CURRICULUM

OF

FRESH WATER BIOLOGY AND FISHERIES

MS

(Revised 2016)

HIGHER EDUCATION COMMISSION
ISLAMABAD

CURRICULUM DIVISION, HEC

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PREFACE

The curriculum, with varying definitions, is a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives and learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Knowledge in all academic disciplines is expanding and even new disciplines are also emerging, it is imperative that curriculum are developed and revised regularly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII vide Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled **"Supervision of Curricula and Textbooks and Maintenance of Standard of Education".** With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

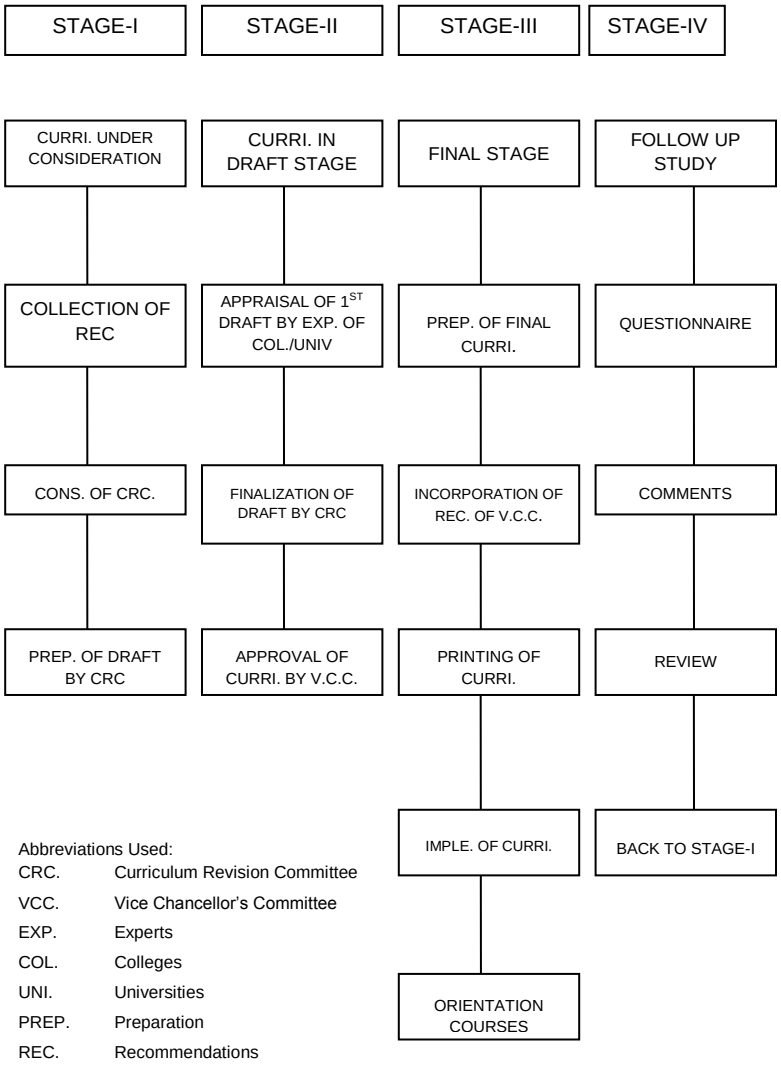
In compliance with the provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs) which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society nominated by their organizations.

In order to impart education at par with quality international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 and 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC (www.hec.gov.pk).

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



Abbreviations Used:

CRC.	Curriculum Revision Committee
VCC.	Vice Chancellor's Committee
EXP.	Experts
COL.	Colleges
UNI.	Universities
PREP.	Preparation
REC.	Recommendations

INTRODUCTION

Final meeting of National Curriculum Revision Committee to review and revise the curriculum for Freshwater Biology and Fisheries at B. Sc, BS (4years) and MS (2 years) degree levels was held at HEC Regional Center, Karachi from April 21-22 2016. The following attended the meeting:

01.	Prof. Dr. Naeem Tariq Narejo Professor Department of Freshwater Biology and Fisheries University of Sindh, Jamshoro	Convener
02.	Prof. Dr. Shahida Husnain Vice Chancellor Department of Molecular Biology & Genetics, The Women University Campus, Multan	Member
03.	Dr. Muhammad Arshad Professor/ Chairman Department of Zoology, University of South Asia 47 Tufail road, Lahore	Member
04.	Dr. Muhammad Afzal The Principal Scientific Officer Aquaculture & Fisheries Program National Agriculture Research Council Chak Shahzad, Islamabad	Member
05.	Dr. Punhal Khan Lashari Associate Professor Department of Freshwater Biology and Fisheries University of Sindh, Jamshoro	Member
06.	Dr. Muhammad Siddique Awan Chairman/Associate Professor Department of Zoology, University of Azad Jammu Kashmir Muzaffarabad	Member
07.	Dr. Shahid Raza Dean/Director Department of Biological Science, University of South Asia, 47 Tufail road, Lahore	Member
08.	Dr. Muhammad Shoaib Associate Professor, Department of Zoology, University of Karachi	Member
09.	Dr. Muhammad Naeem	Member

Professor, Institute of molecular Biology &
Biotechnology, BZU, Multan

10. Dr. Adeela Haroon — Member
Assistant Professor
Department of Botany, The Woman University
Multan, Karachi Campus, LMQ, Road Multan, Multan

11. Dr. Khalid Abbas — Member
Assistant Professor
Department of Zoology, Wild life & Fisheries,
University Agriculture, Faisalabad, Faisalabad

12. Dr. Kifayat ullah Khan — Member
Assistant Professor
Department of Environmental & Conversation
Science, Main Campus, University of Sawat,
Sawat KPK

13. Dr. Zaigham Hasan — Member
Assistant Professor, Department of Zoology,
Zoology, University of Peshawar, Peshawar

14. Dr. M. Nasir Khan Khatak — Member
Assistant Professor, Department of Zoology,
Hazara University, Mansehra

15. Dr. Amina Zubari — Secretary/ Member
Assistant Professor
Department of Animal Sicnec,
Quaid e azam University Islamabad

16. Dr. Muhammad Hafiz- Ur- Rehman — Member
Assistant Professor, Department of Fisheries
and Aquaculture, University of Veterinary &
Animal Sciences, Lahore

17. Dr. Rehan Iqbal — Member
Assistant Professor, Institute of molecular
Biology & Biotechnology, BZU, Multan

18. Dr. Ghulam Abbas — Member
Assistant Professor
Center of Excellence, in Marine Biology,
University of Karachi, Karachi

19. Ghayyur Fatima — Member
Director (Curriculum) HEC, Islamabad

MS /MPhil (2-YEARS) PROGRAM IN FRESHWATER BIOLOGY AND FISHERIES

The MS in Freshwater Biology and Fisheries will be of two years program with 24 credit hours theory and 6 credit hours thesis research work (Total: 24+6=30 C.H.) The courses will be selected from the following list according to specialty of academic staff and research facilities in the institutions

S.No	COURSE NAME	Credit Hours (CH)
1	FISHERIES REGULATIONS AND ADMINISTRATION	4
2	ADVANCES IN AQUACULTURE	4
3	NEW TRENDS AND TECHNIQUES IN AQUACULTURE	4
4	ADVANCED ECO-TOXICOLOGY	4
5	ADVANCED PLANKTOLOGY	4
6	LAKE MANAGEMENT	4
7	RESEARCH METHODOLOGY	4
8	FISH PROCESSING AND QUALITY ASSURANCE	4
9	FISH BREEDING AND CONSERVATION	4
10	FISH BIOTECHNOLOGY	4
11	FISH IMMUNOLOGY	4
12	EXPERIMENTAL BIOSTATISTICS	4
13	FISH MOLECULAR ECOLOGY	4
14	MOLECULAR EVOLUTION AND FISH PHYLOGENETICS	4
15	GLOBAL CLIMATE CHANGES AND IMPACT ON AQUATIC LIFE	4
16	MOLECULAR SYSTEMATICS OF FISH	4
17	FISH GENOMICS	4
18	FISH PROTEOMICS	4
19	FISHERIES AND AQUACULTURE ECONOMICS	4
20	APPLICATIONS OF GIS IN FISHERIES	4
21	FISHERIES EXTENSION	4
22	RECREATIONAL AND ORNAMENTAL FISHERIES	4
22	PROJECT MANAGEMENT	4
	Total:	**88**

DETAILS OF COURSES

FISHERIES REGULATIONS AND ADMINISTRATION (4) CH

Learning outcomes

After the completion of this course, the students would be able to:

- Understand the fisheries policies, laws and monitoring systems
- Manage the conservation of aquatic resources
- Familiarize with trade related aspects of intellectual property rights

Introduction to organizations and administration of fisheries at the federal and provincial levels; responsibilities; implications for livelihoods-centered fisheries management; Monitoring, Control, Surveillance; Enforcement and conflict management; Informal, local community rules; Formal, national regulations; The social consequences of implementing laws on mesh sizes of nets; management and conservation of resources; fisheries legislations and regulations; implementation and monitoring systems, accession of exclusive economic zone EEZ; concept and responsibilities; international and regional bodies conventions and legislations (CBD, Ramsar Convention UNCLOS, etc,. fish inspection and quality control systems, WTO regime (Sanitary and phytosanitary (SPS) measures, Trade-related aspects of intellectual property rights (TRIPS), Agreement on Technical Barriers to Trade (TBT).

Recommended books

1. Scott, J., 2007. The WTO Agreement on Sanitary and Phytosanitary Measures: A Commentary (Oxford Commentaries Gatt/WTO Agreements). Oxford University Press, UK.
2. Pomeroy, R.S. and Andrew N. L., 2003. Small-scale Fisheries Management. CABI, UK.
3. McCoy, H.D., 2000. American and International Aquaculture Law. Blackwell, USA.

ADVANCES IN AQUACULTURE (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Describe the aquaculture production system
- Analyze different aquaculture types and practices
- Describe the latest developments in aquaculture in Pakistan with world

An overview of aquaculture production systems: Present status, constraints and future perspectives of aquaculture production systems in Pakistan and the world. Advances in design and construction: Hatcheries;

Earthen ponds; Concrete tanks; Pens and cages; Rafts; Racks. Aquatic plant production systems: Ornamental aquatic plants; microalgae and seaweeds; Long line production system. Aquaculture production management: monitoring of water quality; feeding and monitoring, sampling and harvesting of finfish and shellfish. Advances in farming systems: enhancing carrying capacity; integrated farming systems; semi-intensive and intensive culture systems; Recirculatory aquaculture system; Flow-through system.

Recommended books

1. Malik, A.**,** 2014**.** Fisheries and Aquaculture Technology. Random Publications.
2. James, M.W., 2012. Aquaculture Management. Springer, USA.
3. Stickney, R.R., 2009. Aquaculture: An Introductory Text. 2nd ed. CABI, UK.
4. Pillay, T.V.R. and Kutty, M.N., 2005. Aquaculture: Principle and Practices. 2nd ed. Blackwell, USA.
5. Chakraborty, C. and Sadhu, A.K., 2003. Biology, Hatchery, Culture Technology of Tiger Prawn and Giant Freshwater Prawn. Daya Publishing, India.
6. Thomas, R. and Mahaputra, L., 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publishing, India

NEW TRENDS AND TECHNIQUES IN AQUACULTURE (4) CH

L**earning outcomes**

After completion of this course, the students would be able to:

- well equipped with the latest trends and development in Fisheries and Aquaculture industries

Latest reviews and books published in last five years will be followed to teach recent advancements in different areas of fisheries and aquaculture. Presentations and group discussions of latest, high impact research articles.

ADVANCED ECO-TOXICOLOGY (4) CH

Learning outcome

After completion of this course, the students would be able to:

- understand the key processes involve in fate, behavior and the bioaccumulation of contaminants
- know the uptake and transport of environmental pollutants in ecosystems and on how pollutants can affect organisms, populations, and thus ecosystem processes.
- link the structures and characteristics of compounds with effects

- get insight in integrative approaches of ecotoxicology

Fate of contaminants, dynamic interactions with the (a)biotic environment, toxikokinetics; physico-chemical properties, partitioning processes in environmental compartments, partitioning to biota, bioavailability and bioaccumulation concepts, partitioning in biota; Toxicodynamics (effect of contaminants on biota), internal concentrations; dose-response concept, molecular mechanisms of toxic actions – classification, Exercise: databases and estimation of toxicity; Toxic effects: from molecular to ecosystems, complex mechanisms and feedback loops, mixtures and multiple stressors, stress- and adaptive responses, dynamic exposures, confounding factors, food web interactions, Exercise: linking compounds with modes of toxic action; metal ecotoxicology: integrative approaches and case studies, bioassays, systems ecotoxicology, phenotypic anchoring, in vivo versus in vitro biotesting, linking chemical with biological analytics, bioassay-directed fractionation and identification, (inter) national case studies and linkage of learned with approaches in practice

Recommended books

1. Walker, C.H., Sibly, R.M., Hopkin, S.P. and Peakall, D.B., 2012. Principles of Ecotoxicology. 4th ed. CRC Press, USA.
2. Schwarzenbach, R.P., Gschwend, P.M. and Imboden, D.M., 2005. Environmental Organic Chemistry, 3rd ed. Blackwell, USA.
3. Adel, D., 2007. Water Pollution Biology. CRC Press, USA.
4. Mason, C.F., 2002. Biology of Freshwater Pollution. Prentice Hall, USA.

ADVANCED PLANKTOLOGY (4) CH

Learning Outcome

After completion of this course, the students would be able to:

- Comprehend ecological and evolutionary processes
- Understand the spatial and temporal distribution of species and organisms
- Acquire knowledge related to the diversity of the aquatic ecosystem
- Conceptualize the ways and means of conversion of energy and matter in ecosystems, mediated by organisms

Introduction to planktology, taxonomic classification of planktons in freshwater systems, biology, distribution, Plankton diversity and their contribution to freshwater productivity, Primary and secondary production - estimation, significance, factors affecting production-biomass ratio (P/B); Indices of productivity; phytoplankton and zooplankton, Biological interrelationship in running water among phytoplankton, macrophytes,

bacteria, zooplankton, benthic animals, periphyton, fish and birds. Distribution of planktons and their periodicities. Importance in aquatic food chain. Economic importance of diatoms.

Recommended books

1. Sardet, C., 2015. Plankton: Wonders of the Drifting World. University of Chicago Press, USA.
2. Kehayias, G., 2014. Zooplankton: Species Diversity, Distribution and Seasonal Dynamics. eBook. NOVA Science Publishers, USA.
3. Bellinger, E. G. and Sigee, D. C., 2015. Freshwater Algae: Identification and Use as Bioindicators.2nd ed. Blackwell, USA.
4. Lambert, M.S., Mirium T.T. and Marseken, S.F., 2010. Phytoplankton. VDM Verlog, USA.
5. Soothers, M. and Rissik, D., 2009. Phytoplankton: A Guide of their Ecology and Monitoring for Water Quality. CSIRO, Australia.
6. Norman, C.F., 2006. A Manual of Aquatic Plants. 2nd ed. University of Wisconsin Press, USA.
7. Bronmark, C. and Hansson, L.A., 2005. The Biology of Lakes and Ponds. Oxford University Press, UK.

LAKE MANAGEMENT (4) CH

Learning outcomes:

After completion of this course, the students would be able to:

- Familiarize with professional approaches of landscape architecture, urban and regional planning
- Contribute in protecting, improving, restoring, and sustaining water resources for humanity and the rest of the biosphere

Lakes origins and evolution, Types, lake basins, biota, biotic and abiotic factors, seasonal cycles, zones, ecosystem processes, land-water subsidies, watershed issues: water levels and erosion, pollution, characterization on the basis of productivity, aquatic weed and management, watershed protection case study, ecosystem services, temporary waters, habitat, conservation and design issues. Science of lake management: economic and the social/regulatory framework, plan organization and development, implementation and evaluation. Lake monitoring: problems and solutions for monitoring inland freshwater lakes. Managing and analyzing physical, chemical and biological parameters.

Recommended books

1. Jorgenson, S. E., Loffler, H., Rast, W. and Straskraba, M., 2005. Lake and Reservoir Management. Elsevier, USA.
2. Steve, M. C., 2003. Lake and Pond Management: Guide Book. Taylor and Francis, UK.

3. Stephen, T. T., 2000. Water Quality Processes and Policy. Wiley and Sons, USA.
4. Lorna, F., 2000. Water Quality Guidelines: Standard and Health. World Health Organization, Geneva.

RESEARCH METHODOLOGY (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Understand the basic framework of scientific research process
- Overview various research designs and techniques
- Identify various sources of information for literature review and data collection
- Comprehend the ethical dimensions of conducting applied research

Philosophy of scientific research. Problem identification and defining research questions, formulation of the research hypotheses, Research design – experimental and non-experimental, field research and survey research. Qualitative and quantitative research, choosing research methods: Interviewing (methods of recording, the interview schedule, establishing rapport, asking questions and probing for information), focus groups, questionnaires (constructing questionnaires - deciding which questionnaire to use, wording and structure of questions, length and ordering of questions, piloting the questionnaire) and participant observation, concept of research background, Primary and secondary research. Sampling strategies, Preparation of research proposal: contents of a good proposal, reasons of research proposals failure, Data analysis: qualitative and quantitative data analysis, Presentation of research findings: Technical report writing, journal articles and oral presentations. Ethics in scientific research; overt and covert research, code of ethics

Recommended books

1. Alan, B. and Emma, B., 2011. Business Research Methods. 3rd ed. Oxford University Press, UK.
2. Deepak, C. and Neena, S., 2011. Research Methodology: Concepts and Cases. Vikas Publishing, India.
3. Pawar, B.S., 2009. Theory Building for Hypothesis Specification in Organizational Studies. Response Books, India.
4. Dawson, C., 2002. Practicals Research Methods. How-To-Books, UK.
5. Laake, P., Benestad, H.B. and Olsen, B.R., 2004. Research Methodology in the Medical and Biological Sciences. Academic Press, USA.

Fish Processing and Quality Assurance **4 (3+1) CH**

Learning outcomes

After completion of this course, the students would be able to:

- Familiarize with the advancements in the fields of Fish Processing and Quality Assurance
- Gain the knowledge about freshwater fish processing technology
- Demonstrate various preservation techniques of fish and fisheries products
- Know the importance of an efficient post-harvest and fish marketing chain promotes in accordance with consumer needs.

Biological preservation, fermentation, biochemical dynamics and quality of fresh and frozen fish, Biochemical composition, methods of assessing and selecting for quality, microbiology of products, identifying allergens in fish, rapid detection of sea food toxins, preservation of fish, traditional preservation (curing, drying, salting, smoking etc.), New preservation techniques for finfish and shellfish (chilling, freezing, canning etc.), Special processing procedures, value addition (minced fish, surimi products, gelatin); industrial processing; fish meals, oils, protein concentrate and by-products; concepts of quality and freshness. International standards; food laws; food safety; organization for quality assurance and standards, HACCP, Codex alimentarix, ISO 9002, ISO 14000

Practicals

- Detection of microorganisms
- Biochemical analyses of value added fish products
- Tests for freshness and food safety
- Peroxide value determination,
- pH value determination in meat,
- Near Infra Red (NIR) Analysis.

Recommended books

1. FDA., 2003. Fish and Fisheries Products: Hazards and Control Guidance. US Food and Drug Administration.
2. Bremner, H.A., 2002. Safety and Quality Issues in Fish Processing. Woodhead Publishing, UK.
3. Connell, J.J., 2001. Control of Fish Quality. Blackwell, USA.

FISH BREEDING AND CONSERVATION (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Understand the hatchery infrastructure, components and allied nursery and rearing ponds.
- Enhance skills in induced breeding of fish
- Know about the endangered and threatened species and conservation strategies
- Understand the fish biodiversity and stock replenishment program

Introduction to fish hatchery and its components (broodstock pond, nursery ponds and rearing ponds, glass hatching jars, circular tanks, holding tanks, nursing tanks), Broodstock selection and management, Assessment of male and female ripeness, artificial propagation; Natural and induced spawning, cryopreservation of gametes, gametes quality analysis, Egg fertilization, enumeration, development, and incubation, Rearing techniques (larval, fry and fingerlings). Conservation strategies for threatened and endangered species; sustainable use of fisheries resources; stock replenishment program, management of natural resources (lakes, reservoirs, dams and rivers); habitat management practices and biological conservation policy; national, regional and international conventions; rules and regulations for conservation of natural resources (awareness program and community participation).

Practicals

- Study of gonadal development in carps and other culturable fish species.
- Broodstock selection and identification.
- Induced breeding (striping and fertilization) of fishes through various inducing agents.
- Evaluation of carp milt and egg; estimation of fecundity, fertilization and hatching success.
- Packing and transportation of fish seed.
- Visit to different coldwater and warmwater fish hatcheries.
- Field survey of different natural aquatic habitats.

Recommended books

1. Stickney, R.R., 2009. Aquaculture: An Introductory Text. 2nd ed. CABI ,UK
2. Pillay, T.V.R. and Kutty, M.N., 2005. Aquaculture: Principle and Practices. Blackwell, USA
3. Huet, M. and Timmerman, J.A., 1994. Text Book of Fish Culture: Breeding and Cultivation. Fishing News Books, U.K
4. Thomas, P.C, Rath, S.C. and Mohapatra, K.D., 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publishing, India.

FISH BIOTECHNOLOGY (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Understand the basics of biotechnology in relation to fisheries
- Develop a skill into the application of biotechnological advances
- Elucidate different aspects of genetic biotechnology and fish genomics

Introduction, biotechnological approaches in fish, chromosome engineering, meiotic diploid gynogenesis, mitotic diploid gynogenesis, androgenasis, induced triploids, induced tetraploids. Gene manipulation: Introduction, genetic markers, choosing the gene, inserting the gene, assessing the success of the gene transfer, expression of the transferred gene, future development in molecular genetics. Problems in fisheries and aquaculture (seed, feed, breeding). Need for genetic improvement (temperature, salinity, pH tolerance/resistance). Genetic improvement for better growth and reproduction. Actual and potential effects of introduction of GM fishes on environmental balance, ecosystem stability and fauna. Zebra fish (*Danio rerio*) a tool for genetic engineering, examples of GM fish (food and ornamental fish) and their economic importance. Breeding and importance of GIFT. Future prospects in Fish biotechnology. Biotechnology in Fish nutrition and fish disease diagnosis

Recommended books

1. Dunham, R., 2011. Aquaculture and Fisheries Biotechnology. 2nd ed. CABI, UK.
2. Beaumont, A., Boudry, P. and Hoare, K., 2010. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell, USA.
3. Liu, Z. J., 2007. Aquaculture Genome Technologies. Blackwell, USA.
4. Montet, D. and Ray, R. C., 2009. Aquaculture Microbiology and Biotechnology. Science Publishers, USA.
5. Overturf, K., 2009. Molecular Research in Aquaculture. Blackwell, USA.
6. Pandian, T.J., Strüssmann, C.A. and Marian, M.P., 2005. Fish Genetics and Aquaculture Biotechnology. CRC Press, USA.

FISH IMMUNOLOGY (4) CH

Learning outcomes

After completing this course, students would be able to:

- Understand basic knowledge about the structure of the immune system and how it functions

- Know how the immune response is being regulated
- Understand the immunological memory of fishes.
- Know the importance of several factors that affect the immune response.

General concepts in immunology, Fish Leucocytes, monocytes/ macrophages, granulocytes, non-specific cytotoxic cells, Nonspecific immunity, physical barriers, non-specific humoral defence, , Lymphocytes, Specific defence mechanism in Fish, Humoral antibody system (B-cells), Helper T-cells, B-cell activation, cell mediated immunity (T-cells), lymphoid organs in fish, primary lymphoid organs, secondary lymphoid organs. Antibody function, Monoclonal antibody, polyclonal antibody, Immune response: primary and secondary immune response, Immunological memory, recognition and response. Evolution of immune system, Ontogeny of Fish Immune System (evidence of Ig in the eggs and passive transfer of immunity from mother to young, Ontogeny of T and B Cells in lymphoid organs, Ontogeny of specific, non-specific, innate and adaptive immunity). invasions of recombination-activation gene transposon (RAG transposon), Whole genome duplication (WGD,s) immunoglobins, Lymphocytes B-cells and T-cells, the life history of T-lymphocytes, Antibody, basic structure and isotypes,

Recommended Books

1. Secombes, C.J. and Ellis, A.E., 2012. The Immunology of Teleosts: in Fish Pathology. 4th ed. Blackwell, UK.
2. daDouglas P. A., 2003. Textbook of Fish Immunology: Diseases of Fishes. Narendra Publishing, India.

EXPERIMENTAL BIOSTATISTICS (4) CH

Learning outcomes

After studying this course the students would be able to

- Identify completely randomized designs, factorial designs, and complete block designs
- Perform correct analysis of experimental data using SAS
- Plan and estimate treatment comparisons using appropriate multiple comparison techniques
- Assess model fit and validity of assumptions
- Suggest remedial measures or alternative analyses when assumptions are not met
- Distinguish fixed and random effects

Introduction to Biostatistics , Sampling – Random and non-random sampling methods – Description, merits and demerits , Data summarization – measures of averages and dispersion , Data

Presentation techniques – Graphical and tabular , Standard error, Confidence interval and sampling distribution – definition, computation, interpretation and applications , Basic principles of testing of hypothesis , Test of significance - t-test, one way ANOVA, Repeated measures ANOVA, Chi square and Non parametric methods , Sample size in health science research – Basic principles and computations. Correlation and Regression, Software packages-SPSS, Research Design Principles, Completely Randomized Designs, Treatment Comparisons–Contrasts and Multiple Comparisons, Checking Assumptions: Diagnostics and Remedial Measures , Power and Sample Size , Factorial Designs, Random Effects Models , Mixed Models , Nested Effects , Complete Block Designs , Analysis of Covariance, Split-Plot Designs , Repeated Measures Designs

Recommended Books

1. Milliken, G.A. and Johnson, D.E., 2009. Analysis of Messy Data Volume 1: Designed Experiments, 2nd ed. Chapman and Hall/CRC, UK.
2. Clewer, A.G. and Scarisbrick, D.H., 2001. Practical Statistics and Experimental Design for Plant and Crop Science. John Wiley and Sons, USA.
3. Oehlert, G.W., 2000. A First Course in Design and Analysis of Experiments. W. H. Freeman and Company, USA.
4. Morris, T.R. 1999. Experimental Design and Analysis in Animal Sciences. CABI Publishing, USA.

FISH MOLECULAR ECOLOGY (4) CH

Learning outcomes

After studying this course, students would be able to:

- Differentiate the common contemporary molecular markers and analyses used to address ecological questions
- Describe the wide range of research directions that comprise the field of molecular ecology and the common molecular approaches to these research questions
- Analyze and interpret data from common analyses employed in ecological and conservation studies

Emergence of molecular ecology as a discipline, Use of molecular data for ecological studies molecular markers: nuclear and mitochondrial markers, Hardy-Weinberg equilibrium and microevolutioary processes. Quantifying genetic diversity in natural population, Factors affecting genetic diversity, Quantifying population subdivision: genetic distance and F-statistics. Gene flow: measurement methods and its discrepancies. Molecular

analyses of interspecific interactions: parasites-hosts, predator-prey relations. Genetic differentiation of populations, Clinal variations of allelic frequencies, Phylogeography and molecular clocks. Phylogeography and alien species, Molecular analysis of behavior, kinship, mating systems and parentage analysis. Conservations genetics. Molecular identification of species, individuals, and sex. Hybridization and genetic introgression detection. DNA barcoding. Inbreeding depression and outbreeding depression. Translocations and genetic diversity banks as conservation strategies. Applications of molecular ecology: Fisheries forensics, illegal trade, stock enhancement and law enforcement. Integration of morphological, ecological and molecular data in resolving taxonomic uncertainties. Population fragmentation. Genetic management of threatened species. Contributions of molecular genetics to conservation.

Recommended Books

1. Freeland, J. R., 2011. Molecular Ecology. 2nd ed. Wiley and Sons, UK.
2. Beebee, T. and Rowe. G., 2011. An Introduction to Molecular Ecology. Oxford University Press, UK.
3. Avise, J.C., 2010. Molecular Ecology and Evolution: The Organismal Side. World Scientific Publishing, USA.
4. Mayhew, P.J., 2006. Discovering Evolutionary Ecology - Bringing together Ecology and Evolution. Oxford University Press, UK.
5. Straalen, N.M. and Roelofs, D., 2006. An Introduction to Ecological Genomics. Oxford University Press, UK.
6. Avise, J.C., 2004. Molecular Markers: Natural History and Evolution. Chapman and Hall, USA.
7. Fox, C. W., Roff, D. A. and Airbairn, D. J., 2001. Evolutionary Ecology: Concepts and Case Studies. Oxford University Press, USA.
8. Frankham, R., Ballou, J.D. and Briscoe, D. A., 2004. A Primer of Conservation Genetics. Cambridge University Press, UK.

MOLECULAR EVOLUTION AND FISH PHYLOGENETICS (4) CH

Learning outcome

After completion of this course, the students would be able to:

- Know the different molecular processes that leads to changes in the genome and the evolutionary consequences
- Gain experience with internet resources on bioinformatics
- Attain experience with statistical analysis of molecular data and interpretations
- Use data to evaluate and defend phylogenetic hypotheses

Evolutionary histories of genes and organism, Evolution of hereditary molecules, Mutational processes, mutation rates and evolution of DNA sequences, polymorphism and SNPs, molecular clock, selection and genetic drift at the molecular level, Basic methods of phylogenetic analysis and their application in fields. Phylogenetic trees and other models, optimality criteria for selecting phylogenetic hypothesis. Substitution models for DNA and other data types, Super trees, consensus trees, tree compatibility. Algorithms for evaluating the tree space; Markov Chain Monte Carlo, genetic algorithms. Evaluation of results from phylogenetic analyses and phylogenetic dating.

Recommended books

1. Lemey, P., Salemi, M. and Vandamme, A.M., 2009. The Phylogenetic Handbook. Cambridge University Press, UK.
2. Yang, Z., 2006. Computational Molecular Evolution. Oxford Series in Ecology and Evolution. Oxford University Press, UK.
3. Salemi, M. and Vandamme, A.M., 2003. The Phylogenetic Handbook: A Practicals Approach to DNA and Protein Phylogeny. Cambridge University Press, UK
4. Nei, M. and Kumar, S., 2000. Molecular Evolution and Phylogenetics. Oxford University Press, UK.

GLOBAL CLIMATE CHANGES AND IMPACT ON AQUATIC LIFE
(4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Develop an interdisciplinary understanding of social and economic areas
- Develop an awareness of present and future impacts on aquatic life especially on fish
- Equip the stakeholders with fundamental factual elements surrounding climate change in order to facilitate effective participation in the response to realize and predicted climate change

Introduction to Global Warming and Climate Change (history, present status and future predictions) ; Atmospheric carbon dioxide and climate with special reference to aquatic life; Carbon dioxide budget in aquatic atmosphere; Ocean, freshwater and Land; Diversity of aquatic animals; Catastrophic consequences of climatic changes on the Fish; aquatic production and its impact; aquatic habitat destruction and fragmentation; Ocean acidification, stratification and increasing oceanic dead zones; Climate Change Indicators (air temperature, precipitation); possibility of abrupt climate change and its effects on aquatic life; Attribution of rising

temperature and extinction of fish species; Impact of climate change on economic growth with special reference to Pakistan.

Recommended Books

- Issar, I.S. and Zohar, M., 2007. Climate Change. 2nd ed. Springer, USA.
- Keith, A., 2005. Global Change and the Earth System. Springer, USA.
- IPCC Approach, 2005. Climate Impact and Adaptation Assessment: A Guide: Earth Scans, UK.
- Houghton, J.T., 2004. Global Warming: The Complete Briefing. 3rd ed. Cambridge University Press, UK.
- Hardy, J. T., 2003. Climate Change, Causes, Effects and Solutions. 1sted. Wiley and Sons, USA.

MOLECULAR SYSTEMATICS OF FISH **4 (3+1) CH**

Learning outcomes

After completion of this course, the students would be able to:

- Describe the methods and principle of modern molecular systematics including: parsimony, distance, maximum likelihood, Bayesian analyses
- Relate systematics analysis to the evolution of the taxa under investigation
- Use the major software packages associated with performing molecular systematic

Introduction and tree thinking, Molecular data and evolution, Taxonomic units, Sequence alignment, Tree Inference /Models of DNA evolution, Clustering methods, Maximum likelihood, Bayesian analysis. Parsimony, Tree confidence and support, Whole genome base phylogenetics, Introduction to the CLI, Data formats and trouble shooting, Obtaining data and sequence alignment, Substitution models, Distance methods, Hypothesis testing and ancestral state reconstruction.

Practicals

Making buffers, DNA extraction from fresh fish tissues and from museum and ancient sources, Gel eletcropheresis, The Polymerase Chain Reaction, Primer design, nuclear gene amplification, Amplify nuclear genes on gradient and/or touchdown, Different Methods of Cleaning PCR products and sequencing reactions, Searching gene databases and depositing sequences in Genbank, Look at sequences using Sequencer, making contigs, blasting sequences in Genbank, Cloning DNA, RNA: extraction and what it can be used for, Making Gene Libraries, Making

cDNA library; RT-PCR Reverse Transcriptase (RT)-PCR/Real Time PCR, Gene-specific PCR, Aligning DNA/RNA /protein sequences

Recommended Books

1. Lemey, P., Salemi, M. and Vandamme, A.M., 2009. The Phylogenetic Handbook. Cambridge University Press, UK.
2. Yang, Z., 2006. Computational Molecular Evolution. Oxford Series in Ecology and Evolution. Oxford University Press, UK.
3. Hey, J., Walter, M.F. and Francisco, J.A., 2005. Systematics and the Origin of Species. The National Academies Press, USA.
4. Salemi, M. and Vandamme, A.M., 2003. The Phylogenetic Handbook: A Practicals Approach to DNA and Protein Phylogeny. Cambridge University Press, UK
5. Nei, M. and Kumar, S., 2000. Molecular Evolution and Phylogenetics. Oxford University Press, UK.
6. csKocher, T. D. and Stepien, C.A., 1997. Molecular Systematics of Fishes. Academic Press, USA.

FISH GENOMICS (4) CH

Learning outcomes

After studying this course, students would be able to:

- Describe fundamental concepts in genomics
- Elucidate some of the current genomics technologies and illustrate how these can be used to study gene function.
- Perform a range of practical techniques including DNA sequencing, PCR, genotyping and genotypic molecular data analysis.
- Analyze information and data relating to specific genes using a number of general and fish-specific databases, bioinformatics principles and tools.

Introduction, Genomes and genome sizes. Mutations as the source of genetic variations. Restriction enzymes and their applications, Base pairing: the basis of molecular biology techniques; Hybridization techniques; PCR. DNA fingerprinting techniques – RFLP, SSR, AFLP, SNPs, SSCP (Type II markers). Molecular diagnosis. Comparative gene mapping; Type I molecular markers; Expressed sequence tags (ESTs). Functional genomics, Transcriptome analysis, proteome analysis, microarrays, gene chips, and various methodologies used for the analysis of genome expression. Genetic engineering: gene transfer; regulation and inheritance of transgenes. QTL mapping and marker-assisted selection. Application of genome technologies in aquaculture and fisheries.

Recommended Books

1. Campbell, A. M. and Laurie, J. H., 2003. Discovering Genomics, Proteomics and Bioinformatics. 2nd ed. Benjamin Cummings, USA.
2. Liu, Z. J., 2007. Aquaculture Genome Technologies. Blackwell, USA.
3. Liu, Z. J., 2011. Next Generation Sequencing and Whole Genome Selection in Aquaculture. Blackwell, USA.
4. Mount, D.W., 2001. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Press, USA.
5. Overturf, K., 2009. Molecular Research in Aquaculture. Blackwell, USA.
6. Saroglia, M. and Liu, Z. J., 2012. Functional Genomics in Aquaculture. Blackwell, USA.

FISH PROTEOMICS (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Perceive the theoretical and practical knowledge in proteomics
- Know about common workflows for the large-scale analysis of proteins
- Analyze post-translational modifications and protein-protein interactions
- Identify proteins by mass spectrometry and quantification of proteomes through various techniques

Introduction, Amino acids structure, peptide bond, interactions of amino acids, secondary structure, Representations of protein structure, domains, modularity, motifs, Topology diagrams, classification of proteins. Quaternary structure. protein flexibility, metastable folds. Protein Data Bank. Ligand-binding I and II. Homology modeling I, II and III. Protein folding and unfolding *in vitro.* Protein folding *in vivo*: Molecular chaperones; Protein folding catalysts. Protein regulation: phosphorylation, glycosylation and lipid modifications. Functional proteomics. Techniques for studying structure and function of protein: Electron microscopy, Mass spectrometry, NMR, X-ray crystallography, SDS-PAGE, 2D- PAGE). Bioinformatic tools in proteomics, Application of proteomics in fisheries and aquaculture.

Recommended Books

1. Kraj, A. and Silberring, J., 2008. Proteomics – Introduction to Methods and Applications. Interscience, USA.
2. Campbell, A. M. and Laurie, J. H., 2003. Discovering Genomics, Proteomics and Bioinformatics 2nd ed. Benjamin Cummings, USA.

3. Link, A. J. and Joshua, L., 2009. Proteomics: A Cold Spring Harbor Laboratory Course Manual. 1st ed. Cold Spring Harbor Laboratory Press, USA.
4. Lovric, J., 2011. Introducing Proteomics: From Concepts to Sample Separation, Mass Spectrometry and Data Analysis. 1st ed. Blackwell, USA.
5. Mishra, N.C. and Günter, B., 2010. Introduction to Proteomics: Principles and Applications 1st ed. Willy and Sons, USA.
Twyman, R. M., 2014. Principles of Proteomics 2nd ed. Garland Science, USA.

FISHERIES AND AQUACULTURE ECONOMICS (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Analyze the essential elements of Aquaculture and Fisheries economics
- Apply quality benefit and capital theories to quality relationships
- Evaluate projects on Aquaculture and Fisheries
- Evaluate results from aquaculture and fisheries economic analyses for policy decision making
- Synthesize potential risks involved in resource extraction

Review of the Production Function

Production Function:- Overview, Physical and financial Quantities, Stages, Biological efficiency and economic efficiency, Elasticity of Response. Decision making rules, Law of diminishing Returns

Linear Programming

Definition of Linear Programming. Use of LP. Basic Assumptions of LP. Expression of LP (Structure). Existence of optimal solutions

Theory of Demand and Supply

Introduction to Theory of Demand. Approaches to analyzing the theory of Demand. Assumptions of the approaches. Cardinal Approach. Criticisms of cardinal approach. Ordinal Approach. Characteristics of the Indifference Curve. Assumptions to indifferent analysis. Consumer Equilibrium. Criticism of Ordinal Approach

Market Structure, Conduct and Performance

Introduction. Elements of Market Structure. Seller concentration, Product differentiation, Barriers to entry, Barriers to exit, Buyer concentration, Growth rate of market demand. Types of Market system

Perfect/ Pure Competitive Market system

Assumptions for Pure Competitive Market system

Supply Decisions under perfect competition

Imperfect Competition
Monopoly. Characteristics of a monopolist market. Sources of monopoly power. Criticisms of monopoly. Interventions in a Monopoly market. Oligopoly Market. Market Conduct. Market Performance

Time Value of Money
Introduction to Time Value of Money. Future Value of Money. Future Value of a present sum. Applicability. Future Value of a Stream of Investments. Equal payment-future value interest factors. Relationship between $FIF_{r,n}$ and $EFIF_{r,n}$

Present value
Discounting. Present value of a future sum. Present value of a stream of Income. Equal Periodic Income Flows. Relationship between FIF and PIF

Cost Benefit Theory
Introduction to Cost benefit theory. Steps in calculating Benefit-cost ratio. Net Present Value. Decision making rule

Efficient Market Hypothesis - EMH
Definition of EMH. The Effect of Efficiency: Non-Predictability. Anomalies: The Challenge to Efficiency. The EMH Response. How Does a Market Become Efficient? Degrees of Efficiency. *Random Walk Theory*. Conclusion

Welfare Economics
Introduction to Welfare economics. Approaches to studying welfare economics. Efficiency. Income distribution

Recommended Books

1. Franses, P.H., and Paap, R., 2007. Quantitative Models in Marketing Research. 5th ed. Cambridge University Press. UK.
2. Asche, F., Bjorndal, T. and Gordon, D., 2007. Studies in the demand structure for fish and seafood products. Handbook of Operations Research in Natural Resources. Springer, USA
3. Coelli, T.J., Rao, R.S.P., O'Donnell, C.J. and Battese, G.E., 2005. An Introduction to Efficiency and Productivity Analysis. 2nd ed. Springer, USA
4. Grafton, R.Q., Adamowicz, W., Dupont, D., Nelson, H., Hill, R.J. and Renzetti, S., 2004. The Economics of the Environment and Natural Resources. Blackwell, USA.

5. Dasgupta, P., 2001. Human Well-being and the Natural Environment. Oxford University Press, UK.

APPLICATION OF GIS IN FISHERIES 4 (3+1) CH

Learning outcomes

After completion of this course, the students would be able to:

- Create, devise, restructure and relate various GIS components
- Resolve issues involved in choosing a suitable GIS analysis procedure
- Integrate data, vector and raster models, and convert from one to another
- Delineate temporal and spatial distribution of human resources, economic status, natural resources and hazards in a given geographic region

GIS: fundamental concepts, components, data formats, Subsystems, data models, Spatial and attribute data, Vector, Raster and image, Advantages and disadvantages of vector and raster models, Attribute data models, tabular and relational models (RDBMS), Data sources.
Introduction to remote sensing (orbits, satellites, sensors and platforms) , remote sensing as an input to GIS, Use of GPS, Manual digitizing and automatic scanning, Data editing and quality assurance, Map features point, line, polygon, area, Map characteristics, map projection and co-ordinate system, Creation of thematic layers,

Practicals

Practicing of GIS software (ArcGIS, ERDAS, MATLAB)

Recommended Books

1. Paul, B., 2012. GIS Fundamentals (A first Text on Geographic Information Systems), 4th ed. Eider Press, USA.
2. Chang, K.T., 2012. Introduction to Geographic Information Systems. 6thed. McGraw Hill, USA.
3. Abbasi, T. and Abbasi, S.A., 2010. Remote sensing, GIS and Wetland Management. Discovery publishing, India
4. Gorr, W.L. and Kurland, K.S., 2005. GIS Tutorial Workbook for ArcView 9. ESRI Press, USA.

FISHERIES EXTENSION (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Understand the role of fisheries extension in fisheries development and economy
- Describe different methods of fisheries extension
- Grasp the socio economic problems of fish farmers and suggest possible solutions

Introduction to fisheries extension -concepts, objectives and principles; Fisheries extension methods-; Transfer of technology process: models (training sessions, fish festival, role of slogans, handouts, banners, booklets, audio-visual aids etc.). Role of NGOs and CBOs (community based organization) in fisheries. Nature of fisheries extension; Future of fisheries extension and traditional management; Communication and flow of information, Technical and socio-economic problem of fishermen, Role of women in fisheries. Need of technical knowledge to fishermen, community participation.

Recommended Books

1. Saxena, A., 2011. Fisheries Extension. Astral International, India.
2. Dehk., 2010. New trends initiatives in aquaculture extension. Narendra Publishing, India.
3. Ananth, P.N., 2010. Marine Fisheries extension. Discovery publishing, India.

RECREATIONAL AND ORNAMENTAL FISHES (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Realize commercial and aesthetic values of ornamental fish
- Prepare balance feeding and breeding plan
- Design and fabricate the aquaria

Introduction, History of ornamental fish as a pet, commercial importance, benefits, feed and feeding of ornamental fish, culture of live food organisms, preparation of artificial feed, Feed additives, breeding of live bearers, breeding of egg layer, setting up of spawning tank. Common diseases and their control, Genetic improvement, Fabrication of aquaria and its arrangements including aeration filtration, Water quality management and aquarium plants.

Recommended Books

1. Dholakia, A.D., 2010. Ornamental Fish Culture and Aquarium Managements. Daya Publishing, India.
2. Roberts, H.E., 2009. Fundamentals of Ornamental Fish Health. 1st ed. Blackwell, USA

PROJECT MANAGEMENT (4) CH

Learning outcomes

After completion of this course, the students would be able to:

- Plan, execute, control, and close out projects
- Understand the roles and responsibilities of any successful project manager.
- Assess and improve current project management system which can be applied for project management principles

Introduction (Project definition and characteristics with examples, project life cycle),project constraints and risks, project management processes, benefits of structured project ,Work Breakdown Structures (WBS), controlling and managing project schedules, converting effort estimates into activity duration, MS Project, Program Evaluation and Review Technique (PERT) and Critical Path Method (CMP) and Gantt charts , developing project estimates and budgets, managing/controlling project budgets, project procurement management, project risk management , identifying risks qualitative and quantitative risk analysis, monitoring and controlling risks ,project human resource management ,leadership and exercising leadership as a project manager, motivating people, development of project teams and time management , project communications, project monitoring and evaluation, project termination ,bottlenecks faced and lessons learned

Recommended Books

1. Gerard, B., 2015. Agile Project Management - Simple Steps to Win, Insights and Opportunities for maxing out success. Emereo Publishing, Australia.
2. Meredith, J.R. and Samuel, J.M. Jr., 2011. Project Management: A Managerial Approach. Wiley and Sons, USA.

Recommendations

Future Proposed Courses

a) Estuarine Fisheries

Recommendations

1. The Committee feels that this curriculum, as proposed is the step forward to the continuation of the process so that an additional list was suggested by the committee to be considered in future development of this discipline.
2. The committee strongly recommends that the discipline of Fresh Water Biology and Fisheries should also be initiated in other Universities of the country to meet the growing demand of experts to cater the needs of the country.
3. Finally, the committee proposes that adequate facilities must be provided to the respective Universities to conduct quality research. Refresher courses in the subject may also be regularly conducted to train teachers/researchers with modern advancement in the field.