton, Florida. 1254p.