Master of Fisheries Science

in

FISH GENETICS AND BREEDING

Courses at a Glance

(Approved by Academic Council on 26.07.2014)

CENTRAL INSTITUTE OF FISHERIES EDUCATION

(A University Established Under Sec3 of UGC Act 1956)

Indian Council of Agricultural Research

Panch Marg, Off Yari Road

Versova, Mumbai – 400 061

MFSC (FISH GENETICS AND BREEDING)

Course Structure - at a Glance

CODE	COURSE TITLE	CREDITS
FGB 501	PRINCIPLES OF GENETICS AND BREEDING	2+1
FGB 502	POPULATION AND QUANTITATIVE GENETICS	2+2
FGB 503	PRINCIPLES OF SELECTION AND SELECTION METHODS	2+1
FGB 504	FISH BREEDING	1+1
FGB 505	FISH GENETIC RESOURCES AND CONSERVATION	1+1
FGB 506	BIOINFORMATICS AND COMPUTER APPLICATIONS IN FISH GENETICS	0+2
FGB 507	CYTOGENETICS	1+1
FGB 508	CELL AND TISSUE CULTURE	1+1
FGB 509	GENOMICS AND POST GENOMIC TECHNOLOGIES IN FISH	1+1
FGB 510	MOLECULAR BREEDING	1+1
FGB 511	NANOBIOTECHNOLOGY IN FISH GENETICS	1+1
FGB 591	MASTER'S SEMINAR	1
FGB 599	MASTER'S RESEARCH	20
	SKILLED TRAINING	S/ NS

Minimum Credit Requirements

Major subject: The subject (department) in which the students takes admission

Minor subject: The subject closely related to students major subject (e.g., if the major subject is Genetics and Breeding, the appropriate minor subjects should be Fish Biotechnology, Biochemistry and Physiology, etc)

Supporting subject: The subject not related to the major subject. Need to be identified by the respective BoS from the courses offered by other disciplines and these courses are compulsory to all the students of that discipline.

Non-Credit Compulsory Courses: Please see the relevant section for details. Six courses (PGS 501-PGS 506) are of general nature and are compulsory for Master's programme. Ph.D. students may be exempted from these courses if already studied during Master's degree.

Subject	**Master's programme**	**Doctoral programme**
Major	23	17
Minor	06	06
Supporting	05	05
Seminar	01	02
Research	20	45
Field Training	02	
(3 credits from major or minor as required)		
Total Credits	**60**	**75**

Compulsory Non Credit Courses See relevant section

FISH GENETICS AND BREEDING
Course Contents
FGB 501 PRINCIPLES OF GENETICS AND BREEDING 2+1

Objective

To understand the basic principles of genetics and breeding and their application to fisheries management and aquaculture.

Theory

UNIT I

Historical development of genetics; Cell structure, cell division and physical basis of heredity; Probability concepts; Mendelian principles: scope, limitation, Modifications to Mendelian ratios: Multiple alleles, Epistasis; Chromosome theory of inheritance; Genetic variation: Causes and measurement; Linkage and crossing over, Recombination, Interference

UNIT II

Cytogenetics: Cytogenetics and Evolution, Karyotyping and banding. Genetic basis of sex determination. Chromosome manipulation: Ploidy induction, sex reversal, gynogenesis and androgenesis;

UNIT III

Modern concept of gene; DNA as genetic material, Genetic code and protein synthesis, Transfer and regulation of genetic information.

UNIT IV

Introduction to recombinant DNA technology – restriction enzymes, vectors, genetic transformation and genomics.

UNIT V

Basic concepts of Population Genetics: Individual vs population; Gene and genotype Frequency and factors affecting them. Genetic basis of selection: Qualitative vs quantitative traits Pleiotropy; Penetrance; Application of selection for performance improvement; Concept of inbreeding and its management

UNIT VI

Mutation: natural and induced mutagens, Fate of mutant allele in the population; Cross breeding and genetic drift.

UNIT VII

Application of genetics for fish resource conservation, preservation of gametes.

UNIT VIII

Bioinformatics in fish genetics and breeding, Fish Genome: Zebra fish genome; Fish as genetic model

Practical

Exercises on Mendelian laws, Multiple alleles, Epistasis, Gene and genotype frequencies, Linkage and crossing over, Estimation of gene and genotype frequencies and other genetic parameters.

Suggested Readings

1. Kirpichnikov VS. 1981. *Genetic Basis of Fish Selection*. Springer-Verlag.
2. Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
3. Lutz CG. 2003. *Practical Genetics for Aquaculture*. Wiley-Blackwell.
4. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
5. Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.
6. Snustad DP & Simmons MJ. 1999. *Principles of Genetics*. 2nd Ed. John Wiley & Sons.
7. Stansfield WD. 1991**.** *Theory and Problems of Genetics*. McGraw-Hill.
8. Tave D. 1993. *Genetics for Fish Hatchery Managers*. 2nd Ed. Chapman & Hall.

FGB 502 POPULATION AND QUANTITATIVE GENETICS 2+2

Objective

Understanding the concepts of genetic structure of the population and inheritance of quantitative traits

Theory

UNIT I

Historical developments; Scope and applications; Individual vs. population, quantitative vs. qualitative characters, genetic structure of random mating populations. Polygenes and major genes; Polygenic segregation and linkage.

UNIT II

Hardy -Weinberg principles: Test, application and properties of equilibrium populations; Systematic and dispersive forces changing gene and genotype frequencies, Balance between mutation and selection

UNIT III

Genetic bottleneck: genetic drift; Concept of Mutation: drift equilibrium; Effect on population structure, Intensity of selection, Fisher's theorem of natural selection; Whalund effect

UNIT IV

Coefficient of genetic differentiation – FST, RST, QST, GST - their relative merits and demerits, Genetic similarity and distance. Null alleles; Path coefficient: theory, analysis and applications. Basis of relationships: Independent and correlated causes. Idealised population and its properties, Effective population size and inbreeding: types, methods of estimation and consequences; Mechanisms of evolution and speciation; Delineation of species and/or stocks

UNIT V

Estimation tools for population genetic parameters - Genomics and Phenomics

Unit VI

Qualitative traits: Mode of inheritance and continuous variation; Population mean; Components of phenotypic value, Genotypic value, Average effect of gene and gene substitution; Genetic parameters: repeatability, heritability and genetic, phenotypic and environment correlations

UNIT VII

Breeding value: Biometrical relationship among relatives; Selection: Aids and methods; genetic gain and correlated response; Utilization of non-additive genetic variance; Dominance and interaction deviations; Estimation and utilization of variance components.

UNIT VIII

Heterosis: Theories and estimation; Maternal effects; Diallel crossing; General and specific combining ability; Recurrent and reciprocal recurrent selection; Scale effects and their estimation.

PRACTICAL

Exercise on various statistical procedures. Estimation of gene and genotype frequencies and factors maturing them, Equilibrium in sex linked genes; Estimation of effective population size, rate of inbreeding, inbreeding co-efficient, path coefficient; Building of pedigree files; Statistical analysis in relation to genetic stock structure analysis with dominant and co-dominant markers; Type I and Type II markers, Components of Variance, Covariance, Correlation and regression; ANOVA in genetic parameter estimation; Estimation of heritability; Repeatability and their accuracies; Estimation of breeding values and genetic gain. Analysis of diallele crossing.

Suggested Readings

1. Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.
2. Falconer DS &Markay TFC. 1996. *An Introduction to QuantitativeGenetics*. 4th Ed. Addison Wesley Longman.
3. Li CC. 1955. *Population Genetics*. University of Chicago Press.
4. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
5. Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.
6. Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press.
7. Hartl D. 1988. *A Primer in Population Genetics*. Sunderland
8. Hartl D & Clarke AG. 2007. *Principles of Population Genetics*. 4th Ed. Sunderland

FGB 503 PRINCIPLES OF SELECTION AND SELECTION METHODS 2+1

Objective

To learn the application of genetic tools for genetic improvement of aquatic species.

Theory

UNIT I

Selection: Scope, application, role of genetics in fish selection and breeding; National and International scenario of selective breeding programmes in aquaculture.

UNIT II

Selection: Basis of selection, Estimation of breeding values: Various sources of information, Least squares and BLUP methods. Estimation of genetic gain: Response to selection, Accuracy of selection; Aids to selection: Methods of selection; selection indices, combined selection. Realized heritability, repeatability and genetic correlations

UNIT III

Factors affecting response to selection: Bidirectional selection, Selection limits; Renewed selection gain

UNIT IV

Mating systems and genetic consequences; Inbreeding depression: causes and methods to overcome; Selection for threshold characters; Small stock and inbreeding effects; Out breeding: crossbreeding, utilization of heterotic effects.

UNIT V

Formulation of breeding plans: Stock improvement plans fFor different population sizes and environments Development of new strains/synthetic population; Crossbreeding and hybridization. Domestication and inadvertent selection;

UNIT VI

Selection and mating designs for select traits: growth, disease resistance, color enhancement, fin characters; Genotype x Environment interaction and its role in fish/shellfish breeding.

UNIT VII

Application of markers in selection programmes, status and their relevance.QTL and its application in selection; Marker Assisted Selection in Fisheries.

Practical

Estimation of Breeding Values from various sources of information and their accuracies, Estimation of genetic parameters: heritability, repeatability and genetic correlation; Estimation of phenotypic and environmental correlations; construction of selection indices; Analysis of GCA and SCA, Designing and conducting the challenge test for disease resistance. Selection: basis of selection, genetic gain; Response to selection and factors affecting response; Aids to selection; Methods of selection; QTL and MAS.

Suggested Readings

1. Cameron ND. 1997. *Selection Indices and Prediction of Genetic Merit in Animal Breeding*. CABI.
2. Doolittle DP. 1987. *Population Genetics: Basic Principles*. Springer-Verlag.
3. Falconer DS & Markay TFC. 1996. *An Introduction to Quantitative Genetics*. 4th Ed. Addison Wesley Longman.
4. Li CC. 1955. *Population Genetics*. University of Chicago Press.
5. Lynch M & Walsh B. 1997 *Genetics and Analysis of Quantitative Traits*. Sinauer, underland.
6. Pirchner F. 1983. *Population Genetics in Animal Breeding*. Plenum Press.
7. Turner HN & Young SSY. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell niversity Press.

FGB 504 FISH BREEDING **1+1**

Objective

To learn the applications of genetic techniques for stock improvement.

Theory

UNIT I

Historical development of fish breeding and domestication; Current status of aquaculture in world and India; Tagging and maintaining breeding records.

UNIT II

Performance: Growth, disease resistance, productive and reproductive traits and their inheritance; Study of growth curves and their components; Influence of non-genetic factors on growth.

UNIT III

Effect of breeding programme on genetic diversity of farmed animals; Present status of breeding; Cross breeding in aquaculture; Broodstock management; Inbreeding depression and heterosis in various economic characters; Role of Breeders' associations in national breeding programmes.

UNIT IV

FISH breeding guidelines, Policies, programs and economic analyses of breeding programmes.

UNIT V

Reproductive cycle, Sex determination, Age of maturity, Hormone induced ovulation; Gonad developmental stages in fin/shellfish and levels of hormonal intervention; Seed quality and fish seed certification; Live feed development for larvae, Larval feeding and maintenance, Packaging and transport of fish germplasm. Nursery systems and their operation; Biosecurity.

UNIT VI

Gamete quality analysis and preservation.

UNIT VII

Application of recent technologies in stock improvement; Biosafety issues involved with genetically modified organisms; Release and registration of new varieties; Quality seed: classes, production practices and maintenance of pure seed, Seed purity standards.

Practical

Tagging methods; Construction of growth curves; Standardization of the performance records for genetic parameters estimations, Record keeping of stock; Breeding plan and design of breeding programme from successful case studies; Morphometric analysis; Practicals on synchronization of spawning.

Suggested Readings

1. Hoar WS & Randall DJ.1988. *Fish Physiology*. Academic Press.
2. Kinghorn BP. 1981. *Quantitative Genetics in Fish Breeding*. University of Edinburgh.
3. Kshirsagar MA & Smith WB. 1995 .*Growth Curves*. CRC Press.
4. Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.
5. Thomas PC, Rath SC & Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ. House.
6. Weatherely AH & Gill HS. 1988. *The Biology of Fish Growth*. Blackwell Synergy.

FGB 505 FISH GENETIC RESOURCES AND CONSERVATION 1+1

Objective

To impart knowledge on application of genetic principles in conservation and management of aquatic resources.

Theory

UNIT I

Fish genetic resources: Sample survey and distribution; Threatened aquatic species of India and world Genetic diversity -importance, estimation and influencing factors; Determination of sample size.

UNIT II

Conservation and preservation of aquatic species: Issues and strategies, Risk status/population viability analysis and classification; Breeding strategies of threatened species for restocking and live gene bank.

UNIT III

Data bank and Gene bank: Concepts, objectives, resources, uses; Institutes and Societies associated with conservation; Impact of inbreeding on genetic diversity and conservation; Evolutionary potential and heritability.

UNIT IV

Importance of mutation, migration and their interaction with selection in conservation; Application of molecular genetic tools for management of small population for conservation.

UNIT V

Genetics and management of wild and captive populations; Introduction, domestication and acclimatization; Genetic management for reintroduction; *In-situ* and *ex-situ* conservation; gene pool concept - primary, secondary and tertiary gene pool, and gene introgression, Cryopreservation of sperm, eggs and embryos.

UNIT VI

Effective population size and population structure; Factors threatening indigenous species; IPR issues and patenting of genetic resources; Regulations regarding introduction of exotic germplasm; Export import rules and regulations on conservation of aquatic genetic resources; Fish quarantine – status, procedures, scope and significance; Convention on Biodiversity and Biodiversity Authority of India.

UNIT VII

Characterization and identification of Stock. Identification of Farm escapees; Application of Nanobiosensor for tracking of Fish. Genomics in Conservation: DNA Bar coding, Effect of climatic change on biodiversity

Practical

Tagging methods for population; Estimation of gene and genotypic frequencies; Estimation of genetic diversity and relatedness using molecular information; Application of molecular genetic markers for estimation of effective population size, rate of inbreeding and genetic bottleneck; Analysis of genetic variance in population; Morphometric analysis of stocks; Visit to Gene Bank/National/Regional Research Centres. Studies on Domestic and international quarantine process; its weaknesses and measures for its strengthening

Suggested Readings

1. Allendorf FW. 2007. *Conservation and the Genetics of Populations*.Blackwell.
2. Cloud JG & Thorgaard GH. 1993. *Genetic Conservation of Salmonid Fishes*. NATO ASI Series, Life Sciences, Springer.
3. Frankham R, Ballou JD & Briscoe DA. 2004. *A Primer of Conservation Genetics*. Cambridge University Press.
4. Frankham R. 1995. *Introduction to Conservation Genetics.* Annual Reviews of Genetics.
5. Hartl D. 1988. *A Primer in Population Genetics*. Sunderland.

FGB 506 BIOINFORMATICS AND COMPUTER APPLICATIONS IN FISH GENETICS 0+2

Objective

To learn the application of information technology and software packages for the FishGenetics and Breeding studies

UNIT I

File Transfer Protocols; Work stations; Application of spreadsheets in maintaining fish breeding records; Fish breeding data bases; Data input, import, export, modification; Spread sheet in breeding data management; Data manipulation and transformations; data normalization.

UNIT II

Usage of various computer packages for genetic analyses: SAS, AsREML, PEST, SelAction; Variance component estimations; Estimation of genetic parameters; Inbreeding estimation.

UNIT III

Software for molecular genetics data analysis; Estimation of population parameters; Estimation of 'F' Statistics, Association studies; QTL studies.

UNIT IV

Introduction to Bioinformatics and various operating systems employed; Exposure to various open source online bioinformatics tools and applications; Introduction to databases. Bioinformatics databases; Information retrieval from various sequence and structure databases and mock sequence submission; Database searching, Sequence formats and alignments; BLAST, Conversion and handling of various sequence formats, Usage of online sequence alignment tools.

UNIT V

Sequence analysis; Annotation, Sequence conversion and translation, Sequence comparison, Phylogenetic analysis. Protein structure Analysis; analysis of amino acids sequence, practical on secondary and tertiary protein structure analysis and its validation.

Further Reading

1. Attwood TK & Smith DJP. 1999. *Introduction to Bioinformatics*. Addison Wesley Longman.
2. Baxevanis AD &Ouellettee BF. 2002**.** *Bioinformatics, A Practical Guideto the Analysis of Genes and Proteins*. John Wiley & Sons.
3. Brown SM. 2000. *Bioinformatics: A Biologist's Guide to Biocomputing and the Internet*. Eaton Publ.
4. Campbell MA &Heyer LJ. 2003. *Discovering Genomics, Proteomics, and Bioinformatics.* Benjamin Cummings.
5. Lesk AM. 2008**.** *Introduction to Bioinformatics.* Oxford University Press.

6. Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. ColdSpring Harbor Press.
7. Rashidi HH & Buehler LK. 2005. *Bioinformatics Basics: Applications in Biological Sciences and Medicine*. CRC Press.
8. Brown SM. 2000. *Bioinformatics: A Biologist's Guide to Biocomputing and the Internet*. Eaton Publ.
9. Cody RP & Smith JF. 1997. *Applied Statistics and SAS Programming Language*. Elsevier**.**
10. Delviche LD & Slaughter JS. 2003. *The Little SAS Book- A Primer*. 3rd Ed.SAS Publ.
11. Dutkowski G & Gilmour A. 2005. *AsReml Cook Book*. Statistical Software Package.
12. Littell RC, Milliken GA, Stroup WW &Wolfinger RD. 1996. *SAS System for Mixed Models*. SAS Institute.
13. Lynch M & Walsh B. 1997. *Genetics and Analysis of Quantitative Traits*. Sinauer, Sunderland.
14. Saxton AM. 2004. *Genetic Analysis of Complex Traits Using SAS*. SAS Publ.

FGB 507 CYTOGENETICS **1+1**

Objective

To understand chromosome as the basic unit of heredity

Theory

UNIT I

Introduction, Historical background, Importance, Chromosome theory of inheritance: chromosomal models and their ultra structure; Chromosomal movements and position effect.

UNIT II

Sex determination and differentiation, Sex chromatin and Lyon's hypothesis; Chromosome numbers in fish and karyotyping.

UNIT III

Chromosomal aberrations: Genetic and evolutionary implications; Chromosome banding techniques; Molecular Cytogenetics: FISH.

UNIT IV

Cytogenetics and evolution; Genotoxicity (single cell electrophoresis, MNT, SCE).

UNIT V

Extra Chromosomal Inheritance / Cytoplasmic Inheritance: Mitochondrial DNA
DNA and RNA as genetic material; Chemistry and structure of DNA. Fine structure of gene, Split genes, Pseudogenes, Overlapping genes and Multigene families. Mechanisms of DNA amplification.

UNIT VI

Application of nanotechnology in chromosome and genome mapping.

Practical

Preparation of chromosome spreads; Karyotyping; Banding techniques; MNT, SCE, Comet Assay.

Suggested Readings

1. Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. *Fisheries Biotechnology*. Narendra Publ. House.
2. Pisano E. 2007. *Fish Cytogenetics*. Science Publ.
3. Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *FishGenetics and Biotechnology*. ICAR.

FGB 508 CELL AND TISSUE CULTURE 1+1

Objective

To impart knowledge on cell and tissue culture techniques and their application in health management, gene banking and genetic characterization.

Theory

UNIT I

Introduction: Structure and Organization of animal cell; Equipment and materials for animal cell culture technology.

UNIT II

Cell lines and media: Primary and established cell line cultures; media supplements – their metabolic functions; serum and protein free defined media and their application.

UNIT III

Cell culture: Basic techniques of cell culture in vitro; development of primary cultures, cell separation, maintenance of cell lines; biology of cultured cells, transformation and differentiation of cell cultures.

UNIT IV

Characterization of cell lines: Measurement of viability and cytotoxicity assays; measuring parameters of growth; karyotyping, isozyme assays, cryopreservation, assessment of contaminants.

UNIT V

Cell cloning: Micromanipulation, cell transformation, application of fish cell culture, scaling-up of cell culture.

UNIT VI

Cell hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies.

UNIT VII

Stem cell culture and its application.

UNITVIII

Bioproducts from cell culture, cryopreservation of embryos and cells.

Practical

Principles of sterile techniques and cell propagation; Preparation of different cell culture media; Primary cell culture techniques; Establishing cell lines: isolation, characterization identification of cell lines; Pure culture techniques; Maintenance and preservation of cell lines; Propagation of cells in suspension cultures; Hybridoma technology: strategy and techniques; Production of monoclonal antibodies.

Suggested Readings

1. Barnes D & Mathur PJ. 1998. *Methods in Cell Biology*. Vol. 57. *Animal Cell Culture Methods*. Academic Press.
2. Basega R. (Ed.). 1989. *Cell Growth and Division: A Practical Approach*.IRL Press.
3. Butler M & Dawson M. (Ed.). 1992. *Cell Culture*. Bios Scientific Publ.
4. Clynes M. 1998. *Animal Cell Culture Techniques*. Springer.
5. Freshney I. 1994. *Culture of Animal Cells: A Manual of Basic Techniques*. 4th Ed. Wiley-Liss.
6. Harrison AM, Rae FI & Harris A. 1997. *General Techniques of Cell Culture*. Cambridge University Press.
7. Lan FR. 1994. *Culture of Animal Cells*. 3rd Ed. Wiley-Liss.
8. Masters RW. 2000. *Animal Cell Culture-Practical Approach*. Oxford University Press.

FGB 509: GENOMICS AND POST GENOMIC TECHNOLOGIES IN FISH 1+1

Objective

To acquaint the students with techniques used to estimate genetic variation among individuals and populations for stock identification, biodiversity estimation and genetic improvement using marker assisted selection

UNIT I

Sources of genetic diversity: Mutation and recombination of genomic material.

UNIT II

Biochemical markers: Allozyme polymorphism and its application in estimating population genetic parameters.

UNIT III

Molecular markers: RAPD, RFLP, AFLP, EST, SNP, Minisatellites and Microsatellites and application in population genetic analysis and gene mapping, FISH – principle and application. Maternally and paternally inherited genetic markers: Mitochondria and Y chromosome.

UNIT IV

Concept of Marker Assisted Selection.

UNIT V

Analysis: Interpretation of gels and data analysis using various softwares. DNA sequence polymorphism and related software for alignment and analysis.

Practical

Genomic DNA isolation from prokaryotes and eukaryotes, Isolation of RNA and RT-PCR, Agarose gel electrophoresis of DNA and RNA, PCR, primer designing, PCR-RFLP, extraction of DNA from agarose gels, Biochemical markers and Molecular markers, Interpretation of gels and data analysis using various softwares. DNA sequence polymorphism and related software for alignment and analysis.

Suggested Readings

1. Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols, Applications and Overviews*. Wiley-VCH.
2. Pasteur N, Pasteur G, Bonhomme F, Catalan J & Britton-Davidian J. 1988. *Practical Isozyme Genetics*. Ellis Horwood.
3. Sambrook J & Russel WD. 1989. *Molecular Cloning: A Laboratory Manual*. Vols. I-III. Cold Spring Harbor.

FGB 510 MOLECULAR BREEDING 1+1

Objective

To understand the basic concepts of molecular genetics

Theory

UNIT I

Introduction to Molecular Breeding; Molecular mechanism of genetic recombination. Molecular taxonomy and its application in Fisheries; Phylogenetics Recombination:

UNIT II

Mutations: Molecular mechanism of spontaneous and induced mutations, site directed mutagenesis, recombination in bacteria, fungus and virus.

UNIT III

QTL and MAS identification; marker assisted selection with markers in linkage disequilibrium with QTL. Molecular pedigree Assigning

Unit IV

Linkage disequilibrium in fish populations: A brief history of QTL mapping; Definitions and measures of linkage disequilibrium; Causes of linkage disequilibrium in populations; the extent of LD in populations; extent of LD between populations; Haplotype blocks and recombination hotspots

Unit V

Mapping QTL using linkage disequilibrium: Introduction; Genome wide association tests using single marker regression; Genome wide association experiments using haplotypes; IBD LD mapping; comparisons with single markers combined LD-LA mapping

UNIT VI

Introduction; Applying LD-MAS with single markers; applying LD-MAS with marker; haplotypes; marker assisted selection; with the IBD approach; gene assisted selection; optimising the breeding scheme with marker information

UNIT VII

Introduction to genomic selection; Methodologies for genomic selection; Factors affecting the accuracy of genomic selection; Non additive effects in genomic selection; Genomic selection with low marker density; Genomic selection across populations and breeds; How often to re-estimate the chromosome segment effects? Cost effective genomic selection; Optimal breeding program design with genomic selection.

Practical

DNA isolation, Gel electrophoresis and its type, AGE, PAGE, SDS-PAGE, PCR, Cloning; Haplotyping with the phase program; Estimating the extent of linkage disequilibrium; Power of association studies; Building the IDB matrix from linkage disequilibrium information; marker assisted selection with linkage disequilibrium; Genomic selection using BLUP; Genomic selection using a Bayesian approach;

Bayesian Approach using a prior for chromosome segment variances with a large weight at zero (bayesb)

Suggested Readings

1. Caetano-Anolles G & Gresshoff PM. 1998. *DNA Markers: Protocols,Applications and Overviews*. Wiley-VCH.
2. Lehninger LA, Nelson DL & Cox MM. 2008. *Principles of Biochemistry*. 4th Ed. WH Freeman.
3. Lewin B. 2004. *Genes VII*. International Ed. John Wiley & Sons.
4. Pasteur N, Pasteur G, Bonhomne F, Catalan J & Britton–Davidian J. 1988. *Practical Isozyme Genetics*. Ellis Horwood.
5. Sambrook J & Russel WD. 1989. *Molecular Cloning: A LaboratoryManual*. Vols. I-III. Cold Spring Harbor.
6. Stryer L, Berg JM & Tymocz KJL. 2004. *Biochemistry.* 5th Ed. WH Freeman.

FGB 511 NANOBIOTECHNOLOGY IN FISG GENETICS 1+1

Objective

To acquaint students with the applications of tools of nanobiotechnology

Theory

UNIT I

Introduction to nanotechnology and overview of nanoscale materials; Introduction to nanobiotechnology; Challenges and opportunities associated with biology at Nanoscale.

UNIT II

Synthesis of nanostructure: chemical, physical and biological methods; Characterization techniques for molecular nanostructures; Scanning probe microscopy; Electron microscopy; NMR; AFM.

UNIT III

Biomolecules as nanostructure and their application in nanotechnology *viz*. Biosensor, separation of cell and cell organelles, drug delivery, gene therapy, etc.

UNIT IV

Functionalization of nanoparticles for biological application.

UNIT V

Development of nano-DNA particle and its application in Fisheries and Aquaculture.
Nanotechnology in chromosome/genome mapping.

UNIT VI

Toxicology and bioaccumulation of nanomaterials. Environmental behavior of nanoparticles.

Practical

Synthesis of nanoparticles; Characterization of nanoparticles: Size, zeta potential, morphology; Conjugation of DNA/Protein with nanoparticle. Toxicity studies of nanoparticles.

Suggested Readings

1. Nano: The Essential by T. Pradeep
2. Nanotechnology Principlesand Practices by S.K. Kulkarni
3. Nnaotechnology by Booker Boysen