

## **About M Tech Programme in Marine Biotechnology**

The M Tech programme in Marine Biotechnology sponsored by Department of Biotechnology, Government of India is a unique experience of its kind in the country.

Over above two decades, Government of India has been supporting infrastructure development and research in focussed areas of Marine Biotechnology to develop novel processes and products aiming at enhancement of industrial processes, biomedical material development, environment management etc. In spite of these efforts, marine biotechnology industry has not been registering steady growth unlike the developments brought in other streams of biotechnology. Government of India on taking stock of the status realised that it was mainly because of lack of entrepreneurship in the area, much needed for the envisaged industrial growth. Realizing this requirement, National Centre for Aquatic Animal Health proposed the present M Tech programme in Marine Biotechnology with the objective of generating the much needed entrepreneurs in this area. Precisely this is a programme for generating job makers rather than job seekers.

To satisfy this requirement, a curriculum was built in consultation with experts in the field. The four semester programme consists of two semesters of theory, practical classes, assignments, problem analysis, short term projects and case studies with full time industry based research during the third and fourth semesters. The programme has an Advisory Committee with Vice chancellor as Chairman and members drawn from industry, academia and planners. Under the patronage of this Committee and with the state-of-the art infrastructure built in this Centre we look forward to generate manpower to transform the marine biotechnology industry in the country to world class level experience.

The curriculum offered is as given below:

### **M. Tech in Marine Biotechnology Syllabus**

#### **Semester – 1 (20 credits)**

**Focus: Biotechnological approaches to conservation, utilization and enhancement of marine natural products and biomaterials**

#### **Core Papers**

##### **CAH 3101. Dynamics of marine and estuarine productivity and biodiversity – 3 Credits**

Unit – 1. Primary production in the oceans: Dynamics of primary production, contributing factors, role of Bacteria, Archaeae and Eucaryae and phages in primary production, methods of assessing primary production, molecular methods in determining primary productivity, biogeochemical cycles and the role of microbes, microbial community structure and diversity.

Unit – 2. Diversity and abundance of marine and estuarine algae: distribution of macroalgae in the oceans, associations with the algae, commercially important algae, and their methods and extend of exploitation, constraints.

Unit – 3. Secondary producers: Processes and dynamics of secondary production in marine and estuarine systems, interactions between secondary producers and other trophic levels, modeling of secondary production, methods of estimation.

Unit – 4. Tertiary producers: Processes and dynamics of tertiary production in marine and estuarine systems, interactions between tertiary producers and other trophic levels, modeling of tertiary production, methods of estimation.

Unit – 5. Marine reptiles, birds and mammals: Seasonal distribution, geographic ranges, patterns of migration and population dynamics, application of remote in sensing and modeling in marine productivity estimation.

Unit – 6. Marine biodiversity conservation: a holistic approach to marine environment as source of natural products, biomaterials for biotechnology interventions, conservation of genetic resources and biomedical modeling.

## References

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14. Munn, C.B. 2004. Marine Microbiology. Ecology and Applications. Garland Science/ BIOS Scientific Publishers, Oxon and New York. 282 p.
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21. Ruth, M. and Lindholm J. 2002. Dynamic Modeling for Marine Conservation. Springer, New York. 272p.
22. Tanoue, E. and Hama T. 2001. Dynamics and Characterizations of Marine Organic Matter, Springer, New York. 572p.
23. Valiela, I. and Valiera, I. 1995. Marine Ecological Processes. Springer, New York. 705p.
24. Wetzel R.G. Limnology. Lake and River Ecosystems. 3<sup>rd</sup> Edition. Academic Press.
25. Yale Eawson, E., 1966. Marine Botany: an introduction. Hole Reinhart and Winston Inc., New York.

## **CAH 3102. Marine and brackish-water productivity management through culture operations– 3 credits**

Unit – 1. General biotechnological tools for enhancing and sustaining marine and brackish water productivity through culture operations: Production of disease free disease resistant brood stock and seed, selective breeding, molecular breeding and transgenics, extensive, semi-intensive and intensive grow-out systems, general methods for enhancing productivity in grow-out systems, bioremediation and enhancement of carrying capacity, supplementary feeding, probiotics, immunostimulants, vaccines, anesthetics

Unit – 2. Biotechnological interventions in enhancing and sustaining marine algal production: Micropropagation, raft and rope culture- designing and commercial implications

Unit – 3. Biotechnological interventions in enhancing and sustaining crustacean production: Enhancement of growth, reproduction, assisting early development, larval and post larval production, nutrition and nutritional requirements, improvement of general health and well being and improvement of quality and value.

Unit – 4. Biotechnological interventions in enhancing and sustaining Molluscan production: Molluscan seed production technology, problems involved, remedial measures, different methods of culture and innovations, raft and cage culture, biotechnology in enhancing survival, growth and well being, improvement of quality and well being.

Unit – 5. Biotechnological interventions in enhancing and sustaining finfish production: The cultivable species of finfishes, seed production technology, problems encountered, possible way out and biotechnological interventions, growth enhancement through transgenesis.

Unit – 6. Biotechnological interventions in live feed organisms culture: Diatoms and micro-algae, moina, rotifers, *Artemia salina*, polychaetes, development of new cultures, recent advancements in their mass production techniques, bio-encapsulation using live feed organisms and delivery of bio-molecules, value addition.

### **References**

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### **CAH 3103. Marine Genomics and proteomics - 3 credits**

Unit – 1. Introduction to genomics and proteomics: Structural genomics- organization and structure of genomes, mapping and sequencing of genomes, DNA microarray technology, comparative genomics, large-scale mutagenesis and interference, Functional genomics: transcriptomics, proteomics and metabolomics; proteomics - structural proteomics, expression proteomics, Interaction proteomics and functional proteomics, protein separation- gel electrophoresis and chromatography techniques, protein digestion techniques, protein identification- mass spectrometry, strategies for protein quantitation, peptide mapping, peptide sequence analysis, protein expression profiling, identification of protein-protein interactions, mapping of protein modifications, protein arrays and functional proteomics,

Unit – 2. Bioinformatics: Introduction to bioinformatics – Computational molecular biology- Basic concepts of molecular biology, strings and graphs and algorithms, sequence comparison, physical map of DNA and database search, fragment assembly of DNA, phylogenetic tree, genomic rearrangements, molecular structure prediction, epilogue and computing with DNA.

Unit – 3. Marine Genomics: Structural and functional genomics of marine organisms, sequence analysis, cloning strategy for a functional gene, data mining for gene hunting, sequence comparison and alignment, ORF analysis (Introns, Exons and ESTs), BLAST search, clustal out put.

Unit – 4. Marine proteomics: Proteins – an overview - Protein sequencing and sequence strategy, protein structure prediction, primary structure, secondary structure, tertiary structure and quaternary structure, protein denaturation.

Unit – 5. Novel genes and gene products – profiling genes and metabolic transcriptional pathways, identification of model organism's bioinformatics.

Unit – 6. New algorithms for specific production of drug action based on models of biological processes.

### **References**

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2. Cooksey K.E. (Ed.). 1998. Molecular approaches to the study of the ocean. Chapman and Hall, London. 549p.
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#### **CAH 3104. Bioprospecting and bioprocess technology of natural products – 3 credits**

Unit – 1. Bio-prospecting: isolation and culture of bacteria, actinomycetes, filamentous fungi, yeasts, micro-algae, anaerobic microorganisms, thermophiles, psychrophiles and other extremophiles and screening for bioactive molecules.

Unit – 2. Marine natural products and Biomaterials: Pharmaceuticals, enzymes, bio-molecular materials, bio-monitors, bio-pesticides, bio-plastics, biomass for energy production and bio-augmenters from marine organisms – prokaryotes, marine micro-algae, seaweeds, sponges, Cnidarians, Bryozoans, Mollusks, Ascidians, Echinoderms and Fishes.

Unit – 3. Specific bioactive molecules: Bioactive marine toxins – paralytic shell fish poisoning, ciguatera poisoning, diarrhetic shell fish poisoning and miscellaneous toxins; Bioactive marine nucleosides – pyrimidines and purine – D – arabinosides, pyrimidine – 2' – deoxyribosides, pyrimidine and purine 1-B – D – ribosides other miscellaneous nucleosides; bioactive marine alkaloids, bioactive marine peptides from marine algae, sponges, tunicates, ascidians, coelenterates, mollusks, cone shell, sea urchins, , marine worms, marine vertebrates; those marine peptides under clinical trials and Marine prostaglandins.

Unit – 4. Bio-process technology: Fundamentals, engineering biology of cells and molecules, medium engineering for cell cultivation and bioreactors, contamination free fluids for process biotechnology, aeration, mixing and agitation, Archaea bacterial bio-processing, biosensors in bioreactors, product estimation and bioassay, conventional and modern methods of bioproducts recovery, treatment of effluent generated during bioprocess, control of undesirable microbes during bioprocess, bioprocess plant design.

Unit – 5. Bio-separation: Removal of insolubles – filtration, centrifugation, cell disruption, isolation- extraction and adsorption; product purification – elution chromatography, precipitation, ultrafiltration and electrophoresis; polishing – crystallization, drying and ancillary operation.

Unit – 6. Biological, Toxicological and Clinical evaluation: Types of screening – individual and broad biological screening; screening models and activity – antibacterial and antifungal, antileishmanial, anthelmintic, antimalarial, antiviral, anti-inflammatory, analgesic, antiallergic, antiarrhythmic and antithrombotic, hypolipidaemic, hypoglycaemic, hypotensive, antihypertensive, diuretic, adaptogenic and immunomodulatory, hepatoprotective, choleric and anti – choleric, acute toxicity and Central Nervous System activities; Anticancer screening, toxicity evaluation- regulatory toxicity, reproductive studies, teratological studies, pre and post natal study and mutagenic study; use of animals in experiments; clinical trials- trial protocols, duplicating trials and ethical considerations.

## References

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## CAH 3105. Marine biotechnology industry management - 3 Credits

Unit 1: Principles of Industry management: Evolution of management theory and practice and approaches, management functions- planning- planning tools, organizing- human resource management and organizational behaviour; influencing- leadership, motivation, groups and corporate culture; controlling- operation management, production management, total quality management, Management Information Systems, managerial economics and financial management, marketing management, project management and accounting, managing labour relations; Legal aspects of management, managing technology and knowledge, entrepreneurship., international management.

Unit 2. Overview of biotechnology Industry management: Business of Biotechnology, Emerging Areas of Biotechnology Industry, corporate governance and bioethics and societal issues in biotechnology industry; Biotechnology Product Management: Product development, assessment of market potential, testing and life cycle analysis, preclinical and clinical trial design and conduct, risk analysis, quality control and assurance, fundamentals of validation, good manufacturing practices.

Unit 3. Biotechnology Regulatory Affairs: Regulatory processes and agencies, Legal Aspects of Biotechnology, Intellectual Property Rights- Basis of Patentability, Patent Application Procedure, Compulsory License, Infringement of Patents, Product Registration for Regulated and Non Regulated Markets, Scientific Exchange in Biotechnology research, Treaties/Conventions and regulatory policies relevant to India, International regulatory affairs, regulatory information, drug submissions, biologics

submissions, medical device submissions, GLP, GCP, GMP, inventorship and ownership issues in academia and industry

Unit 4: Biotechnology Entrepreneurship: Entrepreneurial process and the practicalities of venture creation, specific features of biotechnology-based products and services, human resource management, partnerships with other businesses; negotiation techniques and motivation, leadership skills, communication, conflict resolution, and goal integration, key tasks and challenges faced by biotech entrepreneurs, crisis management principles, strategies, tactics, and communications methods

Unit 5. Marketing in biotechnology industry: Marketing practices and application, marketing plan, relationship between the marketing and sales functions, marketing a scientific product and a scientific service, pricing strategies, distribution alternatives, communications, promotion, and the importance of perception. International business and marketing trends in biotechnology; advertising approved products.

Unit 6: Finance management for biotechnology industry: Defining and distinguishing the biotechnology industry, competitive forces and impact on strategy, regulation of genetic products, planning under uncertainty, system thinking and system failure, the economic environment, estimating costs and benefits, strategic components, marketing and sales, modeling, costs and benefits, and ratio and break-even analysis, commercializing biotechnology and technology transfer

## References

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9. Easterby-Smith, M. and Lyles, M.A. (Eds) 2003. The Blackwell Handbook of Organizational Learning and Knowledge Management. Blackwell Publishing, Oxford 676p.
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### **Electives:**

#### **CAH 3106. Advances in microbial population and biomass estimation – 1 credit**

Molecular tools for estimating microbial diversity and productivity in marine and estuarine environment – Molecular tools in marine microbial diversity – 16S – rDNA sequence analysis, 18S – rDNA sequence analysis, Fluorescent – *in situ* – hybridization (FISH), Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), DNA – DNA & DNA – RNA hybridization; Molecular tools in Marine Microbial productivity – Epifluorescence, Muramic acid estimation, tritiated thymidine incorporation, ATP estimation.

### **References**

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11. Towner K.J. and Cockayne. 1993. Molecular Methods of Microbial Identification and Typing. Chapman and Hall, London. 202p.
12. Toranzo, G.A. and Toranzo T.A. 1997. Environmental Applications of Nucleic Acid Amplification Methods. CRC Press, Boca Raton, 213p.

#### **CAH 3107. Down stream process in Marine Natural Products – 1 credit**

Recent advances in the methods of extraction, purification, concentration of marine natural products and development of an application module – Initial extraction and product capture, supercritical fluid methods, isolation by low pressure column chromatography, isolation by ion exchange methods, isolation by preparative HPLC, isolation by planar chromatography, separation by high speed counter current chromatography, crystallization and final stage of purification, Dereplication and partial identification of natural products, purification of water soluble natural products, problems in the extraction and purification of natural products, scale up of marine natural products isolation.

### **References:**

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#### **CAH 3108. Advances in Molecular Biology – 1 credit**

Emerging techniques in molecular biology and the recent advancements – Molecular aspects of chromosome structure, DNA methylation and epigenetic regulation, gene structure and architecture, Gene expression and regulation, gene transfer in prokaryotes and eucaryotes, genomic libraries, cDNA libraries, cloning vectors, expression vectors, reporter genes the genetic code, genomes and mappings, mobile genetic elements, mutagenesis and DNA repair, mutation and selection, nucleic acid – Binding properties, organelle genome, PCR and its modification, micro-array, plasmids and classification, recombinants – analysis of recombinants – bacteria, yeasts and viruses, gene transfer to animal cells. Proteins – structure, function and evolution, protein synthesis, RNA processing, signal transduction, transcription, virus and sub-viral agents, marine animal cell culture, cell signaling and stem cells.

#### **References:**

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3. Levy. 1995. Non-isotopic Methods in Molecular Biology. Oxford University Press. 221p.
4. Malacinski G.M. 2003. Essentials of Molecular Biology. Jones and Bartlet Publishers, Sudbury. 491p.
5. Nelson, K.E., Read, T.D., Fraser, C.M. 2004. Microbial Genomes. Humana Press Inc., New Jersey. 536p.
6. Sambrook J. and Russel D.W. 2001. Molecular Cloning : A Lab Manual. Vol.1, 2&3. Cols Spring Laboratory Press, Cold Spring Harbor, New York
7. Schmauder H. 1997. Methods in Biotechnology. Taylor and Francis, 257p.
8. Twyman R.M. 2003. Advanced Molecular Biology. A concise reference. Viva Books Private Limited, New Delhi
9. Wu, W., Welsh M.J., Kaufman, P.B. and Zhang H.H. 1997. Methods in Gene Biotechnology, CRC Press, LLC, Boac Raton
10. Richard R. Siden, 1994. DNA structure and function, Academic Press.

#### **CAH 3109. Introduction to marine sciences- 1 Credit**

Fundamentals of physical oceanography: Physical properties of sea water, distribution of temperature, salinity, density, oxygen. Global circulation, major wind systems, coriolis effect, El Nino/ La Nina, Ekman motion, eddies, global circulation, ocean currents, upwelling and down welling processes, waves and tides ocean-atmosphere coupling, marine weather and climate, Estuaries and near shore environment

Fundamentals of chemical oceanography: Elemental composition of sea water, major and minor elements, dissolved gases, chemical properties of sea water, nutrients and biogeochemical cycles, chemical features of estuaries and coastal waters

Fundamentals of marine geology: The ocean floor- bathymetry, Structure and origin of ocean basins, sea floor spreading, plate tectonics, continental shelves, slopes, ocean basins, submarine canyons, trenches, guyots, ocean ridges, geothermal vents, continental margins, polar oceans, icebergs and tropical oceans, classification of sea coasts and shorelines, coastal land forms, marine sediments-types and distribution, mineral wealth of the sea, methods of exploring the ocean floor. Marine pollution, treaties and conventions for ocean protection, oceans and global change, recent advances in the study of marine sciences

Fundamentals of Marine Biology - Life in the Oceans- Marine algae, sea weeds, sea grasses, mangrove swamps and marshes. Planktons – classification, major taxa of phytoplankton and zooplankton. Plankton as food in the sea. Nekton- crustaceans, cephalopods, fish. Benthos – Epifauna, Infauna .Coral reefs. Vertical migration. Deep scattering layer.

Biological divisions of the sea. Intertidal zone - rocky shore, sandy shore, muddy shore Intertidal communities. Marine ecosystems. Estuaries- types of estuaries, estuarine ecology. Community concept- Stratification in marine communities. Standing crop, productivity. Food chain and food web, trophic structure. Predator prey effects. Energy flow and ecological pyramids.

#### References:

1. Gibson R.N. Barnes M. and Atkinson RJA. 2002. Oceanography and Marine Biology. Taylor and Francis. 704p.
2. Gianguzza, A., Pelizzetti E. and Sammartano S. 2000. Chemical Processes in Marine Environment. Springer, New York. 436p.
3. John D.G. and Tyler P.A. 1992. Deep Sea Biology: A Natural History of Organisms at the Deep Sea Floor. Cambridge University Press. 520p.
4. Kennish M.J. (Ed.). 1994. Practical Handbook of Marine Science. Second Edition. CRC Press Inc., Boca Raton. 566p.
5. Karleskint Jr., G. 1998. Introduction to Marine Biology. Harcourt Brace & Company, Philadelphia. 378p.
6. Levinton J.S. 1995. Marine Biology. Function, Biodiversity, Ecology. Oxford University Press Inc., Oxford. 420 p.
7. Meller G. 1996. Introduction to Physical Oceanography. Springer, New York. 284p.
8. Millero F.J. 2005. Chemical Oceanography. CRC Press, Boca Raton. 496p.
9. Nybakken J.W. 1997. Marine Biology . An Ecological Approach. Addison-Wesley Educational Publishers Inc., California. 481p.
10. Norton W.H. 2004. The Elements of Geology. Kessinger Publishing. 272p.
11. Pickard, G.L. and Emery W.J. 1990. Descriptive Physical Oceanography. Elsevier, 336p.
12. Pinet P.R. 2000. Invitation to Oceanography. 2<sup>nd</sup> Edition. Jones and Bartlett Publishers, Sudbury. 555p.
13. Sohn M.L. 1996. Chemical Oceanography. CRC Press, Boca Raton. 578p.
14. Schulz, H.D. and Zabel M. 2000. Marine Geochemistry. Springer, New York. 455p.

#### Practical (Core) - 4 credits

##### CAH3110 - Advanced Molecular Biology – 2 credits

**Nucleic Acid Technology** –General methods of DNA Isolation and purification

**Nucleic Acid Technology**\_- RNA Isolation, Purification and Characterization, cDNA synthesis, Probe synthesis, Radiolabelling and autoradiography. Analysis of RNA genomes. Size fractionation of RNA and DNA using AGE, PAGE, and PFGE, Sequencing of DNA – Dideoxy method. Site directed mutagenesis using PCR. DNA Fingerprinting and Footprinting, Random Subclone Generation: Sonication, Nebulization, DNA Restriction analysis and ligation. Bacterial transformation, Screening of transformants. Screening bacterial colonies by hybridization. PCR, cDNA library construction.

**Molecular Taxonomy** - Lipid profiling (MIS), 16S, 18S, 23S rDNA analysis, DNA fingerprinting - RFLP, RAPD, Microsatellite, AFLP, SSCP, SNP. DNA-DNA and DNA-RNA hybridization. Intergenic spacers, Analysis of phylogenetic trees. DGGE. Molecular markers and bar coding. BLAST

**Blotting Techniques** – Southern, Northern, Western, South–Western and North–Western blotting.

**DNA Array Technology** – Microarray- process, production using contact printing, photolithography and Pin & Ring. Imaging and analysis techniques. Application of microarray in marine system. Bioinformatics Tools – BLAST, FASTA. Databases - GenBank and EMBL. RNA Databases, Construction of databases.

Proteomics – Extraction and Purification of proteins, Native & SDS PAGE, and Gradient Gel Electrophoresis, 2-D PAGE. Protein Sequencing, Mass spectroscopic analysis and mapping of proteins. Structural Proteomics - X-ray crystallography, NMR, Maldi-TOF, Chromatography, HPLC. Protein Microarray

– construction. Protein – protein interaction studies – Bioinformatic method, affinity method, Yeast two-hybrid system. Protein modifications. Protein Databases and protein chips. Prediction of protein conformation using Ramachandran plot. Optimal production of recombinant marine proteins.

#### References:

1. Blin N. and Stafford D.W. 1976. A general method for isolation of high molecular weight DNA from eukaryotes. *Nucleic Acid Res.* 3: 2303-2308.
2. Balra S.K., Metzagar R.S. and Hollingsworth M.A. 1991. A Simple effective method for the construction of subtracted cDNA libraries. *Genet. Anal. Tech. Appl.* 8: 129-133
3. Bowtell D and Sambrook, J. 2003. *DNA Microarrays: A Molecular Cloning Manual*. CSHL Press, New York. 712p.
4. Brown P.O. and Botslein D. 1999. Exploring the new world of the genome with DNA microarrays. *Nat. Genetics* 21: 33-37
5. Church G.M. and Gilbert W. 1984. Genomic sequencing. *Proc. Natnl. Acad. Sci.* 81: 1991-1995
6. Cseke L.J. and Podila G.K. 2004. *Handbook of Molecular and Cellular Methods in Biology and Medicine*. CRC Press, Boca Raton. 580p.
7. Cohen A. and Clark A.J. 1986. Synthesis of linear plasmid membranes in E.coli k12. *J. Bacteriol.* 167: 327-335.
8. Erlich H.A. 1989. Polymerase Chain Reaction. *J. Clin. Immunology.* 9: 437-447.
9. Figey S.D. (2003). Novel approaches to map protein-protein interactions. *Curr. Opin. Biotechnolo.* 14: 1-7.
10. Janson J. and Ryden L. 1997. *Protein Purification: Principles, High Resolution Methods and Applications*. Wiley-VCH. 712p.
11. Mitsuhashi M., Cooper A., Ogura M., Shragawa T., Yaro, K. and Hosokawa T. 1994. Oligonucleotide probe design- A new approach . *Nature.* 367: 759-761.
12. Sambrook J. and Russel D.W. 2001. *Molecular Cloning : A Lab Manual*. Vol.1, 2&3. Cols Spring Laboratory Press, Cold Spring Harbor, New York.
11. Schmauder H. 1997. *Methods in Biotechnology*. Taylor and Francis, 257p.
13. Tatusova T.A. and Madder T.L. 1999. BLAST 2 sequences, a new tool for comparing protein and nucleotide sequences. (erratum *FEMS Microbiol. Lett*(1999) 177:187-188). *FEMS Microbiol. Lett.* 174: 247-250.
12. Twyman R.M. 2003. *Advanced Molecular Biology. A concise reference*. Viva Books Private Limited, New Delhi
13. Wu, W., Welsh M.J., Kaufman, P.B. and Zhang H.H. 1997. *Methods in Gene Biotechnology*, CRC Press, LLC, Boca Raton

#### CAH3111 - Bioprocess Technology – 2credits

**Enzymes** – Production and separation technologies. Mass production using fermenters - Optimization of culture conditions, Application of statistical tools and soft wares for mass production; Separation - Centrifugation, Membrane filtration; Cell Breakage – Enzymatic, Chemical and Mechanical cell disruption; Precipitation - Salting out (ammonium sulphate/sodium sulphate), Using non-ionic polymers (eg:- Polyethylene glycol), Organic solvents (eg: - Chilled acetone/ethanol); Dialysis and lyophilization; Chromatographic separation - Ion-exchange chromatography, Gelfiltration, Affinity chromatography, Reverse phase chromatography; Molecular mass determination - SDS PAGE, LC-MS, Immobilization techniques.

**Antibiotics** – Methods of assay. Mass production using fomenterers - Optimization of culture conditions, Application of statistical tools and soft wares for mass production; Separation and techniques, Concentration, Structural elucidation.

**Production of probiotics**, Seaweed extraction and purification of major polysaccharides, characterization

**Single Cell Protein** - Mass production of bacteria, yeast and, algae - Optimization of culture conditions; Separation of biomass - Centrifugation, Cell aggregation and flocculation, Filtration; Drying - Spray drying, Freeze drying.

## References

1. Bryce, C.F.A. (Ed). 1999. Fermentation Microbiology and Biotechnology. Taylor and Francis. 308p.
2. Demain, AL, Davies, JE & Atlas, RM (1999) Manual of Industrial Microbiology and Biotechnology. American Society for Microbiology, Washington DC
3. Dube, H.C., 1994. A test book of fungi, bacteria & viruses, Vikas Publishing House. pp.240.
4. Fuller R. 1997. Probiotics 2. Springer, New York. 228p.
5. Kelly, J. 1991. Applications of Enzyme Biotechnology. Springer, New York.
6. Howard, G.C. and Betholl D.R. 2001. Basic Methods in Antibody Production and Characterization. CRC Press, Boca Raton. 271p.
7. Murray Ed Moo-Young 1986. Microbial Biomass Proteins, Springer, New York. 185p.
8. McCullough K.C. and Spier R.E. 1990. Monoclonal Antibodies in Biotechnology. Cambridge University Press, Cambridge. 399p.
9. Scheper, T. 2000. New Products and New Areas of Bioprocess Engineering. Springer, New York. 247p.
10. Stanbury P.F., Whitaker A. and Hall, S.J. 1998. Principles of Fermentation Technology, 2nd edn. Elsevier Science Publishers, BV, Amsterdam.
11. Waites. 2001. Industrial Microbiology. Blackwell Publishing. 304p.

## Semester – 2 ( 20 credits)

### Focus: Biotechnological approaches to Aquatic Animal Health Management

#### Core Papers

#### CAH 3201. Finfish and shellfish immunology – 3credits

Unit –1. Over view of vertebrate and invertebrate defense mechanisms; **Vertebrate Defense-** Elements of Immune system of vertebrates – the Ig domain, C1, C2, and V domains, and the I – set, Non – specific defense mechanisms – Integumental, phagocytosis, C – reactive proteins, Complement, Properdin, Lysosome, Interferon, Natural agglutinins, Lymphokines, Transferrin other cells involved in defense – Eosinophils, Mast Cells, Non – specific cyto toxic cell; Inflammatory response, Encapsulation; Specific Defense System – Humoral Immunity, Cell Mediated Immunity (CMI). **Invertebrate defense** – Fixed Defenses- Hard shell, Tegumental gland, Autotomy of appendages, Regeneration of appendages, Wound repair; Mobile Defense – Cellular Phagocytosis, Encapsulation, nodule formation, Humoral – Lectins, Lysins and agglutinins, pro-Phenol oxidase system;

Unit – 2. Molecular level analysis of vertebrate and invertebrate defense mechanism: Immunoglobulin loci in vertebrates, immune gene expression in vertebrates, immunoglobulin super family in invertebrates and the genes encoding, molecular evolution of invertebrate versus vertebrates

Unit – 3. Recent advances in understanding crustacean defense mechanism: Recent advances in the understanding of the haemocyte types, haemopoiesis, phagocytosis, nodule formation, encapsulation, cytotoxicity, lectins, the prophenol oxidase activating system, antimicrobial compounds, the clotting reaction, participation of proPo – compounds in cell to cell communication, parasites and the immune defense

Unit – 4. Recent advances in understanding finfish defense mechanism: Structure of immune organs, non-specific defense mechanisms- surface barriers, non-specific humoral factors, non-specific cellular factors, eosinophils, basophiles and mast cells, inflammation; specific defense mechanisms, lymphocytes, lymphoid organs- antigen trapping, immunoglobulins, cell mediated immunity, local immune response, mucosal immune response, memory factors affecting the immune response, immune gene and gene expression, vaccination in fishes.

Unit – 5. Immunostimulation and immunomodulation in finfish and shellfishes: Basic principles, methodology used in their study, applications, problems and prospects.

Unit – 6. Vaccination in cultured species: Concept of Vaccination in finfishes – response of the body to Vaccines, use of adjuvants, practical implications in vaccination, case studies; Concept of vaccinating invertebrates – recent advancements, DNA and recombinant vaccines.

## References:

1. Atass, M.Z, Absolom, D.R., Van OSS, C.J. 1984. Molecular Immunology: A Textbook. Marcel Dekker. 725p.
2. Beschin, A. and Muller, W.E.G. 2004. Invertebrate Cytokines and the Phylogeny of Immunity: Facts and Paradoxes. Springer. 184p.
3. Beck G. 2001. Phylogenetic Perspectives on the Vertebrate Immune System. Springer, New York. 388p.
4. Bright Singh, I.S., Somnath Pai, S., Philip R. & Mohandas, A. (Eds), 2003. Aquaculture Medicine, Centre for Fish Disease Diagnosis and Management, CUSAT, Cochin, P. 336.
5. Cooper. 2002. The Interphase Between Innate and Acquired Immunity. Springer, 116p.
6. Gal Y.L. and Halvorson. 1998. New Developments in Marine Biotechnology. Springer, 343p.
7. Louis Du Pasquier, 2001. Immune system of invertebrates and vertebrates – Review, Comparative Biochemistry and Physiology Part B 129: 1-15.
8. Marshall S.H. and Arenas, G. (2003). Antimicrobial peptides: A natural alternative to chemical antibiotics and a potential for applied biotechnology. Electronic Journal of Biotechnology Vol.6 No.2, 271-284
9. Mente, E. 2003. Nutrition, Physiology and Metabolism in Crustaceans, Science Publishers, USA. 170p.
10. Ratcliffe N.A. and Rowley A.F. (Rds.) Invertebrate blood cells, 2. Academic Press, London, New York.
11. Soderhall K. and Cerenius, L. 1992. Crustacean Immunity, Annual Review of Fish Diseases, pp3-23.
12. Svobodová, Z. and Vykusová, B.(Eds.). 1991. Diagnostics, prevention and therapy of fish diseases and intoxications. Manual for International Training Course on Fresh-Water Fish Diseases and Intoxications: Diagnostics, Prophylaxis and Therapy. ISBN 80-901087-0-9
13. Větvicka V. and Sima P. 1998. Evolutionary Mechanisms of Defense Reactions. Birkhauser, Berlin. 250p.
14. Wedmeyer, G.A. 1996. Physiology of Fish in Intensive Culture Systems. Springer, New York. 232p.
15. Verschuere, L. Rombaut, G. Sorgeloos, P. and Verstraete, W. (2000). Probiotic bacteria as biological control agents in aquaculture. Microbiology & Molecular Biology Reviews. 64(4): 655-671.

## CAH3202. High health brood stock development – 3 credits

Unit – 1. Concept of high health brood stock, Genetics and fish health, genetic manipulations of high health broodstock

Unit – 2. Selection and segregation of high health founder population: Molecular markers, and major genes in the genetic improvement of brood stock, RFLP, Microsatellite, minisatellites,

Unit – 3. Molecular breeding: Genetic selection of high health brood stock, selective breeding, breeding programme and segregation of offspring.

Unit – 4. High health brood stock development of cultivable fin fishes and shell fishes, microsatellite markers in high health broodstock development, segregation of SPF, SPR and high health broodstock, selection from wild population and cultured population, quarantine systems, biosecurity programme implementation, establishment of founder population, improved SPF and SPR larval population, multiplication centers for high health broodstock and commercial hatchery operations, recirculatory systems in broodstock development.

Unit – 5. Transgenesis in high health brood stock development: Concept of Transgenesis for high health brood stock, basic methodology, gene identification, cloning, transformation and expression, transference of the genetic trait to F1, F2, F3 generation, advantages of transgenics in high health brood stock development, examples, environmental risk associated with transgenic fishes, ethical issues involved.

Unit – 6. SPF & SPR brood stock development: Disease resistant fin fishes and shell fishes, Definition of SPF & SPR populations, methods to attain,

## References:

1. Bright Singh, I.S., Somnath Pai, S., Philip R. & Mohandas, A. (Eds), 2003. Aquaculture Medicine, Centre for Fish Disease Diagnosis and Management, CUSAT, Cochin, P. 336.
2. Chistiakov, D.A., Hellemans, B., Volckaert, F.A.M. 2006. Microsatellites and their genomic distribution, evolution, function and applications: A review with special reference to fish genetics Aquaculture 255: 1–29
3. Dunham R.A. 2004. Aquaculture and Fisheries Biotechnology: Genetic Approaches. CABI Publishing Wallingford, Oxfordshire (UK). 400 p.
4. Ennion S. and Goldspink G. 1996. Gene Expression and Manipulation in Aquatic Organisms. Cambridge University Press. 228p
5. Hahn K., Brown C.L. and G.D. Pruder. 1994. Standard Agricultural Practices for the Culture of Specific Pathogen Free Organisms and their Application to Aquaculture. Reviews in Fisheries Science. 2(2): 315-330.
6. Hayes, B., He, J., Moen, T., Bennewitz, J. 2006. Use of molecular markers to maximise diversity of founder populations for aquaculture breeding programs. Aquaculture 255:573–578
7. Maclean, N., Penman, D., 1990. The application of gene manipulation to aquaculture. Aquaculture 85, 1–20.
8. McVey, M.P. and McVey, P.J. 1993. CRC Handbook of Mariculture: Crustacean aquaculture, 2<sup>nd</sup> Edition. CRC Press, Boca Raton. 544p.
9. Nash, C.E. and Novotny. 1995. Production of Aquatic Animals: World Animal Science Series. Elsevier Health Sciences. 405p.
10. Gjedrem T. (Ed.). 2005. Selection and Breeding Program in Aquaculture. Springer, New York. 364p.
11. Gong Z., Korzh, V., 2004. Fish Development and Genetics. World Scientific Publishing Co. Pte. Ltd. Singapore. 688p.
12. Lim C.R. and Webster, C.D. 2001. Nutrition and Fish Health. Haworth Press, New York. 365p.
13. Pillay T.V.R. and Kutty, M.N. 2005. Aquaculture: Principles and Practices. Blackwell Publishing. 624p.
14. Reinertsen H. and Haaland H. (Eds.). 1995. Sustainable Fish Farming. CRC Press. 312p.

## CAH3203. Disease Diagnosis and management 3 credits

Unit – 1. Pathogens and parasites of finfishes: **Bacteria** - Gram positive rods and cocci, Aeromonadaceae, Enterobacteriaceae, *Cytophaga* – *Flavobacterium* – *Flexibacter* group, Pseudomonadaceae, Vibrionaceae, Moraxellaceae, Halomonadaceae, Anaerobic pathogens, other miscellaneous group; – phenotypic, genotypic and serological characteristics of the pathogens, clinical isolation and diagnosis of the diseases, pathology, epidemiology, predisposing environmental factors; **Viruses** – DNA Viruses - Iridoviridae, Adenoviridae, Herpes viridae, RNA Viruses - Reoviridae, Aquareviridae, Birnaviruses, Picornaviridae, Nodaviridae, Togaviridae, Paramyxoviridae, Rhabdoviridae, Retroviridae - diagnosis, epidemiology, host range, global distribution, reservoirs of infection, carriers, Epizootic Ulcerative Syndrome, **Fungi** – Mastigomycotina – Oomycetes, Saprolegniales, Achlya, Aphanomyces, Branchiomyces, Chytridiomycetes - Dermocystidium, Zygomycotina Ichthyophonus hoferi, Deuteromycotina – Aspergillomycosis – Pathology, Diagnosis, identification, epidemiology, predisposing environmental factors; **Protozoans** – Coccidians, myxosporeans and microsporeans - Pathology, Diagnosis, identification, epidemiology, predisposing environmental factors; **Metazoans** – Platyhelminthes, Nematodes, cestodes, trematodes, Crustacea and miscellaneous species – host, tissue and organ specificity, pathology, distribution, intermediate hosts, lifecycle.

Unit – 2. Pathogens and parasites of shellfishes (Crustaceans): Bacteria: *Vibrio* sp., Chitinolytic bacteria, Gaffkemia of Lobsters, Rickettsia like infections, Luminescent *Vibrio*, fouling organisms – *Lucythrix* like organisms, *Flavobacterium* and *flexibacter* sp., Algae – *Nitzschia* sp., *Navicula* sp., *Amphiprorasp*, Filamentous blue green algae – *Spirulina subsala*, *Lyngbya* sp., *Schizothrix* sp., Protozoans – Ciliates – *Zoothamnium*, *Vorticella*, *Epistylis*; Microsporidians, Gregarine infection, Viruses – MBV, BP, HPV, WSSV, IHNV, TSV, YHV; Fungi – Larval Mycosis, *Fusarium* infection, Diagnosis.

Unit – 3. Pathogens and parasites of Molluscs/sea urchins, sea stars and sponges: Oyster velar virus, Haemocytic infection virus, Herpes type virus, Extracellular giant Rickettsiae, Coccidia, Haplosporidium, Microsporidians, Rickettsia like and Chlamydia like Organisms of oysters, *Vibrio* sp., Parasitic Nematodes of Sea urchins,

Unit – 4. Nutritional non infectious diseases and neoplasia: tumors of epithelia cell origin, tumors of mesenchymal origin, tumors of haemopoietic origin, tumors of nerve cell origin, tumors in crustaceans, Haemocytic neoplasia of oysters,

Unit – 5. Prophylactic methods in the management of finfish and shellfish diseases: Prophylactic methods in hatchery systems, Prophylactic methods during seed transportation, Prophylactic methods in grow out systems, Management of water and sediment quality, supplementing nutritional requirement, application of immunostimulants, probiotics, vaccines, avoidance of pathogens, environmental safety and compliances.

Unit – 6. Therapeutic methods in finfish and shellfish population: Applications of chemotherapeutic agents, mode of application, precautions to be taken, environmental impact, and residue in the animal body.

#### References:

1. Allen, Sher (Ed). 1988. Biology of Parasitism. A Molecular and Immunological Approach. Allen Press, New York.
2. Austin B. and Austin, D.A. 1999. Bacterial Fish Pathogens – disease of Farmed and Wild Fish, Springer, Published in Association with Praxis Publishing, P. 457
3. Bright Singh, I.S., Somnath Pai, S., Philip R. & Mohandas, A. (Eds), 2003. Aquaculture Medicine, Centre for Fish Disease Diagnosis and Management, CUSAT, Cochin, P. 336.
4. Buller, N.B. 2004. Bacteria for Fish and Other Aquatic Animals. A Practical Identification Manual. CABI Publishing. 400p.
5. Couch J.A. and Couch C.A. 1992. Pathobiology of marine and estuarine organisms. CRC Press, 576p.
6. Davidson, E. W. (Ed.) 1981. Pathogenesis of invertebrate microbial diseases, Allanheld, Osmum & Co, New Jersey,
7. Holdich, D.M., Lowery, R.S. (Ed.) 1988. Fresh water crayfish: Biology, Management and Exploitation, Croom Held, London Noga, E.J. 2000. Fish Diseases – Diagnosis and Treatment, Iowa State University Press/Ames, P. 367
8. Leung K.Y. 2004. Current Trends in the Study of Bacterial and Viral Fish and Shrimp Diseases. World Scientific Publishing Co. Pte. Ltd., Singapore. 432p.
9. Schaperclaus, W. Kulow, H. and Schreckenbach, K. 1991. Fish Diseases, Volumes 1 & 2, Published for United States Department of Interior and the National Science Foundation, Washington, D.C., by Amerind Publishing Co., Pvt., New Delhi.
10. Roberts, R.J. (Ed), 2001, Fish Pathology, W.B. Saunders, P. 672
11. Ribelin, W. E. and Migaki, G. 1975. The pathology of Fishes, The University of Wisconsin Press, 1003.
12. Sinderman, C.J. 1970. Principal Diseases of marine fish and shell fishes, Academic Press, London, New York, P. 369.
13. Poulin R. 2004. Parasites in Marine Systems. Cambridge University Press. 216p.
14. Provenzano, A. J. (Ed.) 1983 The Biology of Crustaceae, Vol. 6. Academic Press, New York.
15. Woo P.T.K. and Bruno, D.W. 1999. Fish Diseases and Disorders – Volume 1-3, CABI Publishing,
16. Wedemeyer, G.A. 1996. Physiology of Fish in Intensive Culture Systems. Springer, New York. 232p.

#### CAH 3204. Aquaculture Environment Management 3 credits

Unit – 1. Aquaculture environment quality – Water quality of seed production and grow out systems, fresh, brackish and marine – quantitative estimations – salinity, pH, turbidity, alkalinity, hardness, CO<sub>2</sub>, silicates, ammonia, nitrates, nitrites, organic nitrogen, total phosphorus, orthophosphates, sulphides, sulphate, chlorides, iron, BOD and COD, phytoplankton, zooplankton, bacterioplankton, primary and secondary productivity, nitrifying potential, H<sub>2</sub>S assimilation potential, sediment quality of grow out system – pH, E<sub>h</sub>, inorganic and organic nitrogen, inorganic and organic sulphur, inorganic and organic phosphorous, total organic carbon, cation exchange capacity, iron, sodium, potassium, sediment oxygen demand, calcium and magnesium.

Unit – 2. Benthic productivity in grow out system – benthic community in fresh, brackish and marine grow out system, benthic algae, sessile and sedentary animals, polychaetes, benthic productivity in relation to physical, chemical and biological quality of the sediment,

Unit – 3. Bioremediation in seed production and grow out systems – Detritus management, nitrification and H<sub>2</sub>S removal, commercial bioaugmentors, concept of *ex – situ* bioremediation, organic matter resuspension and bottom soil oxidation, anaerobiosis in grow out systems and the methods of management, role of electron acceptors in bioremediation, bioremediation and stress management.

Unit – 4. Recirculation aquaculture system - The concept of RAS, various designs of RAS both for seed production and grow out systems, bioreactor technology in RAS, basic kinetics problems and remedial measures, economic considerations.

Unit – 5. Zero water exchange culture system: carrying capacity of grow out systems under zero exchange mode, methods of determining carrying capacity, integrated disease management in zero water exchange culture system.

Unit – 6. Effluents from aquaculture systems – Impact of the effluent from aquaculture systems on the surrounding environment, increase of BOD, COD, TSD, TDS, antibiotic residue, detergents, other management chemicals, remedial measures.

#### References:

1. Bardach, J.E. 1997. Sustainable Aquaculture. John Wiley & Sons. 251p..
2. Boyd, C.A. and Tucker C.S. 1998. Pond Aquaculture Water Quality Management. Springer, New York
3. Coimbra J. (Ed). 2001. Modern Aquaculture in the Coastal Zone. Lessons and Opportunities. IOS Press, 302p.
4. Boyd, C.E. 1995. Bottom Soils, Sediment and Pond aquaculture. Springer, 350p.
5. Boyd, C.E. and Eyna, H.S. 1997. Dynamics of Pond Aquaculture. CRC Press. 437p.
6. Davenport. 2003. Aquaculture: The Ecological Issues. Blackwell Publishing. 89p.
7. Dunham R.A. 2004. Aquaculture and Fisheries Biotechnology: Genetic Approaches. CABI Publishing Wallingford, Oxfordshire (UK). 400 p.
8. Grasshoff, K., K. Kremling and Ehrhardt M. 1999. Methods of Sea Water Analysis. Wiley-VCH. 632p.
9. Kugelman, I.J., Van Gorder, S., 1991. Water and energy recycling in closed aquaculture systems. Engineering
10. Aspects of Intensive Aquaculture. Northeast Regional Agricultural Engineering Service, Ithaca, NY,
11. pp. 80– 87.
12. Lawson T.B. 1994. Fundamentals of Aquacultural Engineering. Springer, 364p.
13. Midelen A., Alex Milden, Redding T. and Reading T.A. 1998. Environmental Management for Aquaculture. Springer, New York. 244p.
14. Pillai, TVR and Kutty, M.N. 2005. Aquaculture: Principles and Practices. Blackwell Publishing. 624p.
15. Parsons T.R. and Strickland J.D..H. 1978. A Practical Handbook of Seawater Analysis. 2<sup>nd</sup> Edition. Fisheries Research Boards of Canada. 311p. Tucker, J. 1998. Marine Fish Culture. Springer. 760p.

#### CAH 3205. Aquaculture Medicine – 4 credits

Unit – 1. Diagnostics in finfish and shellfish health management: Antibody based diagnostics – monoclonal and polyclonal antibody based, various tools based on antibody, commercial kits available, economics, nucleic acid based diagnostics – PCR and its modifications, commercial kits available, economics, companies involved in the manufacturing of commercial tools for diagnostics; use of electron microscopy in disease diagnosis, detection and isolation of pathogens for disease diagnosis, importance and use of cell lines as tools for detection, isolation and study of viruses, rickettsias and other obligate pathogens of finfish and shell fishes; early disease diagnosis for protecting the crop – an integrative approach an aquaculture health management.

Unit – 2. Antimicrobials and chemotherapeutics in aquaculture: Antibacterial, antiviral, antiprotozoal and antimetazoal compound in aquaculture as prophylactic and therapeutic agents, antialgal compounds as weedicides, general management chemicals in aquaculture – chemical name and structure, target organisms, mode of action, mode of application, shelf life and storage, recommended dosage, metabolism of the drugs in the animal body, retentivity and mode of excretion, residue in the host species, host species



safety, environmental safety and operators safety, companies involved in manufacturing and marketing antimicrobials and chemotherapeutics in aquaculture.

Unit – 3. Probiotics in aquaculture: Origin and concept of probiotics in aquaculture, classification as gut probiotics and water/sediment probiotics, major groups of gut probiotics – *Lactobacillus* sp., *Lactococcus* sp., *Pediococcus* sp., *Leuconostoc* sp., *Carnobacterium* sp., *Bacillus* sp., *Vibrio* sp., *Aeromonas* sp., *Saccharomyces bouldardii*, *Alteromonas* sp., *Pseudomonas* sp., Origin/Status/Description, mode of action, target organism, impact on environment/ animal, fate of the organism in animal/environment, mode of application/recommended dosage, implication in human health; Water/Sediment probiotics – Detritus degraders, nitrifying bacteria, H<sub>2</sub>S splitting bacteria, Phosphate immobilizes, antagonistic microorganisms to various pathogens – Origin/Status/Description, mode of action, target organisms, impact on environment/animal, fate of the organisms in animal and environment, mode of application/recommended dosage, implication in human health; Companies manufacturing commercial probiotics, major research initiatives in this area.

Unit – 4. Immunostimulants: Concept and basic principle of immunostimulation in finfish and shell fishes; Fungal derivatives, Bacterial products, products from mycelial fungi, algal derivatives, synthetic compounds, animal and plant extracts, vitamins, hormones, cytokins and others – chemical structure, product name, mode of extraction/ preparation, source, active ingredients, mode of action, mode of application & recommended preparation required for applying in aquatic system, fate of the immunostimulants in animal body, side effects if any; companies manufacturing immunostimulants, major research initiatives in this area.

Unit – 5. Vaccines/ bacterins / hormones/ anaesthetics in aquaculture: Concept of vaccines and vaccination in finfish and shellfishes, global scenario of vaccination in finfishes, commercial fish vaccines available globally, fish vaccines in the tropics, Indian scenario, Bacterins – mode of preparation, commercial preparations available, Recombinant Vaccines, DNA vaccines – problems and prospects; Vaccinating invertebrates – problems and prospects; Application of hormones in aquaculture – Growth hormone (GH)/ Somatotropin, gonadotropin release hormone (Gn RH), Human Chorionic Gonadotropin (HCG & Chorionic gonadotropin (CG), 17 alpha methyltestosterone (MT), 17 alpha – methyl dihydrotestosterone (MDT), 17 alpha – ethynyltestosterone (ET), 17 beta – oestradiol (E2), 17 alpha – ethinyl oestradiol, diethylstilbestrol, serotonin – chemical name and structure, functional component, mode of action, mode of application, side effects in animals if any, deleterious effects in the environment, recommended preparation required for applying in aquaculture, metabolism of the hormone in the animal body and mode of excretion, residues in animals and environment, target organism, shelf life, uses, recommended dosage. hormones approved internationally; anaesthetics in aquaculture – characteristics of an ideal anaesthetic agent, route of administration, stages of anaesthesia, mode of action, factors influencing action of anaesthetics, anaesthetics and legislation, MS – 222, Benzocaine, Diazepam, Quinaldine & quinaldine sulphate, Metomidate, Etomidate, Barbitol Sodium, 2- phenoxyethanol, clove oil, menthol, carbondioxide – chemical name and structure, mode of action, mode of application, precaution, health status, dosage, side effects, metabolism and fate in the environment, Commercially available anaesthetics and anti-stress compounds.

Unit – 6. Aquaculture pharmacology/population medicine/Brood stock seed certification and quarantine and Aquaculture drug regulations: Methods of drug delivery – micro encapsulation and bio-encapsulation-pharmacokinetics and pharmacodynamics of drugs used in aquaculture; epidemiological approaches to aquatic disease control; principles and practices of brood stock/seed certification and quarantine; Principles and practice of aquaculture drug regulation.

## References:

1. Bright Singh, I.S., S.Somnath Pai, Rosamma Philip & A. Mohandas (Eds), 2003. Aquaculture Medicine, Centre for Fish Disease Diagnosis and Management, CUSAT, Cochin, P. 336.
2. Coll, M.J. and Dominiguez-Juncal J. 1995. Applications Of Monoclonal Antibodies In Aquaculture. *Biotech. Adv.* Vol. 13, pp. 45-73.
3. Fingerman, M. and Nagabhushanam, R. (eds.). 2000. Recent Advances in Marine Biotechnology, (Series) Immunobiology and Pathology. Science Publishers, USA, 392p.
4. Fingerman, M. and Nagabhushanam, R. (eds.) 2002. Recent Advances in Marine Biotechnology (Series) Seafood Safety and Human Health. Science Publishers, USA. 328p.
5. Heppell, J., Davis, H.L. 2000. Application of DNA vaccine technology to aquaculture. *Advanced Drug Delivery Reviews* 43 (2000) 29–43
6. Luis Balcazar, J., de Blas, I Ruiz-Zarzuola I., Cunningham, D., Vendrell, D., Luis Mu'zquiz, J. 2006. The role of probiotics in aquaculture. *Veterinary Microbiology* 114: 173–186

7. Marshall S.H. and Arenas, G. (2003). Antimicrobial peptides: A natural alternative to chemical antibiotics and a potential for applied biotechnology. *Electronic Journal of Biotechnology* Vol.6 No.2, 271-284
8. National Research Council.. 1998. The Use of Drugs in Food animals. National Academic Press, 253p.
9. Noga, E J. 2000. Fish Diseases – Diagnosis and Treatment, Iowa State University Press/Ames, P. 367
10. Raa J. The use of immunostimulatory substances in fish and shellfish farming. *Reviews in Fisheries Science* 1996;4:229–88.
11. Roberts R.J> (Ed), 2001, Fish Pathology, W.B. Saunders, P. 672
12. Shao, Z. 2001. Aquaculture pharmaceuticals and biologicals: current perspectives and future possibilities. *Advanced Drug Delivery Reviews* 50 (2001) 229–243
13. Smith V.J., Brown J.H. and Houton C. 2003. Immunostimulation in crustaceans: does it really protect against infection?. *Fish and Shellfish Immunology*. 15: 71-90
14. Svobodová, Z. and Vykusová, B.(Eds.). 1991. Diagnostics, prevention and therapy of fish diseases and intoxications. Manual for International Training Course on Fresh-Water Fish Diseases and Intoxications: Diagnostics, Prophylaxis and Therapy. ISBN 80-901087-0-9
15. Treves – Brown, K. M. 2000. Applied Fish Pharmacology, Kluwer Academic Publishers, P. 308
16. Verschuere, L. Rombaut, G. Sorgeloos, P. and Verstraete, W. (2000). Probiotic bacteria as biological control agents in aquaculture. *Microbiology & Molecular Biology Reviews*. 64(4): 655-671.
17. Vadstein, O. 1997. The use of immunostimulation in marine larviculture: possibilities and challenges. *Aquaculture* 155 (1997) 401-417

#### **Electives:**

##### **CAH3206. Organic Aquaculture - 1credit**

Concept of organic aquaculture – Principles and practices, organic production of seed, feed, and organic grow out systems, protocols for organic aquaculture, International certifying agencies, mode of operation of the certifying agencies, problems and prospects of introducing organic aquaculture in India; HACCP in Aquaculture.

Pre-requisite for granting the producer control, producer contract, standards, management practices, operational changes, documentation and inspection, certification, approval, labeling and marketing and ecolabelling.

Selection of site location, interaction with surrounding ecosystems, species and origin of stock. Breeding for organic culture: Design of holding tanks, water quality, stocking density, health and hygiene, oxygen supply, organic fertilization, feeding feed additives, transport and slaughtering, requirement of fish meal/oil used as feed, feed for augmenting protein content in organic aquaculture.

#### **References:**

1. Botta J.R. 1995. Evaluation of Seafood freshness Quality. Wiley-IEEE. 180p.
2. Jana, B.B. 2003. Sustainable Aquaculture. Global Perspectives. Haworth Press. 380p.
3. Lawson T.B. 1994. Fundamentals of Aquacultural Engineering. Springer, 364p. Welt, A.M. 1995. Seafood Regulations and Compliance Manual. Springer. 832p.
4. Midelen A., Alex Milden, Redding T. and Reading T.A. 1998. Environmental Management for Aquaculture. Springer, New York. 244p.
5. Pillai, TVR and Kutty, M.N. 2005. Aquaculture: Principles and Practices. Blackwell Publishing. 624p.
6. Pruder, G.D. 2004. Biosecurity: application in aquaculture. *Aquacultural Engineering* 32:3–10
7. Robert R Stickney, James P McVey. 2002. Responsible Marine Aquaculture. CABI Publishing, 320p.

### **CAH3207. Anatomy and physiology of cultivable finfish and shell fishes – 1credit**

Anatomy and physiology of cultivable species of finfishes and shell fishes – integumentary system, Musculoskeletal system, Respiratory system, circulatory system, blood haemolymph composition, haematopoietic tissue, reticuloendothelial system, renal and excretory system, digestive system, reproductive system, nervous system, swim – bladder, endocrine system, nutrition, metabolism and growth.

#### **References:**

1. David H Evans, James B Claiborne. 2005. The Physiology of Fishes. CRC Press. 601p.
2. Evan D.H. 1997. The Physiology of Fishes. CRC Press. 519p.
3. Jobling M. 1994. Environmental Biology of Fishes. Springer. 476p.
4. Wedemeyer, G.A. 1996. Physiology of Fish in Intensive Culture Systems. Springer, New York. 232p.

### **Practicals (Core)**

#### **CAH3208 Fin Fish and Shell Fish Immunology – 2 credits**

**Haematology** -Biochemical analysis of blood /haemolymph of Fish and prawn, Total cell count, agglutination assays, immunoprecipitation.

**Immunoassays** -Phagocytic index – Neutral Red uptake assay and respiratory burst activity (NBT reduction); Enzymes -pro phenol oxidase activity Acid and Alkaline phosphatase and peroxidase activity., lysozyme activity.

**Immunostimulants** – Administration in fish and prawns. Estimation of the immunostimulant property.

**Antimicrobial peptides** – Isolation and identification

**Antioxidants** – Analysis of blood /Haemolymph and tissues for antioxidant enzymes and products.

**Antibodies** –Demonstration of polyclonal and monoclonal antibodies, western blotting, ELISA, antibody purification by affinity chromatography, FISH.

**Virus purification** – Virus detection and enumeration

#### **References:**

1. Fingerman, M. and Nagabhushanam, R. (eds.) 2002. Recent Advances in Marine Biotechnology (Series) Seafood Safety and Human Health. Science Publishers, USA. 328p.
2. Fingerman, M. and Nagabhushanam, R. (eds.). 2000. Recent Advances in Marine Biotechnology, (Series) Immunobiology and Pathology. Science Publishers, USA, 392p.
3. Hudson, L. and Hay, F. 1930. Practical Immunology. Blackwell Scientific Publications, London.
4. Louis Du Pasquier, 2001. Immune system of invertebrates and vertebrates – Review, Comparative Biochemistry and Physiology Part B 129: 1-15.
5. Marshall S.H. and Arenas, G. (2003). Antimicrobial peptides: A natural alternative to chemical antibiotics and a potential for applied biotechnology. Electronic Journal of Biotechnology Vol.6 No.2, 271-284
6. Ratcliffe N.A. and Rowley A.F. (Rds.) Invertebrate blood cells, 2. Academic Press, London, New York.
7. Soderhall K. and Cerenius, L. 1992. Crustacean Immunity, Annual Review of Fish Diseases, pp3-23.
8. Svobodová, Z. and Vykusová, B.(Eds.). 1991. Diagnostics, prevention and therapy of fish diseases and intoxications. Manual for International Training Course on Fresh-Water Fish Diseases and Intoxications: Diagnostics, Prophylaxis and Therapy. ISBN 80-901087-0-9
9. Verschuere, L. Rombaut, G. Sorgeloos, P. and Verstraete, W. (2000). Probiotic bacteria as biological control agents in aquaculture. Microbiology & Molecular Biology Reviews. 64(4): 655-671.

## CAH3209. Disease Diagnosis and Management – 2 credits

**Diagnosis-** First level on basic diagnosis – Water quality, behaviour, gross external features. Second level on Laboratory based diagnosis- Fish sampling for laboratory observation, clinical study – skin and gill biopsy, Collection of blood samples, examination of internal organs. Histological methods, Microbiological methods, Isolation of aetiological agents - identification, characterization, Immunodiagnostic techniques – Agglutination test, precipitation tests, radial immunodiffusion, immunoelectrophoresis, countercurrent electrophoresis, Immunofluorescence, ELISA, Use of cell lines in disease diagnosis, Bioassay, Electron microscopy in disease diagnosis, nucleic acid probes, Dot blot hybridization, *in situ* hybridization, polymerase chain reaction.

**Management:** Prophylaxis- Environmental management, bioremediation, application of probiotics, vaccines; Therapy – Application of antibiotics in non-edible fish, other chemotherapeutants.

### References:

1. Austin, B. and Austin, D.A. 1999. Bacterial Fish Pathogens – disease of Farmed and Wild Fish, Springer, Published in Association with Praxis Publishing, P. 457
2. Bright Singh, I.S., Somnath Pai S., Rosamma Philip and Mohandas, A. (Eds), 2003. Aquaculture Medicine, Centre for Fish Disease Diagnosis and Management, CUSAT, Cochin, P. 336.
3. Buller, N.B. 2004. Bacteria from Fish and Other Aquatic Animals: A Practical Identification Manual. CABI Publishing, Cambridge. 361p.
4. Davidson, E. W. (Ed.) 1981. Pathogenesis of invertebrate microbial diseases, Allanheld, Osmum & Co, New Jersey
5. Edward J. Noga, 2000. Fish Diseases – Diagnosis and Treatment, Iowa State University Press/Ames, P. 367
6. Holdich, D.M. and Lowery, R.S. (Ed.) 1988. Fresh water crayfish: Biology, Management and Exploitation, Croom Held, London.
7. Leung, K.Y. 2004. Current Trends in the Study of Bacterial and Viral Fish and Shrimp Diseases. World Scientific, 432p.
8. Louis Du Pasquier, 2001. Immune system of invertebrates and vertebrates – Review, Comparative Biochemistry and Physiology Part B 129: 1-15.
9. Provenzano, (J. Ed.) 1983 The Biology of Crustaceae, Vol. 6. Academic Press, New York.
10. Ribelin, W. E. and Migaki, G. 1975. The pathology of Fishes, The University of Wisconsin Press, 1003.
11. Ratcliffe, N.A. and Rowley, A.F. (Eds.) Invertebrate blood cells, 2. Academic Press, London, New York.
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13. Soderhall, K. and Cerenius, L. 1992. Crustacean Immunity, Annual Review of Fish Diseases, pp3-23.
14. Sinderman, C.J. Principal Diseases of marine fish and shell fishes, Academic Press, London, New York, P. 369.
15. Schaperclaus, W., Kulow, H. and Schreckenbach, K. 1991. Fish Diseases, Volumes 1 & 2, Published for United States Department of Interior and the National Science Foundation, Washington, D.C., Amerind Publishing Co., Pvt., New Delhi.
16. Treves – Brown, K. M. 2000. Applied Fish Pharmacology, Kluwer Academic Publishers, P. 308
17. Woo, P.T.K. and Bruno, D.W. 1999. Fish Diseases and Disorders – Volume 1-3, CABI Publishing,

**Note on Reference Books:** As such appropriate reference books on the subject are very less. Intention of the course is to take the students to the frontiers of knowledge and therefore every paper will end with a thorough examination of the literature on the subject to the current year. This will form part of the assignment given to the students during the period.

### CAH 3301. Semester 3 & 4

**A. Full Time Project Work 30 credits**  
**B. Submission of Write up on Marine Biotechnology Industry and an hour presentation: 10 Credits**

**Note on the 3<sup>rd</sup> and 4<sup>th</sup> semester:** During the period of One year the candidate will be working in an R&D Lab of any Biotech Industry.

**Total Credits:** Semester 1 = 20, Semester 2 = 20, Semester 3 & 4 = 40, **Total = 80**