Meeting Educational Needs with “Course” Correction
Remodelled M.Sc. Marine Biotechnology Curriculum
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with “Course” Correction
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Ministry of Science & Technology
Government of India

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Department of Biotechnology initiated Integrated Human Resource Development Programme way back in 1985-86 to cater to the requirement of quality manpower for R&D, teaching and manufacturing activities. I am very proud that India is one of the first countries in the world to initiate postgraduate teaching programme in Biotechnology. M.Sc./M.Tech. programme was initiated in 5 universities and has been expanded to over 70 universities/IITs in the country to cover general, medical, agricultural, veterinary, environmental, industrial, marine, food, pharmaceutical biotech.

Students for these programmes are selected on the basis of an All India entrance test and all selected students are paid studentships. I am very happy to know that the Department has initiated major curriculum revision exercise for specialisations offered under DBT supported teaching programme. The exercise has been coordinated by Biotech Consortium India Limited. The Department invited feedback from researchers, academic community, biotech industries and past as well as present students. Feedback has been considered by the Expert groups and areas with recent developments have been included and identified gap areas which need inclusion and updation have been taken care of. I compliment the Department for taking up this major exercise for the benefit of student community and congratulate the group for bringing out this publication.

(Dr. Harsh Vardhan)
Andy Hargreaves, a renowned educational expert, has once remarked, “Capacity building originally meant helping people to help themselves. Now it means required trainee to deliver imposed policies”. In the Indian context, the Integrated Human Resource Development Programme of the Department of Biotechnology is a flagship and dynamic program which has done exceedingly well to meet the requirements of capacity building. The central idea should be to take enough care in the selection of quality students and provide hands-on practical training to students.

I am extremely happy to note that the Department is revising the curriculum for various PG programmes in Biotechnology at regular intervals to incorporate the latest developments in the field. While doing so, I am told that Biotech Consortium India Limited has obtained necessary feedback from different stakeholders viz., researchers, academia, industries, and students regarding the proposed changes in the curriculum. Feedback was analysed and considered by the Expert Groups vis-a-vis with curricula followed by best international universities. I am assured that the proposed curricula have incorporated papers on research methodology, scientific communication, prevailing regulations in the country, etc.

I am confident that this curriculum revision exercise would be very beneficial for faculty and students of not only DBT supported programmes but also other universities involved in biotechnology teaching. I compliment the Department for undertaking this valuable exercise.
Integrated Human Resource Development Programme in biotechnology is a unique, innovative initiative taken by Department of Biotechnology way back in 1985-86. Human Resource Development programmes of the Department are highly dynamic and have evolved continuously based on need, regional aspirations and feedback from different stakeholders.

Emphasis is laid on selection of institutions based on existing expertise, infrastructure, nearby institutions engaged in research in relevant areas and students are provided hands on practical training. These programmes are continuously mentored and monitored by Advisory Committee, Expert Task Force and Course Coordinators meeting. An attempt is made to conduct curriculum revision exercise at frequent intervals to incorporate feedback from stakeholders as well as inclusion of latest developments. I am confident that revised curriculum has been framed after intense deliberations and would serve as a valuable resource to experts and student community.

I thank the Biotech Consortium India Limited for assisting DBT in this important exercise and compliment my colleague Dr. Suman Govil, Adviser, DBT for bringing out this publication.

(K. VijayRaghavan)
The two-pronged objective of this course comprises of giving students a thorough understanding of basic science behind the salient marine biological processes related to marine ecosystem and microbiology as well as familiarize them with the possible applications leading to marine biotechnology. This revised syllabus carefully combines fundamental theory and practical aspects. The syllabus provides an overview of the different biological and microbiological processes so as to equip students with an integrated approach to the so-called marine environmental system and fisheries. This curriculum hopes to focus the ecosystem services in a rather fundamental manner from both the perspectives of science and technology – especially from the perspective of gainful use of fisheries resources, conservation of marine ecosystem and oceanography. Effort has been made to impart a working knowledge to support the related industrial sector by emphasizing the relevant applications or even in development of marine biotechnological processes. I take this opportunity to thank the entire Committee for offering the “expert opinion” as well as for providing the valuable inputs and timely help. The overall management and facilitation of various tasks was diligently provided by Biotech Consortium India Limited and the Committee is appreciative of their efforts.

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Preface

Promotion of Indian Biotechnology sector is high on policy agenda of Government of India. Biotechnology has also been recognized as one of the key priority sectors under ‘Make in India,’ ‘Skill India’ and ‘Startup India’ initiatives of Government of India, as it is one of sectors expected to contribute towards enterprise creation, innovation and economic growth. Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India has immensely contributed to this dynamism through various policies and initiatives, establishment of innovation clusters, academia-industry partnerships, increasing capabilities for technology development, etc. The National Biotechnology Development Strategy (2015 – 2020) released by DBT provides a strategic roadmap for India’s emergence as a global biotechnology innovation and manufacturing hub. It has also highlighted importance of human resource development and need for nurturing tailor-made human capital for advanced scientific research and entrepreneurship.

DBT has taken a number of initiatives aimed at integrated human resource development to evolve an ecosystem where scientists, innovators and future entrepreneurs can be nurtured. Keeping in mind requirement for trained manpower in various areas of Biotechnology, DBT initiated Post-Graduate Teaching Programme way back in 1985 with 5 universities which has expanded to 74 universities imparting M.Sc./M.Tech./M.V.Sc. degrees in general, agricultural, animal, food, environmental, industrial marine, medical, neuroscience and pharmaceutical biotechnology. 10 programmes are being phased out. These universities and institutes are provided liberal financial support towards strengthening of laboratory facilities, equipment, consumables, fellowships to students, dissertation grant per student etc. Post-Graduate Teaching Programme selects best students and trains them to join research or industry workforce contributing significantly to biotechnology workforce.

Taking into cognizance the changing needs of the economy and to keep abreast with latest developments in the field of biotechnology, DBT proactively initiated revision of course curricula of Post-Graduate Programmes in biotechnology. The present exercise has been undertaken by Biotech Consortium India Limited (BCIL), New Delhi. Earlier exercise was carried out in 2008. The Course Curriculum Revision Exercise has been carried out for 13 Post-Graduate programmes in Biotechnology supported by DBT.

The revision of course curriculum of M.Sc. Marine Biotechnology aims to address mismatch between ‘knowledge’ gained by students and appropriate skill set required for technology development and implementation including present contemporary needs of economy.

Methodology

A meticulous and structured approach has been adopted to accomplish the Course Curriculum Revision exercise.

BCIL had initiated the exercise with a review of literature of relevant national and international documents on curriculum design and planning for biotechnology programmes of premier national as well as international universities, guidelines by University Grants Commission, recent curricular guidelines released by Indian Council of Agricultural Research, Ministry of Health and Family Welfare and Indian Institute of Science Education & Research and other relevant research papers on curriculum development in peer-reviewed journals.
The findings of the literature review were adopted to design questionnaires for eliciting feedback from stakeholders of Biotechnology community i.e. academicians, scientists, industry representatives and students. Feedback was received from 165 experts and 20 students belonging to academic institutions, research organizations and industry regarding addition of advanced topics, deletion of elementary, redundant and overlapping topics, updation of laboratory practicals, re-adjustment of credit load, incorporating 'technology' component in the curriculum, among others. It was also suggested that re-orientation of curricula should be done keeping in view the needs of the industry.

**Strategic Approach**

A Core Committee along with 9 subject specific subcommittees comprising of 63 academicians, scientists and industry representatives were constituted to revise and update the curricula. The constitution of subject specific subcommittee for M.Sc. Marine Biotechnology is given at Annexure-1.

The salient recommendations identified from stakeholder survey were presented to the Committee. Several brainstorming discussion sessions were held for achieving the desired balance between the foundation courses, recent developments in biotechnology and updation needs identified during the stakeholder survey. Core Committee finalized broad contours for revising all the course curricula. The guidelines set by the Core Committee were taken up by the subject specific subcommittee of M.Sc. Marine Biotechnology for updating the curriculum. The subject specific subcommittee incorporated latest advancements in areas of Marine Biotechnology in the curriculum. Separate meeting was held to discuss and deliberate the updations to be made in the curriculum. The revised curriculum was vetted and finalized by the Core Committee.

**Course Curriculum Revision**

The members of Committee agreed that revised course curriculum should provide skill and outcome based education and help the students to gain domain knowledge, ability to design and interpret research experiments and acquire effective communication skills. The course curriculum has been re-designed accordingly to promote skill-based and outcome-based education. The revised course curriculum totals to 98 credits comprising of theory, practical, technology-based topics, electives and dissertation. Each course includes learning objectives, student learning outcomes, course plan (number of lectures/unit) and reference textbooks/resources. Theory and practical courses include relevant examples, case scenarios and tutorials for inculcating critical thinking against rote learning. Several new courses have been included and content for existing courses has also been updated. Specialized courses like Fisheries Resources, Conservation and Oceanography, Marine Microbiology, Aquaculture Bioprocessing and Fish Immunology have been introduced to make the curriculum focussed towards marine sciences. With importance of students being able to execute research projects independently, separate credits have been allotted for proposal preparation and presentation before initiating dissertation and also credits for dissertation have been increased accordingly.

We hope that model course curriculum shall serve as guidelines for academicians and researchers from different parts of the country for adoption in their institutions with modifications as per availability of expertise, infrastructure and specific needs.

We wish to put on record our sincere appreciation for constant guidance and encouragement received from Dr. K. VijayRaghavan, Secretary, DBT for bringing out this publication. We wish to acknowledge whole-hearted support of Core Committee and subject specific subcommittees members. Sincere thanks are due to Dr. Manoj Singh Rohilla, Scientist- D, DBT, Ms. Shweta for creative design, Mrs. Rita Bhatla, DBT and Shri. Dilip Joy, BCIL.
# M.Sc. Marine Biotechnology

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**TOTAL CREDITS**: 98

**Recommended Electives**:  
1. Genomics and Proteomics  
2. Nanobiotechnology  
3. Molecular Diagnostics  
4. Marine Food Technology  
4. Stem Cell Biology
# Semester One

## Biochemistry

**Credits**
3

### 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

5 lectures

- 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

5 lectures

- 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

2 lectures

- 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

3 lectures

- 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

8 lectures

- 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.

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:

### 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 II
**DNA replication, repair and recombination**  
6 lectures
- 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**  
10 lectures
- 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**  
13 lectures
- 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**  
8 lectures
- 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 Textbooks and References:**


**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.

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**Fisheries Resources, Conservation and Oceanography**

**Credits**

3

**Unit I**

**Marine biology and ecology**

10 lectures

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**

10 lectures

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 I

Marine microbial ecology and diversity
11 lectures

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, Phosphorus cycling and other cycles. Photosynthesis, Quorum sensing, Temperature dependent microbial growth, Lethal and mutagenic factors, Protection system from osmotic damage; Taxonomy of

Unit III

Oceanography
10 lectures

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:

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.
Marine Microorganisms: Prokaryotes: Phototrophs containing bacterial chlorophyll, 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
8 lectures

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
11 lectures

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:
### Biostatistics

**Credits**

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#### 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.

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**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.
Recommended Textbooks and References:


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**

8 lectures

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**

6 lectures

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**

8 lectures

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:**

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.

Syllabus
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)
   h) Computing specific activity of enzyme preparation at each stage of purification
   i) Assessing purity of samples from each step of purification by SDS-PAGE
   j) Enzyme Kinetic Parameters: Km, Vmax and Kcat.
   k) 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)
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.

Laboratory II: Microbiology and Experimental Methods in Fisheries

Credits

Syllabus

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.
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.

Syllabus

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.
Semester Two

Cell and Developmental Biology

Credits 3

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
10 lectures

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
6 lectures

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.
### 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:


#### 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.

### Genetic Engineering

**Credits**

**3**

#### Unit I

**Introduction and tools for genetic engineering**

5 lectures

- 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**

7 lectures

- 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**

7 lectures

- 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
7 lectures
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
13 lectures
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 (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:
5. Technical Literature from Stratagene, Promega, Novagen, New England Biolab etc.

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.
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**
10 lectures

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**
10 lectures

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**
2 lectures

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:

### 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.
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.

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; 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.

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:
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
7 lectures
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
7 lectures
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
7 lectures
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:
# Bioinformatics

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

Unit IX
Systems biology
3 lectures
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:
5. Web-resources and suggested reviews/research papers.

Lab III: Molecular Biology and Genetic Engineering

Course Objectives
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.

Credits
4

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.
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.
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.

### Laboratory 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.

### Syllabus
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.

### Laboratory 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.
1. Estimation of dissolved oxygen, salinity, H₂S, 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.

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 microorganisms 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
4 lectures
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
4 lectures
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.

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 glucose 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:

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.
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.

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.

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:
8. Ramachandran, V., Aquaculture Biotechnology, Black Prints
<table>
<thead>
<tr>
<th>Unit I</th>
<th>Introduction to IPR</th>
<th>5 lectures</th>
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<tr>
<td></td>
<td>Introduction to intellectual property; types of IP: patents, trademarks, copyright &amp; 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&amp;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 &quot;prior art&quot;; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation.</td>
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<tr>
<th>Unit II</th>
<th>Patenting</th>
<th>5 lectures</th>
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<tr>
<td></td>
<td>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.</td>
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<tr>
<th>Unit III</th>
<th>Biosafety</th>
<th>5 lectures</th>
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<tbody>
<tr>
<td></td>
<td>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 &amp; 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.</td>
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<tr>
<th>Unit IV</th>
<th>National and international regulations</th>
<th>5 lectures</th>
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<tbody>
<tr>
<td></td>
<td>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).</td>
<td></td>
</tr>
</tbody>
</table>

Recommended Textbooks and References:
2. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI
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/

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

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
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. Should also help students to be able to build up a strong network within the industry.

Unit I

Innovation and entrepreneurship in bio-business
8 lectures

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

Bio markets: business strategy and marketing
8 lectures

Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, 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
8 lectures

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
8 lectures

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:
Project Proposal Preparation & 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.

Syllabus
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.

Syllabus
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.

Syllabus
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.

Laboratory 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.

Syllabus
1. Basic Microbiology techniques
   a) Scale up from frozen vial to agar plate to shake flask culture
   b) Instrumentation: Microplate reader, spectrophotometer, microscopy
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:

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.

Laboratory VII: Aquaculture Biotechnology

Credits
2

Syllabus
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.

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.

Syllabus
1. Using NCBI and Uniprot web resources.
2. Introduction and use of various genome databases.
4. Similarity searches using tools like BLAST and interpretation of results.
5. Multiple sequence alignment using ClustalW.
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.
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).

Semester Four

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
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.

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.

**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.
<table>
<thead>
<tr>
<th>Unit I</th>
<th>Basics of genomics and proteomics</th>
<th>3 lectures</th>
<th>Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast.</th>
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</thead>
<tbody>
<tr>
<td>Unit II</td>
<td>Genome mapping</td>
<td>4 lectures</td>
<td>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.</td>
</tr>
<tr>
<td>Unit III</td>
<td>Genome sequencing projects</td>
<td>3 lectures</td>
<td>Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web.</td>
</tr>
<tr>
<td>Unit IV</td>
<td>Comparative genomics</td>
<td>5 lectures</td>
<td>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.</td>
</tr>
<tr>
<td>Unit V</td>
<td>Proteomics</td>
<td>5 lectures</td>
<td>Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases.</td>
</tr>
<tr>
<td>Unit VI</td>
<td>Functional genomics and proteomics</td>
<td>8 lectures</td>
<td>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.</td>
</tr>
</tbody>
</table>

Recommended Textbooks and References:

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 micro-mechanics 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
5 lectures
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
5 lectures
Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit III
Nano-particles
6 lectures
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
5 lectures
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit V
Nano-materials
6 lectures
Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit VI
Nano-toxicity
5 lectures
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. Gero Decher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
5. Recent review papers in the area of Nanomedicine.

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
5 lectures
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

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.

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.

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.

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:**


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<table>
<thead>
<tr>
<th>Marine Food Technology</th>
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<tbody>
<tr>
<td><strong>Course Objectives</strong></td>
</tr>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

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

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<table>
<thead>
<tr>
<th>Unit I</th>
<th>Food preservation and processing</th>
<th>2 lectures</th>
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<tbody>
<tr>
<td></td>
<td>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.</td>
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<tr>
<th>Unit II</th>
<th>Food packaging</th>
<th>2 lectures</th>
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<tbody>
<tr>
<td></td>
<td>Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-products, canny waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer.</td>
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<tr>
<th>Unit III</th>
<th>Seafood microbiology</th>
<th>2 lectures</th>
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<tr>
<td></td>
<td>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.</td>
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<tr>
<th>Unit IV</th>
<th>Quality management</th>
<th>3 lectures</th>
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<tbody>
<tr>
<td></td>
<td>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.</td>
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**Recommended Textbooks and References:**

Stem Cell Biology

Credits

2

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
2 lectures

Definition, classification and source of stem cells.

Unit II
Embryonic stem cells
2 lectures

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

Unit III
Application of stem cells
2 lectures

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
1 lecture

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:
DBT Supported Teaching Programmes

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of University</th>
<th>Contact Details of Course Coordinator</th>
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</thead>
</table>
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Annexure I

Subject Specific Subcommittee of M.Sc. Marine Biotechnology

<table>
<thead>
<tr>
<th>Chairperson</th>
<th>1. Dr. Shyam Asolekar, Professor, Centre for Environmental Science and Engineering, Indian Institute of Technology, Bombay</th>
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<tbody>
<tr>
<td>Members</td>
<td>2. Dr. S. Felix, Professor and Dean, Fisheries College and Research Institute, Tamil Nadu Fisheries University, Chennai</td>
</tr>
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<td>3. Dr. S. P. Govindwar, Professor, Department of Biochemistry, Shivaji University, Kolhapur</td>
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<td>4. Dr. Hemant Purohit, Chief Scientist, National Environmental Engineering Research Institute, Nagpur</td>
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<td>5. Dr. Sanjeev C. Ghadi, Professor, Department of Biotechnology, Goa University, Goa</td>
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<td>6. Dr. Dilip R. Ranade, Consultant, Microbial Culture Collection, National Centre for Cell Science, Pune</td>
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<td>7. Dr. Lidita Khandeparker, Senior Scientist, National Institute of Oceanography, Goa</td>
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<tr>
<td>Member Secretary</td>
<td>8. Ms. Shreya Malik, Deputy Manager, Biotech Consortium India Limited, New Delhi</td>
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</tbody>
</table>
Universities/ Institutes offering M.Sc./ M.Tech teaching programmes in biotechnology in India with DBT support
As on May, 2017

M.Sc. GENERAL BIOTECHNOLOGY
M.V.Sc. ANIMAL BIOTECHNOLOGY
M.Sc. MARINE BIOTECHNOLOGY
M.Sc. NEUROSCIENCE
M.TECH. FOOD BIOTECHNOLOGY
M.Sc. ENVIRONMENTAL BIOTECHNOLOGY
M.TECH. PHARMACEUTICAL BIOTECHNOLOGY

M.Sc. AGRICULTURAL BIOTECHNOLOGY
M.Sc. MEDICAL BIOTECHNOLOGY
M.Sc. MOLECULAR & HUMAN GENETICS
M.Sc. INDUSTRIAL BIOTECHNOLOGY
M.Sc. BIORESOURCE BIOTECHNOLOGY