ANNAMALAI UNIVERSITY
ANNAMALAINAGAR

HAND BOOK

DEGREE OF MASTER OF SCIENCE
MARINE BIOTECHNOLOGY
(CHOICE BASED CREDIT SYSTEM)

2018 – 2019

ANNAMALAI UNIVERSITY
ANNAMALAI NAGAR

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MARINE BIOTECHNOLOGY
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FACULTY OF MARINE SCIENCES

REGULATIONS

MASTER'S PROGRAMME

A Master's Programme consists of a number of courses. Master's Programme consists of a set of Core Courses and elective Courses.

Core courses are basic courses required for each programme. The number and distribution of credits for core courses will be decided by the faculty.

Elective course will be suggested by the respective department(s), and it may be distributed in IV semester.

A course is divided into five units to enable the students to achieve modular and progressive learning.

SEMESTERS

An academic year is divided into two semesters, Odd Semester and Even Semester. The normal semester periods are:

Odd Semester: July to November (90 Working days)

Even Semester: December to April (90 Working days)

CREDITS

The term credit is used to describe the quantum of syllabus for various programmes and hours of study. It indicates differential weightage given according to the contents and duration of the courses in the curriculum design.

The minimum credit requirement for a two year Master's Programme shall be 98.

The core courses shall carry 96 credits and the elective course shall carry 2 credits.

ELIGIBILITY

Under graduate Degree in Biotechnology, Biochemistry, Microbiology, Industrial Microbiology, Industrial Fish and Fisheries, Agricultural Microbiology, Plant Science & Biotechnology and Animal Science & Biotechnology, Plant Biology & Plant Biotechnology, Plant Science, Zoology, Animal Science, Biotechnology & Bioinformatics, Bioinformatics, Chemistry, Animal Biotechnology, Advanced Zoology & Biotechnology, B.Tech. Biotechnology/ Genetic Engineering with a minimum of 50% marks in part – III.

COURSES

Each course may consist of lectures / laboratory work / seminar / project work / practical training / report / viva voce etc.

COURSE WEIGHT

Core and elective courses may carry different weightage. For example, a course carrying one credit for lectures, will have instruction of one period per week during the semester, if three hours of lecture is necessary in each week for that course then 3 credits will be the weightage. Thus normally, in each of the courses, credits will be assigned on the basis of the lectures / laboratory work and other form of learning in a 15 week schedule:

(i) One credit for each lecture period per week.

(ii) One credit for every three periods of laboratory or practical work per week.

(iii) One credit for 3 contact hours of project work in a week.

(iv) One credit for every two periods of seminar.

GRADING SYSTEM

The term Grading System indicates a 10-point scale of evaluation of the performance of students in terms of marks, grade points, letter grade and class.

DURATION

The duration for completion of a two year Master's Programme is four semesters.

STRUCTURE OF THE PROGRAMME

The Master's Programme will consist of:

(i) Core courses which are compulsory for all students.
(ii) Elective course which students can choose from amongst the courses offered the faculty as well as by Departments of other faculties (Arts, Science, Education and Indian Language).
(iii) The Elective subjects will be allotted by counseling by a committee of the respective Heads of the Departments under the Chairmanship of the Dean of the Faculty.
(iv) Dissertation / Project work / Practical training / Field work can be done in an organization (Government, Industry, Firm, Public Enterprise etc.) approved by the concerned department.

ATTENDANCE

Every teaching faculty handling a course shall be responsible for the maintenance of attendance register for candidates who have registered for the course.

The teacher of the course must intimate the Head of the Department at least Seven Calendar days before the last instruction day in the semester about the attendance particulars of all students.

Each student should fulfil the attendance requirement of 75% as prescribed by the University, to be eligible to appear for the University Examinations.

EXAMINATIONS

The internal assessment for each course carries 25% marks and is based on two sessional tests. The pattern of question paper will be decided by the faculty. The tests are compulsory.

There will be one End Semester Examination (75% marks) of 3 hours duration for each course. The pattern of question paper will be decided by the faculty.

The Internal assessment for each practical course carries 40% of marks while the end semester practical examination of 4 hours duration carries 60% of marks.

EVALUATION

The performance of a student in each course is evaluated in terms of Percentage of Marks (PM) with a provision for conversion to Grade Point (GP). The total performance in each semester will be rated by Grade Point Average (GPA) while the continuous performance from the 2nd Semester onwards will be marked by Overall Grade Point Average (OGPA).

MARKS AND GRADING

A student cannot repeat the assessment of Sessional Test I and Sessional Test II. However, if for any compulsive reason, the student could not attend the test, the prerogative of arranging a special test lies with the teacher in consultation with the Head of the Department.

A student has to secure 50% minimum in the End Semester Examination.

The student who has not secured a minimum of 50% of marks (sessional plus end semester examination) in a course shall be deemed to have failed in that course.

A candidate who has secured a minimum of 50% marks in all the papers prescribed in the programme and earned a minimum of 98 credits will be considered to have passed the Master's Programme.

GRADING

A ten point rating scale is used for the evaluation of the performance of the student to provide letter grade for each course and overall grade for the Master's Programme.

Marks	Grade	Letter grade	Class
90 and above	10	S	Exemplary
85 – 89	9.0	D	Distinction
80 – 84	8.5	D	Distinction
75 – 79	8.0	D	Distinction
70 – 74	7.5	A	First Class
65 – 69	7.0	A	First Class
60 – 64	6.5	A	First Class
55 – 59	6.0	B	Second Class
50 – 54	5.5	C	Second Class
49 or Less	-	F	Fail

The successful candidates are classified as follows:

I Class – 60% Marks and above in overall percentage of Marks (OPM).

II Class – 50-59% Marks in overall percentage of marks.

Candidates who obtain 75% and above but below 90% of marks (OPM) shall be deemed to have passed the examination in FIRST CLASS (Distinction) provided he / she passes all the papers prescribed for the programme at the first appearance.

For the Internal Assessment Evaluation, the details shall be as follows:

Test (2 tests)	-	15
Assignment	-	5
Seminar	-	5

Total	-	25 Marks

COURSE – WISE LETTER GRADES

The percentage of marks obtained by a candidate in a course will be indicated in a letter grade.

A student is considered to have completed a course successfully and earned the credits if he / she secures an overall letter grade other than F. A letter grade F in any course implies a failure in that course. A course successfully completed cannot be repeated for the purpose of improving the Grade point.

The F grade once awarded in the grade card of the student is not deleted even when he / she completes the course successfully later. The grade acquired later by the student will be indicated in the grade sheet of the odd / even semester in which the candidate has appeared for clearance of the arrears.

A student who secures F grade in any course which is listed as a core course has to repeat it compulsorily when the examination is held next. If it is an Elective course, the student has the option to repeat it when it is offered next or to choose a new elective if he / she so desires in order to get a successful grade. When new elective is chosen in the place of failed elective, the failed elective will be indicated as dropped in the subsequent grade card.

If a student secures F grade in the Project Work / Field Work / Practical Work / Dissertation, he / she shall improve it and resubmit it if it involves only rewriting incorporating the clarifications of the evaluators or he / she can re-register and carry out the same in the subsequent semesters for evaluation.

M. Sc. MARINE BIOTECHNOLOGY

CHOICE BASED CREDIT SYSTEM - 2018 – 2019

I SEMESTER

MBTC	101	Biochemistry
MBTC	102	Molecular Biology
MBTC	103	Fisheries Resources, Conservation and Oceanography
MBTC	104	Marine Microbiology
MBTC	105	Biostatistics
MBTC	106	Biophysical Principles and Analytical Techniques
MBTP	107	Practical – I (Biochemistry and Analytical Techniques)
MBTP	108	Practical – II (Microbiology and Experimental Methods in Fisheries)
MBTP	109	Seminar / Journal Club / Assignment / Communication skills

II SEMESTER

MBTC	201	Cell and Developmental Biology
MBTC	202	Genetic Engineering
MBTC	203	Aquaculture Bioprocessing and Pharmacology
MBTC	204	Fish Immunology and Health Management
MBTC	205	Aquatic Environmental Biotechnology
MBTP	206	Practical – III (Molecular Biology and Genetic Engineering)
MBTP	207	Practical – IV (Aquaculture and Fish Immunology and Health Management)
MBTP	208	Practical – V (Aquatic Environmental Biotechnology)
MBTP	209	Seminar / Journal Club / Assignment / Communication skills

III SEMESTER

MBTC	301	Marine Bioprocess Technology
MBTC	302	Aquaculture Biotechnology
MBTC	303	Bioinformatics
MBTC	304	Intellectual Property Rights, Biosafety and Bioethics
MBTC	305	Bioentrepreneurship
MBTP	306	Practical – VI (Bioprocess Technology)
MBTP	307	Practical – VII (Aquaculture Biotechnology)
MBTP	308	Practical – VIII (Bioinformatics and Biostatistics)
MBTP	309	Project Proposal Preparation and Presentation

IV SEMESTER

MBTC	401	Dissertation
MBTC	402	Elective

M.Sc. MARINE BIOTECHNOLOGY

CREDITS, INTERNAL ASSESSMENT MARKS AND ENDSEMESTER EXAM MARKS

Course Code Theory/Practical	Credit Points	Int. Ass.	End Sem. Exam Marks	Total Marks
I SEMESTER				
MBTC 101 Biochemistry	3	25	75	100
MBTC 102 Molecular Biology	3	25	75	100
MBTC 103 Fisheries Resources, Conservation and Oceanography	4	25	75	100
MBTC 104 Marine Microbiology	2	25	75	100
MBTC 105 Biostatistics	2	25	75	100
MBTC 106 Biophysical Principles and Analytical Techniques	2	25	75	100
MBTP 107 Practical – I (Biochemistry and Analytical Techniques)	4	40	60	100
MBTP 108 Practical – II (Microbiology and Experimental Methods in Fisheries)	4	40	60	100
MBTP 109 Seminar / Journal Club / Assignment / Communication Skills	1	40	60	100
Total	**25**			
II SEMESTER				
MBTC 201 Cell and Developmental Biology	3	25	75	100
MBTC 202 Genetic Engineering	3	25	75	100
MBTC 203 Aquaculture Bioprocessing and Pharmacology	3	25	75	100
MBTC 204 Fish Immunology and Health Management	3	25	75	100
MBTC 205 Aquatic Environmental Biotechnology	2	25	75	100
MBTP 206 Practical – III (Molecular Biology and Genetic Engineering)	4	40	60	100
MBTP 207 Practical – IV (Aquaculture and Fish Immunology and Health Management)	4	40	60	100
MBTP 208 Practical – V (Aquatic Environmental Biotechnology)	2	40	60	100
MBTP 209 Seminar / Journal Club / Assignment / Communication Skills	1	40	60	100
Total	**25**			

III SEMESTER				
MBTC 301 Marine Bioprocess Technology	3	25	75	100
MBTC 302 Aquaculture Biotechnology	3	25	75	100
MBTC 303 Bioinformatics	2	25	75	100
MBTC 304 Intellectual Property Rights, Biosafety and Bioethics	2	25	75	100
MBTC 305 Bioentrepreneurship	2	25	75	100
MBTP 306 Practical – VI (Bioprocess Technology)	2	40	60	100
MBTP 307 Practical – VII (Aquaculture Biotechnology)	2	40	60	100
MBTP 308 Practical – VIII (Bioinformatics and Biostatistics)	2	40	60	100
MBTP 309 Project Proposal Preparation and Presentation	2			100
Total	**20**			
IV SEMESTER				
MBTC 401 Dissertation	26	25	75	100
MBTC 402 Elective	2	25	75	100
Total	**28**			

Credit

Core	**Optional**	**Total Credit**
96	2	98

Suggested Electives

1. Genetics and Proteomics
2. Nanobiotechnology
3. Molecular Diagnostics
4. Marine Food Technology
5. Stem Cell Biology

I SEMESTER
MBTC 101 BIOCHEMISTRY

Course Objectives:

The objectives of this course are to build upon undergraduate level knowledge of biochemical principles with specific emphasis on different metabolic pathways. The course shall make the students aware of various disease pathologies within the context of each topic.

Student Learning Outcomes:

On completion of this course, students should be able to:

- Gain fundamental knowledge in biochemistry;
- Understand the molecular basis of various pathological conditions from the perspective of biochemical reactions.

Unit I Chemical basis of life and proteins

Chemical basis of life: Miller-Urey experiment, abiotic formation of amino acid oligomers, composition of living matter; Water – properties of water, essential role of water for life on earth pH, buffer, maintenance of blood pH and pH of gastric juice, pH optima of different enzymes (pepsin, trypsin and alkaline phosphatase), ionization and hydrophobicity, emergent properties of biomolecules in water, biomolecular hierarchy, macromolecules, molecular assemblies; Structure-function relationships: amino acids – structure and functional group properties, peptides and covalent structure of proteins, elucidation of primary and higher order structures, Ramachandran plot, evolution of protein structure, protein degradation and introduction to molecular pathways controlling protein degradation, structure-function relationships in model proteins like ribonuclease A, myoglobin, hemoglobin, chymotrypsin *etc.*; basic principles of protein purification; tools to characterize expressed proteins; Protein folding: Anfinsen's Dogma, Levinthal paradox, cooperativity in protein folding, free energy landscape of protein folding and pathways of protein folding, molten globule state, chaperons, diseases associated with protein folding, introduction to molecular dynamic simulation.

Unit II Enzyme kinetics

Enzyme catalysis – general principles of catalysis; quantitation of enzyme activity and efficiency; enzyme characterization and Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation, activation, inhibition and covalent modification; single substrate enzymes; concept of catalytic antibodies; catalytic strategies with specific examples of proteases, carbonic anhydrases, restriction enzymes and nucleoside monophosphate kinase; regulatory strategies with specific example of hemoglobin; isozymes; role of covalent modification in enzymatic activity; zymogens.

Unit III Glycobiology

Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose, glycosylation of other biomolecules-glycoproteins and glycolipids; lipids- structure and properties of important members of storage and membrane lipids; lipoproteins.

Unit IV Lipids, DNA and RNA

Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane bound proteins - structure, properties and function; transport phenomena; nucleosides, nucleotides, nucleic acids - structure, a historical perspective leading up to the proposition of DNA double helical structure; difference in RNA and DNA structure and their importance in evolution of DNA as the genetic material.

Unit V Bio-energetics

Bioenergetics-basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels; recurring motifs in metabolism; Introduction to GPCR, Inositol/DAG//PKC and Ca++ signaling pathways; glycolysis and gluconeogenesis; reciprocal regulations and non-carbohydrate sources of glucose; Citric acid cycle, entry to citric acid cycle, citric acid cycle as a source of biosynthetic precursors; Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F1-F0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation; Photosynthesis – chloroplasts and two photosystems; proton gradient across thylakoid membrane.

Unit VI Role of vitamins & cofactors in metabolism

Calvin cycle and pentose phosphate pathway; glycogen metabolism, reciprocal control of glycogen synthesis and breakdown, roles of epinephrine and glucagon and insulin in glycogen metabolism; Fatty acid metabolism; protein turnover and amino acid catabolism; nucleotide biosynthesis; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and mevalonate pathway; elucidation of metabolic pathways; logic and integration of central metabolism; entry/ exit of various biomolecules from central pathways; principles of metabolic regulation; steps for regulation; TOR (target of rapamycin) & autophagy regulation in relation to C & N metabolism, starvation responses and insulin signaling.

Recommended Textbooks and References:

1. Stryer, L. (2015). *Biochemistry* (8th ed.). New York: Freeman.
2. Lehninger, A. L. (2012). *Principles of Biochemistry* (6th ed.). New York, NY: Worth.
3. Voet, D., & Voet, J. G. (2016). *Biochemistry* (5th ed.). Hoboken, NJ: J. Wiley & Sons.
4. Dobson, C. M. (2003). *Protein Folding and Misfolding*. Nature, 426(6968), 884-890. doi:10.1038/nature02261.
5. Richards, F. M. (1991). *The Protein Folding Problem.* Scientific American, 264(1), 54-63. doi:10.1038/scientificamerican0191-54.

MBTC 102 MOLECULAR BIOLOGY

Course Objectives

The aim of this course is to obtain and understand fundamental knowledge of molecular and cellular processes: epigenetics, gene regulation, RNA transcription, protein synthesis, protein targeting and trafficking, and cell signaling. Students participate in a computer tutorial aimed at mastering basic web tools for genome and proteome analysis. The knowledge discussed in the lectures and practiced at the computer tutorial is the basis for an assignment that aims to train students in a critical evaluation of literature. Through presentation of their topic and feedback of lecturers and their peers, students become acquainted with the scientific method.

Student Learning Outcomes

Upon successful completion of this course, students should be able to:

- Explain and summarize the scientific principles of the molecular biology of DNA and RNA;
- Use specialized DNA/RNA isolation, manipulation, and cloning methods, individually and collaboratively that are typical of molecular biology laboratory investigations and communicate the results as written laboratory reports;
- Describe and explain the results of DNA and/or RNA experiments based on the scientific principles of nucleic acid structure.

Unit I DNA structure and genome organization

Structure of DNA - A,B, Z and triplex DNA; Central dogma, DNA as genetic material; Organization of bacterial genome; Structure of eukaryotic chromosomes: DNA compaction, nucleosome, 10 nm "beads-on-a-string" fibre, 30 nm chromatin fibre and metaphase chromosome; Nuclear matrix in chromosome organization and function; Heterochromatin and Euchromatin; DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis); Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects.

Unit II DNA replication, repair and recombination

Replication: initiation, elongation and termination in prokaryotes and eukaryotes; Enzymes and accessory proteins and mechanisms; Fidelity; Replication of single stranded circular DNA; link with cell cycle; DNA damaging agents - Physical, chemical and biological mutagens; types of damage caused by endogenous and exogenous agents; mutations- Nonsense, missense, silent and point mutations, frameshift mutations; Intragenic and Intergenic suppression. DNA repair mechanisms- direct reversal, photoreactivation, base excision repair, nucleotide excision repair, mismatch repair, double strand break repair, SOS repair; Recombination: Chi sequences in prokaryotes; Homologous,non-homologous and site specific recombination.

Unit III RNA transcription, RNA processing and regulation in prokaryotes

Structure and function of prokaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes); Prokaryotic Transcription -RNA polymerase and sigma factors, Transcription unit, Promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent); Processing of mRNA, rRNA and tRNA transcripts; Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac, trp, his* operons, attenuation, anti-termination, stringent control, translational control, DNA re-arrangement, two component system; regulatory RNA – riboswitch, tmRNA, antisense RNA; transcriptional control in lambda phage.

Unit IV RNA transcription, RNA processing and regulation in eukaryotes

Structure and function of eukaryotic mRNA, tRNA (including initiator tRNA) and rRNA (and ribosomes). Eukaryotic transcription - RNA polymerase I, II and III mediated transcription: RNA polymerase enzymes, eukaryotic promoters and enhancers, General Transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs; Processing of hnRNA, tRNA, rRNA; 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of tRNA and hnRNA; snRNPs and snoRNPs in RNA processing; Regulation of RNA processing: capping, splicing, polyadenylation; mRNA stability and degradation: degradation and surveillance pathways; RNA editing; Nuclear export of mRNA; Catalytic RNA: Group I and Group II introns splicing, Peptidyl transferase; Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; Silencers and insulators, enhancers, mechanism of silencing and activation; Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; 2C 2H zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loop-helix), nuclear receptors; Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors; Nuclear receptor; histone modifications and chromatin remodeling; Methods for studying DNA-protein interaction: EMSA, DNase I footprinting, methylation interference assay, chromatin immunoprecipitation.

Unit V Protein translation, post translational modifications and control in prokaryotes and eukaryotes

Ribosomes; Composition and assembly; universal genetic code; Genetic code in mitochondria; Degeneracy of codons; Termination codons; Wobble hypothesis; Isoaccepting tRNA; Translational machinery; Mechanism of Translation in prokaryotes and eukaryotes; Co- and Post-translational modifications of proteins; triple helix of collagen; Translational control; Protein stability; Protein turnover and degradation.

Recommended Text Books and References:

1. Krebs JE, Goldstein ES and Kilpatrick ST (2014) *Lewin's Gene XI*, Jones and Barlett Publishers.
2. RF Weaver *Molecular Biology* 5th edition (2012) McGraw Hill Higher Education
3. Watson JD, Baker TA, Bell SP, Gann A, Levine M & Losick R (2014) *Molecular*
4. *Biology of the Gene*, 7th Edition, Cold Spring Harbor Laboratory Press, New York.

MBTC 103 Fisheries Resources, Conservation and Oceanography

Course Objectives

The objectives of this course are to:
- Introduce students to marine environment and its physical features;
- Introduce students to principal marine fisheries of India;
- Educate students on status and trends of major fish resources and their conservation in region.

Student Learning Outcomes

Upon successful completion of this course, students should be able to:
- Understand status and trends of major fish resources in the region;
- Familiarise with factors influencing primary and secondary production.

Unit I **Marine biology and ecology**

Classification of marine environment, Types of aquatic habitats such as coral reefs, sand dunes, mangroves, sea grasses *etc.*, Diversity and taxonomy of marine organisms (Bacteria, Phytoplankton, zooplankton, seaweeds, sea grasses, mangroves, corals *etc.*),Species abundance, richness and diversity indices, Biogeography, Recruitment, Growth, Mortality, Culture of microalgae and invertebrates; Habitat preferences, Adaptations in marine organisms and energy transfer, Marine biomass and productivity - primary production, photosynthetic efficiency; secondary production, productivity distribution in ocean environment, Mechanism and factors affecting primary production, Assessment of impact of changing environment on biodiversity of coastal ecosystems - delineating natural and anthropogenic impacts, Ocean acidification and impacts on marine organisms, Bio-communication in oceans, Microbe-microbe interaction, Microbe-metazoa interaction, Population connectivity, Ecology of benthic organisms, Benthic biological processes and benthic biodiversity, Benthic-pelagic coupling, Bio-invasion ecology, Food web dynamics and ecosystem functioning, Microbial loop - Role of microbes in marine food web dynamics and biogeochemical processes; Bioluminescence and indicator species, Red tides.

Unit II **Biodiversity and conservation of aquatic species**

Principles, Importance; Fish genetic resources- survey and distribution; Marine living resources assessment - Principal methods of exploitation of marine living resources, Development of novel methods for optimisation of marine aquaculture; Influencing Factors, Planning and management; IUCN criteria-Red List; Wildlife protection Act; International Treaties & conventions; Marine protected Areas, Sanctuaries and Biosphere reserves, Establishment of Marine Parks, *in situ* and *ex situ* conservation; Cryopreservation of Gametes or Gene Banking; Institutes and societies involved in conservation; Artificial Hybridization: Heterosis, Control of fish diseases by selection; selective breeding of disease resistant fish; Marine Bioprospecting: Mining untapped potential of living marine resources; Molecular Tools in Conservation of Fisheries Resources: Molecular Markers: development of RAPD, RFLP, AFLP, ESTs, SNPs,
Micro-satellites and micro-satellites.

Unit III **Oceanography**

Physical Oceanography: Seawater and its properties; Air-Sea interaction; Geotrophy & large scale circulation of upper ocean; Tides, Waves, Currents, Ocean circulation and Monsoon; Chemical Oceanography: composition of sea water, including trace elements and dissolved organics, elemental and nutrient cycles, salinity & chemical transformations, Gas solubility; inorganic Characteristics of Seawater; Biological Oceanography: Living organisms of ocean: physical parameters & their effects on organisms; characteristics of organisms living in water column; Characterization of Marine Sediments - Constituents, Mass properties, Texture *etc.*; Molecular tool to study Bacterial diversity in sediments; Geographical and seasonal variation in plankton production and trophic dynamics; Indicator species.

Recommended Textbooks and References:

1. Carl E. Bond, (1996) *Biology of Fishes*, 2nd Edition, W.B. Saunders Company, Philadelphia
2. Miller RI, (1994) *Mapping the Diversity of Nature*, Chapman &HaIl. pp. 218
3. Heywood V.H., (1995) *Global Biodiversity Assessment*. UNEP, Cambridge University Press PP. 1140
4. Levitus, (2000) *Warming the World Ocean*, Science
5. Kortzinger, (2004) *The Ocean Takes a Breath*, Science
6. King, M., (1995). *Fisheries Biology: Assessment and Management, Fishing* News Books.
7. Agarwal *et. al.*,(1996). *Biodiversity and Environment*. APH, pp 351
8. Naskar K. and Mandal R., (1999) *Ecology and Biodiversity of Indian Mangroves*. Daya. pp 361
9. Jeffrey S. Levinton, CD (2001). *Marine Biology: Function, Biodiversity*, *Ecology* (515pp)
10. Artikeya, K., (2005) *Biodiversity: Extinction and Conservation*, (202pp).

MBTC 104 **Marine Microbiology**

Course Objectives

The objective of this course is to provide information about the microbes available in aquatic environment, their role and interaction with environment.

Student Learning Outcomes

After completing this course, students should be able to -

- Explain principle features of microbial diversity in oceans;
- Describe and discuss marine microbes in terms of physiological capability and biogeochemical role;
- Synthesize microbial ecosystem function in pelagic and benthic marine habitats.

Unit I **Marine microbial ecology and diversity**

Introduction: Marine environment, Seawater, Marine sediments, Habitats for marine microorganisms; Diversity of Marine microorganisms: Archaea, Bacteria, Cyanobacteria, Algae, Fungi, Viruses, viroids and prions and actinomycetes in coastal, shallow, deep sea, hydrothermal vents, mangrove and in coral ecosystem; Marine Symbiotic Microorganisms; Ecology: Survival of indigenous organisms and fate of non-indigenous organisms in the marine environment, Predatory-prey relationship (food-web), Degradation of complex molecules, Colonisation of surfaces Chemotaxis, Attachment, Symbiotic Association; Biogeochemical Processes:Nutrient cycling, Carbon cycle, Nitrogen cycle, sulphur cycle, Iron cycling, Phophorus cycling and other cycles. Photosynthesis, Quorum sensing, Temperature dependent microbial growth, Lethal and mutagenic factors, Protection system from osmotic damage; Taxonomy of Marine Microorganisms: Prokaryotes: Phototrophs containing bacterialchlorophyll, Cyanobacteria, Prochloron, Gliding bacteria, Budding and appendaged bacteria, Aerobic gram negative rods and cocci, Facultatively anaerobic gram negative rods, Gram negative anaerobic rods and cocci, Gram negative chemolithotrophs (ammonia or nitrogen oxidizing or sulphur bacteria), Methane bacteria, Aerobic positive cocci, Actinomycetes and related bacteria, Spirochaetes, Oceanospiralles, Magnetotactic bacteria, Bdellovibrio, Sulphur and sulphurreducing bacteria. Eukaryotes: Micro algae, Diatoms, Fungi, Yeast, Protozoa; Virus: Classification; Extremophiles.

Unit II **Techniques in marine microbiology**

Sampling: Water, Sediment and aquatic content (General Experimental Procedures and remote sensing). Direct observation and enumeration of microbes: Light and electron microscopy to study morphology and structure of microbes, Epifluorescence light microscopy - enumeration of marine microbes, confocal laser scanning microscopy - recognition of living microbes within their habitat, Flow cytometry - number and size of particles. Culture based methods for isolation and identification of microbes: Specific culture media and conditions for growth, Enrichment cultures, Phenotypic testing, Analysis of microbial components for classification and identification. Nucleic acid based methods: Sequencing of ribosomal RNA genes, Isolation of genomic DNA or RNA from the culture, PCR, Genomic finger printing, GC ratio and DNA-DNA hybridization used in taxanomy, DNA sequencing, Denaturing gradient gel electrophoresis (DGGE) and Terminal restriction fragment length polymorphism (TRFLP), Metagenomics, Fluorescent hybridization for

visualization and quantification of microbes, Metatranscriptomics, Metaproteomics and Microarrays.

Unit III **Marine microbiology of organisms**

Microbiology of healthy organisms: Plants, Invertebrates and Vertebrates; Diseases of Invertebrates: Vibriosis, Shell disease, Gaffkemia, Epibiotic associations, Fungal diseases, Viral diseases, Rickettsial diseases; Diseases of Vertebrates: Bacterial pathogens, fungi, protozoa and viruses; Sea Food Microbiology: Classification of seafood: Chilled and frozen raw fish, Chilled and frozen prepared fish products, Molluscan and crustacean shellfish, Cured, smoked and Dried fish, Fermented fish. Micro flora of seafood: Initial flora, Processing and its effect on Microflora, Spoilage and causative flora, Pathogens profile, Pathogens growth and survival; Food born infection and Intoxication caused by seafood microbes: Fish and Shellfish Toxins originated from marine microbes; Microbiological standard for seafood: HACCP in seafood product and Manufacture, EU food hygiene Legislation; Marine Microbes and Biotechnology: Pharmaceutical compounds: Antibiotic, Antiviral, Antitumor compounds; Health promoting products: probiotic, prebiotic, immune-stimulants, enzymes; Other products: Biofuels, Antifouling compounds, Surfactants; Application in different fields: Aquaculture, Food Industry, Biomimetics, Nanotechnology and Bioelectronics.

Recommended Textbooks and References:

1. Munn, C. B., (2004) *Marine Microbiology: Ecology and Applications,* BIOS scientific Publishers
2. Krichman, D.L., (2000) *Microbial Ecology of the Oceans*. Wiley-liss, New York.
3. Paul, J., (2001). *Methods in Microbiology: Marine Microbiology*, Academic Press,
4. Gram, L., (2009) *Microbial Spoilage of Fish and Seafood*, Springer.
5. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R., (2001) *Microbiology,* (5th Edition), Tata McGraw Hill.
6. G Reed, Prescott and Dunn's, (2004) *Industrial Microbiology,* (4th Edition), CBS Publishers.
7. M.T. Madigan and J.M. Martinko., (2006) *Biology of Microorganisms*, 11th Edition, Pearson Prentice Hall, USA.
8. Rheinhemer, G., (1980). *Aquatic Microbiology*, Johnwiley & Sons, 235 pp.
9. Elay, A.R.(1992). *Microbial Food Poisoning*. Chapman and Hall, London, 191 pp.
10. Ford, T.E., (1993). *Aquatic Microbiology. an Ecological Approach.* Blackwell scientific publications, London, 518 pp.
11. Krichman, D.L., (2000). *Microbial Ecology of the Oceans*. Wiley-liss, New york, 542 pp.

MBTC 105 Biostatistics

Course Objectives

The objective of this course is to introduce students to statistical methods and to understand underlying principles, as well as practical guidelines of "how to do it" and "how to interpret it" statistical data.

Student Learning Outcomes

On completion of this course, students should be able to:

- Understand how to summarise statistical data;
- Apply appropriate statistical tests based on an understanding of study question, type of study and type of data;
- Interpret results of statistical tests.

Unit I **Introduction**

Types of biological data (ordinal scale, nominal scale, continuous and discrete data), frequency distribution and graphical representations (bar graph, histogram, box plot and frequency polygon), cumulative frequency distribution, populations, samples, simple random, stratified and systematic sampling.

Unit II **Descriptive statistics**

Measures of Location, Properties of the Arithmetic Mean, median, mode, range, Properties of the Variance and Standard Deviation, Coefficient of Variation, Grouped Data, Graphic Methods, Obtaining Descriptive Statistics on Computer, Case study.

Unit III **Probability and distribution**

Introduction to probability and laws of probability, Random Events, Events-exhaustive, Mutually exclusive and equally likely (with simple exercises), Definition and properties of binomial distribution, poisson distribution and normal distribution.

Unit IV **Correlation and regression analysis**

Correlation, Covariance, calculation of covariance and correlation, Correlation coefficient from ungrouped data Spearson's Rank Correlation Coefficient, scatter and dot diagram, General Concepts of regression, Fitting Regression Lines, regression coefficient, properties of Regression Coefficients, Standard error of estimate.

Unit V **Statistical hypothesis testing**

Making assumption, Null and alternate hypothesis, error in hypothesis testing, confidence interval, one-tailed and two-tailed testing, decision making.

Unit VI **Tests of significance**

Steps in testing statistical significance, selection and computation of test of significance and interpretation of results; Sampling distribution of mean and standard error,
Large sample tests (test for an assumed mean and equality of two population means with known S.D.), z-test; Small sample tests (t-test for an assumed mean and equality of means of two populations when sample observations are independent); Parametric and Non parametric tests (Mann-Whitney test); paired and unpaired t-test,
chi square test.

Unit VII **Experimental designs**

Introduction to study designs: Longitudinal, cross-sectional, retrospective and prospective study, Principles of experimental designs, Randomized block, and Simple factorial designs, Analysis of variance (ANOVA) and its use in the analysis of RBD, introduction to meta-analysis and systematic reviews, ethics in statistics.

1. Jaype Brothers, (2011), *Methods in Biostatistics for Medical Students and Research Workers* (English), 7th Edition
2. Norman T.J. Bailey, (1995), *Statistical Methods in Biology*, 3rd Edition, Cambridge University Press.
3. P. N. Arora and P. K. Malhan, (2006), *Biostatistics*, 2nd Edition, Himalaya Publishing House.
4. Jerold Zar, *Biostatistical Analysis*, 4th Edition. Pearson Education.
5. *Biostatistics: A Foundation for Analysis in the Health Sciences*, 7th Edition, Wiley.
6. ML Samuels, JA Witmer (2003) *Statistics for the Life Sciences*, 3rd edition. Prentice Hall.

MBTC 106 Biophysical Principles and Analytical Techniques

Course Objectives

The course is designed to provide a broad exposure to all basic techniques (Biochemical & Biophysical) used in current Modern Biology research. The goal is to impart basic conceptual understanding of principles of these techniques and emphasize Biochemical utility of same & underlying Biophysics. Student is expected to have clear understanding of all analytical techniques such that the barrier to implement same is abated to a great extent.

Student Learning Outcomes

Students will learn how to combine previously acquired knowledge of physical chemistry and biochemistry in order to understand biochemical processes at molecular level.

Unit I **Introduction to biomolecules**

Nucleic Acid, Protein-Polymer Description of Macromolecular Structure, Intermolecular and Intramolecular forces, Non Covalent Interaction; Hydrodynamic properties: Diffusion and sedimentation, determination of molecular weight from sedimentation and diffusion; Concept and application of Chemical and Physical equilibria in Biological system, Equilibrium constant and Standard Gibbs Free energies of reactants and products, Temperature dependence of equilibrium constant. Basic Concepts: Rate, order and molecularity of a reaction, First, second and third order reactions – effect of concentration on reaction rate, rate expressions and integrated form, pseudo-unimolecular and second order autocatalytic reactions, nth order reaction of a single component, effect of temperature on reaction rate – Arrhenius equation and activation energy.

Unit II **Cellular and molecular mechanisms**

Physical biochemistry of cell: Chemical forces translation and rotation, diffusion, directed movements, biomolecules as machines, work, power and energy, thermal, chemical and mechanical switching of biomolecules, Responses to light and environmental cues; Molecular recognition: principles of specificity in biological recognition, hormonereceptor interaction, antigenantibody interaction, transient interactions, importance of transient interaction in biology. Stochasticity in Biological systems; Overexpression and purification of protein: Bulk scale bacterial cell culture and IPTG induction for protein expression, Detection of protein by western blotting in soluble and insoluble fraction after bacterial cell lysis, Affinity purification of the protein from the soluble fraction of the bacterial cell lysate (for His-tagged protein, Ni-agarose matrix will be used), Biochemical and biophysical characterizations of the purified protein: Purified protein will be assayed for its biological activity, (Fluorescence from GFP), UV-VIS absorption and emission spectra resulting from intrinsic Tryptophan and GFP chromophores, Fluorescence quenching and polarization studies, Unfolding

and refolding studies using CD and fluorescence methods, Fluorescence correlation spectroscopy experiment to measure the protein diffusion and hydrodynamic size, Atomic force microscopy of plasmid DNA.

Unit III **Analytical instrumentation**

Spectroscopic properties of proteins and nucleic acid: UV/Vis, Intrinsic fluorescence, Circular dichroism. Double Strand formation in nucleic acid, Ligand-protein binding, Protein denaturation and stability, Introduction of DSC and ITC; Protein folding kinetics and Biophysical methods, Misfolding and aggregation; Physical basis of conformation diseases; Introduction to basic principles of protein X-ray crystallography, protein NMR, Small Angle X-ray scattering (SAXS), and Electron microscopy (EM), cryo-EM, Graphics and structural validation, Structural databases, Other biophysical and spectroscopic techniques to understand conformations of biomolecules; Mass Spectroscopy: Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; Optical Imaging Methods: Light Microscopy: fluorescence and fluorescence microscopy: confocal microscope: scanning optical microscope, confocal principle, nonlinear microscopy: multiphoton microscopy; tandem scanning (spinning disk) microscopes, deconvolving confocal images; image processing, advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS), Evanescent Wave Microscopy; Beyond Diffraction Limit: Stimulated Emission Depletion (STED), Super-Resolution Summary, Super-Resolution Imaging with Stochastic Optical Reconstruction Microscopy (STORM) and Photoactivated Localization Microscopy (PALM).

Recommended Textbooks and References:

1. Tinoco, Sauer, Wang, and Puglisi. (2013) *Physical Chemistry: Principles and Applications in the Biological Sciences*. Prentice Hall, Inc.
2. Atkins, de Paula. (2011) *Physical Chemistry for the Life Sciences* (2nd Edition). W.H. Freeman.
3. K. E. van Holde, C. Johnson, P. S. Ho (2005) *Principles of Physical Biochemistry*, 2nd Edn., Prentice Hall.
4. C. R. Cantor and P. R. Schimmel, *Biophysical Chemistry* (Part 1-3), 2nd Edn.
5. *Energy and Entropy Equilibrium to Stationary States*, Starzak, Michael E. 2010, XI, 303 p.
6. Schulz GE and Schirmer RH, *Principles of Protein Structure*, SpringerVerlag.
7. Branden C and Tooze J, *Introduction to Protein Structure*, Garland Science.
8. Stout GH and Jensen LH, *Xray Structure Determination*, John;Wiley and Sons Inc., New York.
9. Joachim Frank. *Textbook of Structural Biology,* 1st edition, World Scientific Publishing.
10. Joachim Frank. (2006) *Three Dimensional Electron Microscopy of Macromolecular Assemblies*, Academic Press.
11. A. K. Downing, Protein NMR techniques, *Methods in Molecular Biology* Volume 278, 2004.

MBTP 107 Practical I (Biochemistry and Analytical Techniques)

Course Objectives

The objective of this laboratory course is to introduce students to experiments in biochemistry. The course is designed to teach utility of experimental methods in biochemistry in a problem oriented manner.

Student Learning Outcomes

Students should be able:

- To elaborate concepts of biochemistry with easy to run experiments.
- To familiarize with basic laboratory instruments and understand principle of measurements using those instruments with experiments in biochemistry.

1. Preparing various stock solutions and working solutions that will be needed for the course.
2. To prepare an Acetic-Na Acetate Buffer and validate Henderson-Hasselbach equation.
3. To determine an unknown protein concentration by plotting a standard graph of BSA using UV-VIS Spectrophotometer and validating the Beer- Lambert's Law.
4. Titration of Amino Acids and separation of aliphatic, aromatic and polar amino acids by thin layer chromatography.
5. Purification and characterization of an enzyme from a recombinant source (such as Alkaline Phosphatase or Lactate Dehydrogenase or any enzyme of institution's choice).
    a. Preparation of cell-free lysates
    b. Ammonium Sulfate precipitation
    c. Ion-exchange Chromatography
    d. Gel Filtration
    e. Affinity Chromatography
    f. Generating a Purification Table (protein concentration, amount of total protein)
    g. Computing specific activity of enzyme preparation at each stage of purification
    h. Assessing purity of samples from each step of purification by SDS-PAGE Gel Electrophoresis
    i. Enzyme Kinetic Parameters: Km, Vmax and Kcat.
    j. Dialysis of the purified protein solution against 60% glycerol as a demonstration of storage method
6. Experimental verification that absorption at OD260 is more for denatured DNA as compared to native double stranded DNA.
7. Identification of an unknown sample as DNA, RNA or protein using available laboratory tools. (Optional Experiments)
8. Biophysical methods (Circular Dichroism Spectroscopy, Fluorescence Spectroscopy).
9. Determination of mass of small molecules and fragmentation patterns by Mass Spectrometry.

MBTP 108 Practical II (Microbiology and Experimental Methods in Fisheries)

Course Objectives

The objectives of this course are to teach fundamental biochemical, microbiological and molecular biological laboratory techniques for investigating experimental problems. Using data generated in a range of experiments, students should be able to apply relevant theoretical concepts to analyze the data and evaluate experimental outcomes.

Student Learning Outcomes

Upon successful completion of this course, students are expected to demonstrate competence in the laboratory techniques employed in molecular biology and fisheries, conservation and oceanography experiments.

Microbiology

1. Sterilization, disinfection and safety in microbiological laboratory.
2. Preparation of media for cultivation of bacteria (differential and selective).
3. Isolation of bacteria in pure culture by streak plate method.
4. Study of colony and growth characteristics of some common bacteria:
   Bacillus, E. coli, Staphylococcus, Streptococcus, etc.
5. Preparation of bacterial smear and Gram's staining.
6. Enumeration of bacteria: standard plate count.
7. Antimicrobial sensitivity test and demonstration of drug resistance.
8. Maintenance of stock cultures: slants, stabs and glycerol stock cultures
9. Determination of phenol co-efficient of antimicrobial agents.
10. Determination of Minimum Inhibitory Concentration (MIC)
11. Isolation and identification of bacteria from soil/water samples.

Fisheries Resources, Conservation & Oceanography

1. Identification and quantification of phytoplankton (diatoms and dinoflagellates) using microscopy/FlowCAM/ HPLC
2. Qualitative and quantitative enumeration of zooplankton (microscopy/Flowcam)
3. Identification of commercially important crustaceans (prawns, Shrimps, lobsters and crabs), molluscs (pelecypods, gastropods and Cephalopods) and fishes (Cartilaginous & teleost) apart from dolphins & whales.
4. Identification of larval stages of crustaceans (prawns, shrimps, lobsters and crabs), molluscan and fish eggs and larvae.
5. Qualitative and quantitative enumeration of benthos, Sediment characterization
6. Primary productivity - measurement and new production
7. Gut content analysis for assessing food and feeding habits
8. Reproductive biology and ecology of commercially important crustaceans, molluscs and fishes
9. Introduction to basic molecular tools for evaluation of community structure – DNA extraction, PCR/Q-PCR, DGGE, cloning, sequencing
10. Crafts and gears- Principles and operation of different fishing gears.

II SEMESTER

MBTC 201 Cell and Developmental Biology

Course Objectives

The cells are "the fundamental building blocks of all organisms". Therefore, a comprehensive understanding of the cell and cellular function is essential for all biologists. Subsequently, it is equally important to understand how a single cell, develop into an embryo, grow, into an adult, sexually matures, and ages. Along with, stem cell biology which lies at intersection of developmental/cell biology and medicine has emerged as a great promise for future of regenerative medicine. In view of above, this course will provide a conceptual overview of cellular system and functioning, and also discuss how developmental patterns arise using examples from different model systems and highlighting regulatory networks involved in these processes. The course also discusses essential aspects of stem cell biology, their usage for therapeutic purposes and social implications associated with this modern technology.

Student Learning Outcomes

At the end of course students
should be able to:

- Understand major ideas in cell biology
  and developmental biology;
- Familiarize with experimental approaches, and how they are applied to specific problems in cell and developmental biology;
- Carry out and interpret experiments in cell and developmental biology.

Unit – I Cell architecture organisation and function of organelles

Cell theory; diversity of cell size and shape: Microscope and its modifications – Light, phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunnelling and Atomic Force Microscopy, *etc.*; Membrane Structure and Function: Structural models; Composition and dynamics; Transport of ions and macromolecules; Pumps, carriers and channels; Endo- and Exocytosis; Membrane carbohydrates and their significance in cellular recognition; Cellular junctions and adhesions; Structure and functional significance of plasmodesmata; Organelles: Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking; Chromatin organization and packaging; Cell cycle and control mechanisms; Mitochondria – structure, organization of respiratory chain complexes, ATP synthase, Structure-function relationship; Mitochondrial DNA and male sterility; Origin and evolution; Chloroplast– Structure-function relationship; Chloroplast DNA and its significance; Chloroplast biogenesis; Origin and evolution.

Unit – II Cellular motility

Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; Organization and role of microtubules and microfilaments; Cell shape and motility; Actin-binding proteins and their significance; Muscle organization and function;

Molecular motors; Intermediate filaments; Extracellular matrix in plants and animals; Cellular Movements and Pattern Formation- Laying of body axis planes; Differentiation of germ layers; Cellular polarity; Model plants like *Fucus* and *Volvox*; Maternal gene effects; Zygotic gene effects; Homeotic gene effects in *Drosophila*; Embryogenesis and early pattern formation in plants; Cell lineages and developmental control genes in *Caenorhabditis*.

Unit – III Differentiation of specialized cells

Stem cell differentiation; Blood cell formation; Fibroblasts and their differentiation; Cellular basis of immunity; Differentiation of cancerous cells and role of proto-oncogenes; Phase changes in *Salmonella*; Mating cell types in yeast; Surface antigen changes in Trypanosomes; Heterocyst differentiation in *Anabaena*; Sex determination in *Drosophila*; Plant Meristem Organization and Differentiation- Organization of Shoot Apical Meristem(SAM); Organization of Root Apical Meristem (RAM); Pollen germination and pollen tube guidance; Phloem differentiation; Self-incompatibility and its genetic control; Embryo and endosperm development; Heterosis and apomixis.

Recommended Textbooks and References:

1. Lodish *et al.*, (2000) *Molecular Cell Biology*, (4th Edition), W.H. Freeman & Company
2. Smith & Wood, (2005) *Cell Biology,* (2nd Edition), Chapman & Hall, London
3. J.D. Watson, N.H. Hopkins, J.W Roberts, J. A. Seitz & A.M. Weiner; (2014) *Molecular Biology of the Gene*, 7th Edition, Benjamin Cummings Publishing Company Inc.
4. B. M. Turner, (2002) *Chromatin & Gene Regulation*, (1st Edition), Wiley-Blackwell
5. *Benjamin Lewin*, (2013) Gene XI, 11th Edition, Jones and Barlett Publishers.

MBTC 202 Genetic Engineering

Course Objectives

The objectives of this course are to teach various approaches to conducting genetic engineering and its applications in biological research as well as in biotechnology industries.

Student Learning Outcomes

Given the impact of genetic engineering in modern society, students should be endowed with strong theoretical knowledge of this technology. In conjunction with the practicals in molecular biology & genetic engineering, the students should be able to take up biological research as well as placement in the relevant biotech industry.

Unit – I Introduction and tools for genetic engineering

Impact of genetic engineering in modern society; general requirements for performing a genetic engineering experiment; restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; cohesive and blunt end ligation; linkers; adaptors; homopolymer tailing; labelling of DNA: nick translation, random priming, radioactive and non-radioactive probes, hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence *in situ* hybridization.

Unit – II Different types of Vectors

Plasmids; Bacteriophages; M13mp vectors; pUC19 and pBluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag *etc.*; Intein-based vectors; Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; Baculovirus and *Pichia* vectors system, plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.

Unit – III Different types of PCR techniques

Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T - vectors; proof reading enzymes; PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP.

Unit – IV cDNA Analysis

Insertion of foreign DNA into host cells; transformation, electroporation, transfection; construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein - DNA interactions: electrophoretic mobility shift assay; DNase I footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.

Unit – V Gene silencing and genome editing technologies

Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; creation of transgenic plants; debate over GM crops; introduction to methods of genetic manipulation in different model systems *e.g.* fruit flies (*Drosophila*), worms (*C. elegans*), frogs 23 xenopus), fish (zebra fish) and chick; Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials; Cloning genomic targets into CRISPR/Cas9 plasmids; electroporation of Cas9 plasmids into cells; purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing; *in vitro* synthesis of single guide RNA (sgRNA); using Cas9/sgRNA complexes to test for activity on DNA substrates; evaluate Cas9 activity by T7E1 assays and DNA sequence analysis; Applications of CRISPR/cas9 technology.

Recommended Textbooks and References:

1. Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub
2. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006). *Principles of Gene Manipulation and Genomics*, Blackwell Publishing Limited; 7th Edition
3. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.
4. Selected papers from Scientific Journals, particularly Nature & Science.
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab *etc.*

MBTC 203 – Aquaculture Bioprocessing and Marine Pharmacology

Course objectives

This course is designed to give a brief outline of bioprocess methods required for obtaining essential components from marine organisms which may have pharmacological importance.

Student Learning Outcomes

On completion of this course, students should be able to identify technologies and techniques that can be employed to get bioactive compounds from marine ecosystem and use scale up technologies to process and produce them on a large scale.

Unit – I Microbial and micro-algal technologies in aquaculture

Bio-floc technology; Aquaponics; Zero water exchange aquaculture system; Aquamimicry; Hydroponics; Raceway system of aquaculture; Bioremediation in Aquaculture systems: Genetically modified organisms in waste water treatment; Bioremediation for soil and water quality improvement; Probiotics: Preparation and applications; Micro-algae- indoor and mass-culture methods, Biotechnological approaches for production of important microalgae. Single cell protein from *Spirulina*; vitamins, minerals and Omega-3 fatty acids from micro-algae; enrichment of micro-algae with micro-nutrients; cell wall polysaccharides of micro-algae; micro algae biomass for removal of heavy metals; Biofuel production from microalgae; metabolic engineering of microalgae for biofuel production.

Unit – II Industrial aquaculture technology

Fish Feed Technology: Types of feed, conventional feed *vs* functional feeds; Principles of feed formulation and manufacturing, diets suitable for application in different aquaculture systems; feed formulation ingredients; Use of natural and synthetic carotenoids; feed additives; Role of additives; Feed processing: Gelatinization, extrusion Technology, pellet dressing with heat liable nutrients; Feed evaluation; Feeding schedule to different aquatic organisms, check tray operation and feed management, Biomass calculation based on feed intake; Post-harvest Biotechnology: Fundamental aspects of freezing, methods of freezing; Delaying of spoilage; Detection of toxic substances and pathogenic microbes; biosensors for toxin detection; Natural biomaterial used for preservation of fish, Antibiotic residual analysis techniques, detection of human pathogenic bacteria by PCR methods, Microbial and enzymatic standards of different fishery products.

Unit – III Marine Pharmacology

Principles & mechanisms of drug action; Pharmacokinetics & pharmacodynamics; Marine derived pharmaceuticals: Marine bio-resources, secondary metabolites, marine proteins and lipids & molecular biology approaches; Marine actinobacterial metabolites & their pharmacological potential; Potential pharmaceuticals from soft and hard corals; pharmaceutical potential of marine sponges; metagenomic strategies for natural product discovery; marine biotoxins and potential pharmacological uses of phyco-toxins.

Unit – IV Important marine products

Green fluorescent protein (GFP) & red fluorescent protein (RFP) characteristics and their applications; Green mussel adhesive protein; Chitosan and its applications; ornamental fishes.

Recommended Textbooks and References:

1. Se-kwon Kim, (2015) *Handbook of Marine Biotechnology,* Springer,
2. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R., (2001) *Microbiology*, (5th Edition), Tata McGraw Hill.
3. Felix, S., (2010) *Handbook of Marine and Aquaculture Biotechnology*, AGROBIOS INDIA.
4. Ramachandran, V., *Aquaculture Biotechnology*, Black Prints
5. Gautam, N.C., (2007) *Aquaculture Biotechnology*, Shree Publishers and Distributors.
6. Lakra, W.S. (2008) *Fisheries Biotechnology*, Narendra Publishing House.

MBTC 204 – Fish immunology and Health Management

Course Objectives

This course is aimed to teach basic principles of fish and shell immunology along with essential principles in their health management and related issues.

Student Learning Outcomes

On completion of this course,
students should be able to:

- Understand about common immunological threats in marine environment;
- Know brief of health management of fisheries.

Unit – I Defence mechanism in fish and shellfish

Non-specific defence mechanisms: Surface barriers, gastrointestinal tract; Non-specific humoral factors: Growth inhibitors, Enzyme inhibitors, Precipitins and agglutinins; Non-specific cellular factors; Adaptive and Innate immunity: cells, factors and mechanisms, Specific defence mechanism; Antibody molecule; Antibody effector mechanisms; Factors affecting immune response: intrinsic and extrinsic factors; Cellular components of crustacean immunity: Non-self recognition mechanisms, Innate immediate immune reactions; Mechanisms of cellular defence in crustaceans - Phagocytosis, Nodule formation, Encapsulation, Cytotoxicity, Cell adhesion; Humoral components of crustacean immunity: Lectins, ProPO activating system; Antimicrobial compounds; Serine proteinase inhibitors, Clotting reaction; Maternal transmission of immunity to white spot syndrome associated virus (WSSV) in shrimp (Penaeus monodon) Broad antiviral activity in tissues of crustaceans; Circulating haemocytes and haematopoiesis; Toxins as defense mechanism.

Unit – II Fish and shellfish diseases and diagnostic techniques

Significance of fish diseases in relation to Aquaculture; Disease development process in fish; Infectious diseases of cultured finfish and shellfish: Bacterial, viral, fungal diseases of fish and shellfish; Parasitic diseases of fish and shellfish; zoonotic and OIE listed notifiable diseases; non-infectious diseases; Antibody Based Disease diagnostics: Antibodies, sources of antibodies; Basis of antibody based diagnostics; Conventional Antibody based Tests-Neutralisation Test, agglutination Test; Advanced antibody based Tests: ELISA, ELISPOT assay, Immunodot Assay, Western blotting; Molecular Diagnostics: PCR, RT-PCR, LAMP, Real Time PCR, Micro-Array and Probe based techniques in fish disease diagnosis; Cell culture based Diagnostics: Cell culture media & supplements, Primary cell culture, Passaging of cell culture for routine maintenance, Fish cell lines; Isolation and Identification of viruses using cell culture.

Unit – III Health Management

Drugs, chemicals, antibiotics and probiotics used in aquaculture and their mode of action; Preventive strategies; Principles and methods of vaccine production and fish immunization; DNA and RNAi vaccines; Quarantine and health certification in aquaculture; Crop rotation,

Immunostimulants, bioremediation and polyculture as strategies for health management. Probiotics; Quarantine and health certification; Bioremediators and Other prophylactic measures; Pharmacology: Terms and Definitions; Drugs, chemicals, antibiotics, probiotics and their mode of action.

Recommended Textbooks and References:

1. Edward J.Noga, (2010). *Fish Disease: Diagnosis and Treatment*, Wiley Blackwell,
2. Ronald J. Roberts, (2012) *Fish Pathology*, (4th Edition), Wiley-Blackwell,
3. R. Lan Froshney, *Culture of Animal Cells*, (3rd edition), Wiley-Liss.
4. Amilacher, E., (2009) *Textbook of Fish Diseases*, Narendra Publishing House.
5. Thanwal, R., (2014) *A Handbook of Fish Diseases*, Astha publishers & Distributors.
6. Bullock, G.L., (2014) *Diseases of Fishes*. Narendra Publishing House.
7. Inglis, V., (2013) *Bacterial Diseases of Fish*, Wiley Publications.

MBTC – 205 Aquatic Environmental Biotechnology

Course objectives:

The objective of this course is to impart knowledge on biotechnological applications that can be used to tackle environmental issues pertaining to marine ecology and biodiversity.

Student Learning Outcomes
On completion of this course,
students should be able to:

- Identify interaction between marine organisms and environment;
- Employ environmental pollution management technologies to come up with solutions against growing marine pollution.

Unit – I Marine Organisms and environment interaction

Types of marine environment - Physical, Chemical and Biological aspects and their interaction with marine life; Air – Sea interaction; Greenhouse gases (CO2 and Methane); Marine pollution-major pollutants (heavy metal, pesticide, oil, thermal, radioactive, plastics, litter and microbial) & sources; Biological indicators (Marine microbes, algae and crustaceans) as a tool for assessment of aquatic environment: Protein biomarkers; Biosensors and biochips; eutrophication; red tides & pesticide kills; immune responses of aquatic animals in bio-unsafe environment; Bioaccumulation and impact on aquatic fauna; Microbial Pollution: Types of aquatic microbes; autotrophs, heterotroph, saprotrophs and necrotrophs.

Unit – II Biomaterial interaction

Biofilm formation; Biofouling; Marine fouling and boring organisms - their biology, adaptation; Biosensor in pollution detection; Unculturable bacteria- occurrence, characteristics, characterization and exploitation; Factors influencing settlement of macrofoulers; Antifouling and Anti boring treatments; Corrosion Process and control of marine structures.

Unit – III Biotechnology in pollution management

BOD, COD; Marine pollution & its control; genetically modified microbes for wastewater treatment; Biosensors-types & applications; Biomolecules; membrane and transducer; Bioaugmentation- estimation of microbial load; Methods of Inorganic and Organic waste removal; treatment of Oil pollution at sea; Biodegradation; Bioremediation & Phytoremediation; Biodegradation of natural and synthetic waste materials; methods in determining bioaugmentation & biomagnification; Separation, purification and bio removal of pollutants; fermented products and Biogas from wastes; utilization of aquatic slurry for salt-resistant paddy cultivation.

Recommended Textbooks and References:

1. Milton fingerman *et al.* (1999) *Recent Advances in Marine Biotechnology* Volume 3.
2. Tasneem Fatma, (1999).*Cynobacterial and Algal Metabolisms and Environment Biotechnology*.
3. Pawan, B., Zaki, M.S.A., (2014) *Aquatic Ecology and Biotechnology*, Discovery Publishing House Pvt. Ltd,
4. Olguni, E.J. *et al.* (2000) E*nvironmental Biotechnology and Cleaner Bioprocess.*
5. Evans *et al.*, (2000). *Environmental Biotechnology: Theory and Applications.*
6. Gareth M.Evams *et al.*, (2003) *Environmental Biotechnology.*
7. S.Mahesh *et al*., (2003) *Biotechnology, Recombinant DNA Technology, Environmental Biotechnology.*

MBTP 206 Practical – III (Molecular Biology and Genetic Engineering)

Course objective:

The objectives of this course are to provide students with the experimental knowledge of molecular biology and genetic engineering.

Student Learning Outcomes

Students should be able to gain hands-on experience on gene cloning, protein expression and purification. This experience would enable them to begin a career in industry.

Syllabus

1. Concept of lac-operon:
   a) lactose induction of β-galactosidase.
   b) Glucose Repression.
   c) Diauxic growth curve of *E. coli*.
2. UV mutagenesis to isolate amino acid auxotroph.
3. Phage titre with λ phage/M13.
4. Genetic Transfer-Conjugation, gene mapping.
5. Plasmid DNA isolation and DNA quantitation.
6. Restriction Enzyme digestion of plasmid DNA.
7. Agarose gel electrophoresis.
8. Polymerase Chain reaction.
9. DNA Ligation.
10. Preparation of competent cells.
11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency.
12. Confirmation of the insert by Colony PCR and Restriction mapping
13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis
14. Purification of His-Tagged protein on Ni-NTA columns
    a) Random Primer labeling
    b) Southern hybridization.

MBTP 207 Practical – IV (Aquaculture and fish immunology and Health Management)

Course Objectives

This practical course aims to teach basic immunological techniques which can be used for identifying marine parasites and pathogens for health management.

Student Learning Outcomes

On completion of this course, students should be able to identify various parasites and pathogens present in marine environment and effectively perform various immunological tests used in various diagnostics labs.

1. Sampling of fish and shellfish for disease diagnosis
2. Histology techniques
3. Identification of bacteria- staining techniques and biochemical techniques
4. Observation of cellular components of Fish blood and shrimp hemolymph
5. Isolation and characterization of Fungi from fish & slide culture of fungi
6. Identification of fish parasites
7. Antibiotic sensitivity test
8. Bacterial agglutination test
9. Agar gel precipitation test
10. Antibody titre by ELISA, SDS-PAGE, immunoblotting and dot-blotting Nucleic Acid Isolation, PCR, RT-PCR
11. Hybridoma technology and monoclonal antibody production
12. Cell culture and passaging
13. Isolation of virus using cell culture.
14. Identification of fish pathogens using various techniques.

MBTP 208 Practical – V (Aquatic Environmental Biotechnology)

Course Objectives

This practical course aims to impact basic skills in aquatic environmental biotechnology for environmental protection and remediation.

Student Learning Outcomes

On completion of this course, students should be able to conduct basic aquatic environmental biotechnology experiments and design experiments which can be useful in bioremediation in aquatic environment.

Syllabus

1. Estimation of dissolved oxygen, salinity, H_2S, BOD and COD
2. Estimation of heavy metals (Cu, Cd, Pb, Hg)
3. Demonstration – estimation of pesticide residues, petroleum hydrocarbons using GC
4. Experiment on heavy metal removal using biosorbent
5. Microscopic studies of biofilm using test panels
6. Identification of organisms involved in fouling and boring
7. Methods of isolation of viable and unculturable bacteria from the sea
8. Recombinant DNA technology to construct biosensor
9. Detection of sea food associated pathogens using multiplex PCR
10. Metagenomic DNA isolation from coastal water
11. Bacterial diversity by 16S rDNA amplification of metagenomic DNA.

III SEMESTER

MBTC 301Marine Bioprocess Technology

Course Objectives

The objectives of this course are to educate students about fundamental concepts of bioprocess technology and its related applications, thus, preparing them to meet challenges of new and emerging areas of biotechnology industry.

Student Learning Outcomes

On completion of this course,
students should be able to:

- Appreciate relevance of micro-organisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in biological production process, and also interpret data;
- Calculate the need for oxygen and oxygen transfer in bio-production process;
- Critically analyse any bioprocess from an economics/market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Unit I **Biochemical engineering**

Basic principles of Biochemical engineering: Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics; Stoichiometry and Models of Microbial Growth: Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.

Unit II Bioprocess Technology

Bioreactor Design and Analysis: Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation *vs* biotransformations; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters; Downstream Processing and Product Recovery: Separation of insoluble products - filtration, centrifugation, sedimentation, flocculation; Cell disruption; separation of soluble products: liquid-liquid extraction, precipitation, chromatographic techniques, reverse osmosis, ultra and micro filtration, electrophoresis; final purification: drying; crystallization; storage and

packaging; Fermentation Economics: Isolation of microorganisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit III Enzyme Technology in food processing

Applications of enzyme technology in food processing: Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions *e.g.* starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein *etc.* and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing; Applications of Microbial Technology in food process operations and production, biofuels and biorefinery: Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (1997). *Principles of Fermentation Technology*. Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering*. New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals.* New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology.* Boca Raton: CRC/Taylor & Francis.

MBTC 302 Aquaculture Biotechnology

Course Objectives

This course is aimed to teach sustainable use of aquatic resources with various approaches in biotechnology.

Student Learning Outcomes

On completion of this course,
students should be able to:

- Explain fundamental principles of aquaculture biotechnology;
- Identify role of aquaculture biotechnology in society.

Unit I Fish and Shellfish biology and breeding

Male and female of finfish and shellfish; Primary and secondary sex characters; Process of Oogenesis & Spermatogenesis, metabolic changes during gametogenesis; neuroendocrine system in crustacean & molluscs & its role in control of reproduction; mechanism of hormone synthesis, release, transport & action; Pheromones & reproductive behaviour; environmental factors influencing reproduction; Advances in Fish Breeding: Hypophysation, evaluation of carp milt and egg, cryopreservation technique, Genetic basis of determination of sex; chromosome manipulation: ploidy induction, sex reversal; gynogenesis and androgenesis; Broodstock management; Application of Cross breeding in aquaculture; Selective breeding: qualitative and quantitative traits for selection, methods of selection; Inbreeding and heterosis in various economic characters; hormone induced ovulation; Synthetic hormones for induced breeding- GnRH analogue structure and function.

Unit II Culture systems and hatchery techniques

Importance of coastal aquaculture; Aqua farms; Design and construction; Criteria for selecting cultivable species; Culture systems and management practices – extensive, semi intensive and intensive culture practices Seed production in controlled condition; Types; Design and management of hatchery –induced spawning; Mass production of seeds; feed formulation; Artificial insemination - *in vitro* fertilization; Culture of Live food organisms: Candidate species of phytoplankton & zooplankton as live food organisms of freshwater & marine species; biology & culture requirements of live food organisms: green algae, diatoms, rotifers, infusoria, tubifex, brine shrimp and earthworms.

Unit III Advanced techniques in aquaculture management

Fish Cell culture Techniques: Tissue culture, cell lines, primary and secondary culture, cell culture based vaccines, organ and histotypic cultures; measurement of cell death; apoptosis; Cell Hybridization: Somatic cell fusion, hybridoma technology, Production and Application of monoclonal antibodies; Transgenic production of fishes : definition, transgenic fish, Methods of gene transfer in fishes, single gene traits, detection of transgenes, screening for transgenics, site of integration, applications; Evaluation of GFP transgenics; Genetically

modified Fish Production- Prospects and Problems.

Recommended Textbooks and References:

1. Mime, PH., (1972) *Fish and Shellfish Farming in Coastal Waters*, Fishing News Ltd., London.
2. Felix, S., (2010) *Marine and Aquaculture Biotechnology*, AGROBIOS INDIA.
3. Bradach, J.E., H.H. Ryther and W.D. MC Larney, (1972) *Aquaculture, Farming and Husbandry and Fresh and Marine Organisms*, Wiley lnterscience, New York.
4. Lakra, W. S., (2008). *Fisheries Biotechnology.* Narendra Publishing House, Delhi.
5. Ingerman M., (2000) *Recent Advances in Marine Biotechnology*, Science Publishers.
6. *Aquaculture*, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
7. Naha, S., Philopose, P.M., (2014). Dominant Publishers & Distributors Pvt. Ltd.
8. Ramachandran, V., A*quaculture Biotechnology*, Black Prints
9. Gautam, N.C., (2007) *Aquaculture Biotechnology*, Shree Publishers and Distributors.

MBTC 303 Bioinformatics

Course Objectives

The objectives of this course are to provide students with theory and practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

Student Learning Outcomes

Student should be able to:

- Develop an understanding of basic theory of these computational tools.
- Gain working knowledge of these computational tools and methods.
- Appreciate their relevance for investigating specific contemporary biological questions.

Unit I Biological databases

Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Visualizing structural information, Database of structure viewers, Collection of sequences, sequence annotation, sequence description.

Unit II Sequence alignment and database searching

Evolutionary basis of sequence alignment, Optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustral, Muscle; Scoring matrices, Distance matrices.

Unit III Phylogenetic analysis

Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).

Unit IV Structural biology

3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields *etc.* Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally

similar proteins).

Unit V Classification and comparison of 3D structures

DNA & RNA secondary and tertiary structures, t-RNA tertiary structure; Protein Secondary structure prediction: Algorithms viz. Chou Fasman, GOR methods, Tertiary Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding *etc.*) Homology/comparative modeling, fold recognition, threading approaches, and ab initio structure prediction methods; CASP (Critical Assessment of protein Structure Prediction); Computational design of promoters, proteins & enzymes.

Unit VI Applications in drug design

Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of Binding sites and virtual screening; Ligand based drug design: Structure Activity Relationship – QSARs & Pharmacophore; *In silico* predictions of drug activity and ADMET.

Unit VII Analysis of microarray data

Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement ad quantification); Analysis of differentially expressed genes; Experimental designs.

Unit VIII Biological algorithms

Comparison with computer algorithms, string structures, Introduction to programming in computational biology through C/ Perl / Java.

Unit IX Systems biology

System-level understanding of biological systems, use and integration of data from transcriptomics, proteomics and metabolomics; concepts in glycomics, interactomics and fluxomics.

Recommended Textbooks and References:

1. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*, John Wiley and Sons.
2. D.W. Mount, (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press.
3. Jones & Peuzner, (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India.
4. Dov Stekel, (2003); *Microarray Bioinformatics*; Cambridge University Press.
5. Web-resources and suggested reviews/ research papers.

MBTC 304 Intellectual Property Rights, Biosafety and Bioethics

Course Objectives

The objectives of this course are:

- To provide basic knowledge on intellectual property rights and their implications in biological research and product development;
- To become familiar with India's IPR Policy;
- To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products;
- To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.

Student Learning Outcomes

On completion of this course, students should be able to:

- Understand the rationale for and against IPR and especially patents;
- Understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations;
- Understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents;
- Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations;
- Understand ethical aspects related to biological, biomedical, health care and biotechnology research.

Unit I Introduction to IPR

Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.

Unit II Patenting

Basics of patents: types of patents; Indian Patent Act 1970; recent amendments; WIPO Treaties; Budapest Treaty; Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; precautions before patenting-disclosure/non-disclosure - patent application- forms and guidelines including those of National Bio-diversity Authority (NBA) and other regulatory bodies, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and conventional patent applications; international patenting-

requirement, procedures and costs; financial assistance for patenting-introduction to existing schemes; publication of patents-gazette of India, status in Europe and US; patent infringement- meaning, scope, litigation, case studies and examples; commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.

Unit III Biosafety

Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome editing tools.

Unit IV National and International regulations

International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).

Unit V **Bioethics**

Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.

Recommended Textbooks and References:

1. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. New Delhi: Tata McGraw-Hill Pub.
2. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
3. *Complete Reference to Intellectual Property Rights Laws.* (2007). Snow White Publication Oct.
4. Kuhse, H. (2010). *Bioethics: an Anthology.* Malden, MA: Blackwell.

5. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
6. Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences -Case Studies of Policy Challenges from New Technologies*, MIT Press
7. World Trade Organisation. http://www.wto.org
8. World Intellectual Property Organisation. http://www.wipo.int
9. International Union for the Protection of New Varieties of Plants. http://www.upov.int
10. National Portal of India. http://www.archive.india.gov.in
11. National Biodiversity Authority. http://www.nbaindia.org
12. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf
13. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, F. (2009). *Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants*. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
14. Craig, W., Tepfer, M., Degrassi, G., & Ripandelli, D. (2008). *An Overview of General Features of Risk Assessments of Genetically Modified Crops.* Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8
15. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.
16. Guidelines and Standard Operating Procedures for Confined Field Trials of Regulated Genetically Engineered Plants. 2008. Retrieved from http://www.igmoris.nic.in/guidelines1.asp
17. Alonso, G. M. (2013). *Safety Assessment of Food and Feed Derived from GM Crops: Using Problem Formulation to Ensure "Fit for Purpose" Risk Assessments.* Retrieved from http://biosafety.icgeb.org/inhousepublicationscollectionbiosafetyreviews.

MBTC 305 Bioentrepreneurship

Course Objectives

Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.

Student Learning Outcomes

Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.

Unit I Innovation and entrepreneurship in bio-business

Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (*e.g.* pharmaceuticals *vs*. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decision, Entrepreneurship development programs of public and private agencies (MSME, DBT, BIRAC, Make In India), strategic dimensions of patenting & commercialization strategies.

Unit II Biomarkets: business strategy and marketing

Negotiating the road from lab to the market (strategies and processes of negotiation with financers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in joint venture and development agreements, Dispute resolution skills.

Unit III Finance and accounting

Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology.

Unit IV Technology management

Technology – assessment, development & upgradation, Managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP).

Recommended Textbooks and References:

1. Adams, D. J., & Sparrow, J. C. (2008). *Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences*. Bloxham: Scion.
2. Shimasaki, C. D. (2014). *Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies*. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. *Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge.* Routledge.
4. Jordan, J. F. (2014). *Innovation, Commercialization, and Start-Ups in Life Science*s. London: CRC Press.
5. Desai, V. (2009). *The Dynamics of Entrepreneurial Development and Management.* New Delhi: Himalaya Pub. House.

MBTP 306 Practical VI (Bioprocess Technology)

Course Objectives

The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.

Student Learning Outcomes

Students should :

- Gain ability to investigate, design and conduct experiments, analyze and interpret data, and apply laboratory skills to solve complex bioprocess technology problems.
- Use acquired skills and knowledge in solving problems typical of bio industries and research.

1. Basic Microbiology techniques
   a) Scale up from frozen vial to agar plate to shake flask culture
   b) Instrumentation: Microplate reader, spectrophotometer, microscopy
   c) Isolation of microorganisms from soil samples
2. Experimental set-up
   a) Assembly of bioreactor and sterilization
   b) Growth kinetics
   c) Substrate and product inhibitions
   d) Measurement of residual substrates
3. Data analysis
   a) Introduction of Metabolic Flux Analysis (MFA)
4. Fermentation (acids, alcohols, antibiotics)
   a) Batch
   b) Fed-batch
   c) Continuous
5. Unit operations
   a) Microfiltrations: Separation of cells from broth
   b) Bioseparations: Various chromatographies and extractions
6. Bioanalytics
   a) Analytical techniques like HPLC, FPLC, GC, GC-MS *etc.* for measurement of amounts of products/substrates.

Recommended Textbooks and References:

1. Shuler, M. L., & Kargi, F. (2002). *Bioprocess Engineering: Basic Concepts*. Upper Saddle River, NJ: Prentice Hall.
2. Stanbury, P. F., & Whitaker, A. (2008). *Principles of Fermentation Technology*. (2nd Edition). Oxford: Pergamon Press.
3. Blanch, H. W., & Clark, D. S. (1997). *Biochemical Engineering*. New York: M. Dekker.
4. Bailey, J. E., & Ollis, D. F. (1986). *Biochemical Engineering Fundamentals*. New York: McGraw-Hill.
5. El-Mansi, M., & Bryce, C. F. (2007). *Fermentation Microbiology and Biotechnology*. Boca Raton: CRC/Taylor & Francis.

MBTP 307 Practical VII (Aquaculture Biotechnology)

Course Objectives

This practical course is designed to teach basics of aquaculture biotechnology including identification of various organisms and tissue culture techniques for maintenance of aquatic cell lines.

Student Learning Outcomes

On completion of this course, students should have gained hands on experience to maintain various cell lines and have basic identification criteria for marine organisms.

1. Dissection and location of testis and ovary in fishes
2. Dissection and location of 'x' and 'y' organs in shrimps
3. Hypophysation technique in fish
4. Maturity stages of ovary in crustaceans and finfish
5. Identification of phytoplankton and zooplankton
6. Mass culture of Live feed organisms
7. Chromosome manipulation – androgenesis, gynogenesis, triploidy, tetraploidy
8. Induced breeding of carps
9. Development of fish cell culture
10. Maintenance of fish cell lines (Passaging)
11. Methods of gene transfer.

MBTP 308 Practical VIII (Bioinformatics and Statistics)

Course Objectives

The aim is to provide practical training in bioinformatics and statistical methods including accessing major public sequence databases.

Student Learning Outcomes

On completion of this course,

students should be able to:

- Describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyse and discuss results in light of molecular biology knowledge;
- Explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming;
- Predict secondary and tertiary structures of protein sequences;
- Perform and analyse various statistical tools available to analyse the data.

1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
6. Phylogenetic analysis of protein and nucleotide sequences.
7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).
8. Using RNA structure prediction tools.
9. Use of various primer designing and restriction site prediction tools.
10. Use of different protein structure prediction databases (PDB, SCOP, CATH).
11. Construction and study of protein structures using Deepview/PyMol.
12. Homology modelling of proteins.
13. Use of tools for mutation and analysis of the energy minimization of protein structures.
14. Use of miRNA prediction, designing and target prediction tools.
15. Use of Statistical packages like SPSS (Statistical Package for the Social Sciences)/SAS (Statistical Analysis System) & Maple
16. MATLAB (Matrix Laboratory)
17. Performing various statistical analysis like T-test, ANOVA, Regression, Chi-square, PLS (Partial Least Squares) and PCA (Principle Component Analysis).

MBTP 309 Project Proposal Preparation and Presentation

Course Objectives;

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Student Learning Outcomes

Students should be able to demonstrate the following abilities:

- Formulate a scientific question;
- Present scientific approach to solve the problem;
- Interpret, discuss and communicate scientific results in written form;
- Gain experience in writing a scientific proposal;
- Learn how to present and explain their research findings to the audience effectively.

Project Proposal Preparation

Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their dissertation. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven.
Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources.
Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.*
Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for dissertation.

Poster Presentation

Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.

Oral Presentation

At the end of their project, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also
be able to discuss the future expected outcome of their work.

IV SEMESTER

MBTC 401Dissertation

Course Objectives

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

Planning Performing experiments

Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.

Thesis writing

At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.

Recommended Electives

MBTE 402

Elective 1: Genomics and Proteomics

Course Objectives

The objectives of this course are to provide introductory knowledge concerning genomics & proteomics and their applications.

Student Learning Outcomes

Students should be able to acquire knowledge and understanding of the fundamentals of genomics and proteomics, transcriptomics and metabolomics and their applications in various applied areas of biology.

Unit I Basics of genomics and proteomics

Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.

Unit II Genome mapping

Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, *in situ* hybridization, comparative gene mapping.

Unit III Genome sequencing projects

Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.

Unit IV Comparative genomics

Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; use of genomes to understand the evolution of eukaryotes, track emerging diseases and design new drugs; determining gene location in genome sequence.

Unit V Proteomics

Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.

Unit VI Functional genomics and proteomics

Transcriptome analysis for identification and functional annotation of gene, Contig assembly,

chromosome walking and characterization of chromosomes, mining functional genes in the genome, gene function- forward and reverse genetics, gene ethics; protein-protein and protein-DNA interactions; protein chips and functional proteomics; clinical and biomedical applications of proteomics; introduction to metabolomics, lipidomics, metagenomics and systems biology.

Recommended Textbooks and References:

1. Primrose, S. B., Twyman, R. M., Primrose, S. B., & Primrose, S. B. (2006). *Principles of Gene Manipulation and Genomics*. Malden, MA: Blackwell Pub.
2. Liebler, D. C. (2002). *Introduction to Proteomics: Tools for the New Biology.* Totowa, NJ: Humana Press.
3. Campbell, A. M., & Heyer, L. J. (2003). *Discovering Genomics, Proteomics, and Bioinformatics.* San Francisco: Benjamin Cummings.

Elective 2: Nanobiotechnology

Course objectives

The course aims at providing general and broad introduction to multi-disciplinary field of nanotechnology. It will familiarize students with combination of top-down approach of microelectronics and micromechanics with bottom-up approach of chemistry/biochemistry; a development that is creating new and exciting cross-disciplinary research fields and technologies. The course will also give an insight into complete systems where nanotechnology can be used to improve everyday life.

Student Learning Outcomes

On successful completion of this course, students should be able to describe basic science behind the properties of materials at the nanometre scale, and the principles behind advanced experimental and computational techniques for studying nanomaterials.

Unit I **Introduction to nanobiotechnology**

Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials.

Unit II Nano - films

Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III Nano - particles

Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.

Unit IV Applications of nano-particles

Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit V Nano - materials

Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit VI Nano - toxicity

Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life cycle assessment, containment.

Recommended Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff, (2003); *Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials,* Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); *Bionanotechnology: Lessons from Nature*, Wiley-Liss
3. Neelina H. Malsch, *Biomedical Nanotechnology,* CRC Press
4. Greg T. Hermanson, (2013); *Bioconjugate Techniques*, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Elective 3: Molecular Diagnostics

Course Objectives

The objectives of this course are to sensitize students about recent advances in molecular biology and various facets of molecular medicine which has potential to profoundly alter many aspects of modern medicine including the pre- or post-natal analysis of genetic diseases and identification of individuals predisposed to disease ranging from common cold to cancer.

Student Learning Outcomes:

Students should be able to understand various facets of molecular procedures and basics of genomics, proteomics and metabolomics that could be employed in early diagnosis and prognosis of human diseases.

Unit I **Basic molecular diagnostics**

Historical perspective of clinical diagnosis and molecular diagnostics; Nucleic acid based diagnosis: Extraction of Nucleic acids: sample collection, methods of extraction from various diagnostic materials, assessment of quality, storage: Nucleic acid hybridization: Blotting Techniques and their interpretations: Southern and Northern Blotting methods and applications in clinical diagnosis: Polymerase Chain Reaction: Principle, components, optimization and analysis of PCR products: PCR based methods for mutation detection and gene expression: real Time PCR, ARMS, QF-PCR, OLA and primer Extension: Electrophoresis: PAGE and Capillary Electrophoresis: Application of electrophoresis I DNA Diagnosis-SSCP, heteroduplex analysis, denaturing gradient gel, detection of mismatched nucleotides /RNA-DNA duplexes; RFLP and DNA sequencing in the clinical diagnostics.

Unit II **Advanced Techniques in molecular diagnosis**

Testing DNA variation for Disease association: SNPs; Methods of typing :
Traditional approaches (PCR-Sequencing), Microchips (Affymetrix) and Taqman : Microarray in analysis of gene expression; DNA microarray platforms: cDNA analysis, oligonucleotide arrays: Introduction to SAGE, CGH, array CGH and SNP arrays: Analysis of DNA methylation : Methylation in health and disease; Principle and inheritance; DNA methylation in pathology and cancer: PCR based methods in detection of methylation; Bisulfite modification and methylation specific PCR and Restriction analysis; real Time PCR methodologies (MethyLight), Profiling and arrays: Primer Designing for MSPs; Application of DNA methylation in disease diagnosis: cancer (malignancies)and imprinting disorders.

Unit III **Cytogenetic techniques**

Flow Cytometry and LCM: Principle; Clinical applications: enumeration of peripheral; blood cells in HIV infection and Immunophenotype Characterization in various blood disorders; Laser Capture Microdissection and separation of normal and aberrant cells: application and perspective in molecular diagnostics; Molecular Cytogenetic: Chromosomal abnormalities and indications of chromosomal evolution; Fluorescence *in situ* Hybridization; General procedures of FISH, M-FISH, SKY and CGH; Clinical applications of FISH: Correlation

with the pathobiology of disease, disease prognosis and monitoring, correlation with molecular data; protein based molecular diagnostics: Immunoproteomics and detection methods based on Antigen-Antibody interactions; ELISA; western Blotting and Far Western Blotting applications and perspectives; Immunohistochemistry and Immunocytochemistry: Methods and interpretations: application in tumour diagnosis and infectious diseases; correlation with molecular data.

Unit IV **Quality assurance in molecular diagnostics**

Quality assessment, pre-analytic, analytic and post analytic phases; Verification of Molecular Assays: Standards and Standardization of Molecular Diagnostics; Laboratory development of molecular diagnostics : Implementation, validation, verifications(analytical and clinical), quality control and quality assurance of the testing process; Examples of molecular diagnostics of some common genetic and non-genetic diseases (Trinucleotide Repeats: Fragile X syndrome, DMD, Endocrine disorders-Diabetes mellitus, Cystic Fibrosis, Chronic Myeloid Leukemia, Human HIV-1.

Unit V **Immunogenetic techniques and genetic counselling**

HLA Typing: HLA/MHC genetic; Molecular methods of HLA typing; PCR –Sequence specific Primers; Sequence Specific Oligonucleotide probe Hybridization, Forensic Diagnosis: DNA typing : Overview; Techniques for human identification; Evidence collection and sample preparation; PCR amplification of STR loci: Electrophoresis and data analysis: Molecular Diagnosis and Genetic Counselling :Clinical genetic services; Uses of genetic testing; components of genetic counselling process; Genetic Counselling and Genetic testing; Ethical, social and legal issues related to molecular genetic testing; Informed consent for clinical testing and research; Confidentiality and Discrimination; Gene patenting.

Recommended Textbooks and References:

1. WB. Coleman and GJ.Tsongalis, (2006) *Molecular Diagnosis for the Clinical Laboratories*, 2nd Edition, Human Press.
2. Iankowski and Polak, (1996) *Clinical Gene Analysis and Manipulation: Tools, Techniques and Trouble shooting*, 1st Edition, Cambridge University press.
3. Francesco Falciani, (2007), *Microarray Technology through Applications*, Taylor & Francis.
4. Darby & Hewiston, (2006). *In Situ Hybridization Protocols*, (3rd edition), Human press.
5. Sharpe & Carter, (2006). *Genetic Testing, Care, Consent & Liability*, Wiley-Liss.
6. Jochen Decker, *Molecular Diagnosis of Infectious Diseases*, Human press.

Elective 4: Marine Food Technology

Course Objectives

The objectives of this course are to teach the principles of food preservation, processing and packaging and quality management practices for food of marine origin.

Student Learning Outcomes

On completion of this course, students should be able to acquire practical knowledge of food technology for marine foods.

Unit I Food preservation and processing

Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes – causative factors; Drying – conventional methods; Salt curing, pickling and smoking; Freezing and cold storage, Canning procedures; Role of preservatives in processing.

Unit II Food packaging

Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.

Unit III Seafood microbiology

Seafood microbiology – factors influencing microbial growth and activity; Seafood borne pathogens – bacteria, fungi, viruses; Spoilage factors in seafood; Toxins influencing food spoilage; Microbes as food – single cell protein (SCP), microbial neutraceuticals.

Unit IV Quality management

Quality management – concepts, planning, system, quality control, quality assurance, quality improvement; Certification standards – ISO and HACCP; Principles of quality related to food sanitation, contamination, pest control, human resource and occupational hazards; Novel product development, marketing and sea food export – Marine Products Export Development Authority (MPEDA), marketing, government policies, export finance, economic importance; Novel products – nutrition promotion, consumer studies qualitative and quantitative research methods.

Recommended Textbooks and References:

1. A.S. Ninawe & K. Rathnakumar. (2008) *Fish Processing Technology and Product Development*. Narendra Publishing House, New Delhi
2. Fereidoon Shahidi *et al*., (2014) *Seafood Safety, Processing and Biotechnolgy.* Taylor and Francis. A CRC press book
3. K.C. Badapanda (2012. *Fish Processing and Preservation Technology*. Vol IV. NPH

Narendra Publishing House, New Delhi
4. Sachindra NM& Mahendrakar(2015) *Fish Processing Byproducts: Quality Assessment & Aplications*. Studium Presss LLC, USA.
5. K.P. Biswas, (2014). *Fish Processing and Preservation*. Daya Publishing House New Delhi.
6. Ioannis S. Boaziaris (2014) *Seafood Processing: Technology, Quality and Safety*. Wiley Blackwell
7. K.K. Balachandran. *Fish Canning: Fish Canning and Practices.* CIFT, Kochin.

Elective 5: Stem Cell Biology

Course Objectives

The aim of course is to bring together cellular, biochemical, anatomic, histological, physiological and evolutionary medical views to a coherent picture of stem cells in an experimental and clinical context.

Student Learning Outcomes

On completion of course, students should be able to account for basics of stem cell function in body and for their usage in medical context.

Unit I **Introduction to stem cells**

Definition, classification and source of stem cells.

Unit II Embryonic stem cells

Blastocyst and inner cell mass cells; Organogenesis; Mammalian Nuclear Transfer Technology; Stem cell differentiation; Stem cells cryopreservation.

Unit III Application of stem cells

Overview of embryonic and adult stem cells for therapy, Neurodegenerative diseases; Parkinson's, Alzheimer, Spinal Cord injuries and other Brain Syndromes; Tissue systems Failures; Diabetes; Cardiomyopathy; Kidney failure; Liver failure; Cancer; Hemophilia *etc.*

Unit IV Human embryonic stem cells and society

Human stem cells research: Ethical considerations; Stem cell religion consideration; Stem cell based therapies: Pre clinical regulatory consideration and Patient advocacy.

Recommended Textbooks and References:

1. Ann A. Kiessling, (2003) *Human Embryonic Stem Cells: an Introduction to the Science and Therapeutic Potential*, Jones and Bartett.
2. Peter J. Quesenberry (1998), *Stem Cell Biology and Gene Therapy*, (1st Edition), Willy-Less.
3. Robert Lanja, (2006) *Essential of Stem Cell Biology,* 2nd Edition, Academic Press.
4. A.D.Ho., R.Hoffiman, (2006) *Stem Cell Transplantation Biology Processes Therapy*, Willy-VCH.

5. C.S.Potten, (2006) *Stem Cells*, Elsevier.