Syllabus of M.Sc. Marine Biotechnology Proposed Scheme (w.e.f. 2019-2020)

MSc. Marine Biotechnology 2019-2020

Course Code	Core Courses (32 Credits)		
	Course Title	**Credits**	**Course Level**
MBC 181	Marine Microbiology & Ecology	3	100
MBC 182	Concepts in Biochemistry	3	100
MBC 183	Molecular Biology	3	100
MBC 184	Biophysical Principles & Analytical Techniques	2	100
MBC 185	Introductory Immunology	3	100
MBC 186	Oceanography and Marine Bio resources	3	100
MBC 187	Cell Biology	2	100
MBC 188	Biostatistics	2	100
MBC 189	Lab I : Techniques in Microbiology, Marine Biology and Chemistry	3	100
MBC 190	Aquaculture Technology	3	100
MBC 281	Bioprocess Technology	3	200
MBC 282	Potential of Marine Biotechnology	2	200
	Optional Courses (to choose 16-32 Credits)		
MBO 183	Lab IV : Bioprocess Technology	2	100
MBO 184	Lab VI : Bioinformatics	1	100
MBO 185	Lab VII : Immunology & Marine Pathogenesis	3	100
MBO 186	Summer Training Assessment	1	
MBO 187	IPR, Biosafety & Bioethics	2	100
MBO 188	Bio entrepreneurship	2	100
MBO 189	Cellular Biophysics	3	100
MBO 191	Scuba Diving	2	100
MBO 192	Lab II : Biochemistry & Analytical Techniques	3	100
MBO 193	Lab III : Molecular Biology & Genetic Engineering	3	100
MBO 280	Genetic Engineering	3	200
MBO 282	Bioinformatics	2	200
MBO 283	Lab V : Cell & Tissue Culture	2	200
MBO 284	Marine Food Technology	2	200
MBO 285	Nanobiotechnology	2	200
MBO 286	Developmental Biology	2	200
MBO 287	Genomics & Proteomics	2	200
MBO 288	Enzymes: Chemistry & Applications	3	200
MBO 289	Molecular Immunology	3	200
MBO 290	Stem cell Biology	1	200
MBO 381	Dissertation (Marine Biotechnology)	8	300

Programme: M.Sc. Marine Biotechnology

Course Code: MBC 181

Title of the Course: MARINE MICROBIOLOGY & ECOLOGY

Number of Credits: 3

Effective from: 2019-2020

Course Objectives	The objective of this course is to provide information about the microbes available in aquatic environment, their role and interaction with the marine environment	
Learning Outcomes	• Explain principle features of marine ecosystems and the microbial diversity in oceans; • Describe and discuss marine microbes in terms of physiological capability and their biogeochemical role.	
Content	**MODULE I** • Classification of the marine environment. • Marine microbial habitats, Estuarine Ecosystems: Rocky shores, Sand dunes, Salt marshes, Deep sea, hydrothermal vents, mangroves and coral reefs. • Diversity of Marine microorganisms: Archaea, Bacteria, Cyanobacteria, Algae, Fungi, viruses, viroids and prions. • Characteristics of marine microorganisms. • Specialized microorganisms: Extremophiles: barophiles, thermophiles, psychrophiles, , halophiles actinomycetes, polyextremophiles, anaerobes. • An overview of the organization and cell structure of prokaryotes and archaea: i) cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups. **MODULE II** • Techniques in Marine microbiology: • Sampling: Water, Sediments. • Direct observation and enumeration of microbes: Light and electron microscopy to study morphology and structure of microbes. • Culture based methods for isolation and identification of microbes. Phenotypic and Genotypic testing, polyphasic methods of identification. Chemotaxonomy, Metagenomics. • Bergey's manual & identification of marine bacteria. **MODULE III**	12 hours 12 hours 12 hours

	• Microbial nutrition: i) autotrophic & heterotrophic modes, ii) defining culture media to support growth, iii) selective and differential culture media. • Bacterial growth kinetics: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth iv)chemostat & turbidostat. • Flagella and specialized moments in microbes, Chemotaxis, Phototaxis, Bioluminescence and indicator species and Biological Rhythms.	
References/ Reading	1. Munn, C.B. , (2004) Marine Microbiology: Ecology and Applications, BIOS Scientific Publisher. 2. Krichman, D.L.,(2000), Microbial Ecology of the Oceans. Wiley-Liss, New York. 3. Paul,J.,(2001) Methods in Microbiology : marine Microbiology, Academic Press. 4. Gram, L., (2009) Microbial Spolage of Fish and Seafood, Springer 5. Pelczar M.J. Jr., ChanE.C.S. and Kreig N.R. (2001) Microbiology, (5th Edition) CBS Publishers. 6. Josep M Gasol and David L Kirchman (2018) Marine ecology of the oceans, (3rd edition), John Wiley and Sons. Inc 7. Surajit Das Hirak Dash (2018) Microbial Diversity in the Genomic Era, Elsevier 8. Horikoshi K, Antranikian G, Bull A T, Robb F T and Stetter, K O (2011) Extremophiles Handbook, Springer 9. Madigan, Martinko, Bender, Buckley & Stahl and Thomas Brock (2017) Brock Biology of Microorganisms, Pearson	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 182
Title of the course: CONCEPTS IN BIOCHEMISTRY
Number of Credits: 3
Effective from: 2019-2020

Course Objectives	The major objective of this course is to build upon the knowledge of basic biochemical principles with emphasis on different metabolic pathways and their integration. Attention is drawn to the structure-function relationships of biomolecules.	
Learning Outcomes	Gain fundamental knowledge in biochemistry and understand the role of enzymes in the regulation of metabolic pathways.	
Content	**MODULE I** • Biochemistry: the molecular logic of life. • Biochemical evolution: principles and mechanisms. • Buffering in biological systems; ionization and hydrophobicity • Amino acids; structure and functional group properties. • Peptides and covalent structure of proteins • Levels of structural organization, sequencing, 3-D structure and functional diversity of proteins, the concept of the proteome; the Ramachandran Plot; structure-function relationships in model proteins such as ribonuclease A, myoglobin and hemoglobin Enzyme catalysis – general principles of catalysis; catalytic power and specificity quantitation of enzyme activity; Michaelis-Menten kinetics; relevance of enzymes in metabolic regulation **MODULE II** • Carbohydrates - structure and biological role.Sugars-mono, di, and polysaccharides with specific reference to glycogen, amylose and cellulose • Basic concepts and design of metabolism - glycolysis, 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; • The pentose phosphate pathway • Bioenergetics – basic principles; equilibria and concept of free energy; coupled interconnecting reactions in metabolism; oxidation of carbon fuels • Thermodynamic quantities and laws, equilibria and concept of free energy, ATP as the main carrier of free energy in biochemical systems. **MODULE III**	12 hours 12 hours 12 hours

	• Lipids – Structure and properties of important members of storage and membrane lipids; lipoproteins • Fatty acid synthesis, β-oxidation; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and the mevalonate pathway • Protein turnover and amino acid catabolism; nucleotide biosynthesis (*de novo* synthesis and salvage pathways) • General principles of intermediary metabolism and regulation of pathways. • Mitochondrial electron transport and its inhibitors • Oxidative phosphorylation; importance of electron transfer in oxidative phosphorylation; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation. • Photosynthesis; the two photosystems; proton gradient across thylakoid membrane; the Calvin cycle. • Vitamins and hormones: chemistry and physiological role.	
References/ Reading	1. Stryer, L. (2015). Biochemistry (8th ed.) New York, Freeman 2. Lehninger, A.L. (2012). Principles of Biochemistry (6th ed.) New York, NY: Worth. 3. Voet, D., & Voet ,, J.G. (2016) . Biochemistry (5th ed.) Hoboken, NJ: Wiley & Sons. 4. DobsonC.M.(2003) Protein Folding and Misfolding. Nature, 426(6968). 884-890.doi:10.1038/nature02261. 5. Zubay, G.L., Parson, W.W. & Vance, D.E. (1995). *Principles of Biochemistry* 6. Murray, R.K. et al (1990). *Harper's Biochemistry* 7. Elliott, W.H. & Elliott, D.C. (2005). *Biochemistry and Molecular Biology* 8. Branden C. & Tooze J. (1999). *Introduction to Protein Structure*	

Programme : M.Sc. Marine Biotechnology
Course Code : MBC 183
Title of the course: MOLECULAR BIOLOGY
Number of Credits: 3
Effective from: 2019-2020

Course Objectives	The aim of this course is to obtain and understand fundamental knowledge of molecular and cellular processes such asRNA transcription, protein synthesis, mutation, epigenetic modificastion and gene regulation.	
Learning Outcomes	The students should be able to explain and summarize the scientific principles of the molecular biology of DNA, RNA and understand the role played in overall functioning of the cell.	
Content	**MODULE I** • Structure of DNA - A,B, Z and triplex DNA; • Organization of bacterial genome and eukaryotic chromosomes Heterochromatin and Euchromatin • DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis) Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects. • Structure and function of prokaryotic and eukaryotic mRNA, tRNA (including initiatortRNA), rRNA and ribosomes. Processing of eukaryotic hnRNA: 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of mRNA. • Gene transfer in bacteria-Conjugation, transformation and transduction. • DNA mutation and repair, Transposons **MODULE II** • Prokaryotic and eukaryotic transcription -RNA polymerase/s and sigma factors, • Transcription unit, Prokaryotic and eukaryotic promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent) • Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac*, *trp*operons, attenuation, anti-termination, stringent control, translational control. • Eukaryotic transcription - RNA polymerase I, II and III mediated, General eukaryotic 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. ; Silencers, insulators, enhancers,	12 hours 12 hours

	mechanism of silencing and activation. **MODULE III** • Translation in prokaryotes and eukaryotes, • Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA • 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. • DNA replication. • DNA recombination.	12 hours
References/ Reading	1. RF Weaver Molecular Biology 5th edition (2012) McGraw Hill Higher Education 2. Watson JD, Baker TA, Bell SP, Gann A, Levine M &Losick R (2014) Molecular Biology of the Gene, 7th Edition, Cold Spring Harbor Laboratory Press, New York. 3. Principles of Genetics Paperback – Wiley Student Edition, 2006 by Gardner, Simmons, Snustad 4. Concepts of Genetics 10e (2012) Klug/Cummings/Spencer. Pearson 5. Genetics, 3Rd Edn by Strickberger, Pearson India, 2015, 6. iGenetics: A Molecular Approach 2016 by 3Rd Edn Peter J Russell, Pearson Education 7. Lewin's GENES XII 2017 Jocelyn E. Krebs , Elliott S. Goldstein , Stephen T. Kilpatrick Jones and Bartlett Publishers 8. Molecular Cell Biology 2016 Arnold Berk , Chris A. Kaiser , Harvey Lodish , Angelika Amon WH Freeman; 8 edition 9. Molecular Biology of the Gene (2017) by James D. Watson Pearson Publisher	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 184
Title of the course: BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES
Number of the Credits: 2
Effective from: 2019-2020

Course Objectives	The course is designed to provide a broad exposure to basic techniques used in Modern Biology research. The goal is to impart basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same. Student is expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.	
Learning Outcomes	Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.	
Content	**MODULE I** 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 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; 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. **MODULE II** 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	12 hours 12 hours

	(SAXS), 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.	
References/ Reading	1. C.R. Cantor and P.R. Schimmel Biophysical Chemistry (Part1-3), 2nd Edn. 2. Joachim Frank (2006) Three Dimensional Electron Microscopy of Macromolecular Assemblies, Academic Press. 3. Physical Chemistry: Principles and Applications in the Biological Sciences. Tinoco, Sauer, Wang, and Puglisi. (2013) Prentice Hall, Inc. 4. Physical Chemistry for the Life Sciences (2nd Revised Edition). Atkins, de Paula. (2015). 5. Biophysical Chemistry, Allen Cooper, (2011), Royal Society of Chemistry 6. Energy and Entropy Equilibrium to Stationary States, Starzak, Michael E. (2010), XI, 303 p. 7. Principles of Physical Biochemistry, K. E. van Holde, C. Johnson, P. S. Ho. (2010) 3rd Edn., Prentice Hall.	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 185
Title of the course: INTRODUCTORY IMMUNOLOGY
Number of Credits: 3
Effective from 2019-2020

Course Objectives	1) To provide a basic knowledge and to appreciate the components of the human immune response that work together to protect the host. 2) To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity 3) To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immune-deficiencies.	
Learning Outcomes	The mode of continuous assessment and formulation of tests enables students to handle competitive entrance exams. The basic overview of Immunology strengthens their foundations for a career in Biotechnology.	
Content	**MODULE I – Concepts and Basics** • Introduction – History and scope of immunology • Innate immunity:- factors, features, processes • Acquired:- the Specificity, memory, recognition of self from non-self. • Cells of the immune system: Hematopoiesis and differentiation, Lymphoid and Myeloid lineage, lymphocyte trafficking, B lymphocytes, T lymphocytes, macrophages, dendritic cells, natural killer and lymphokine-activated killer cells, eosinophils and mast cells, lymphocyte subpopulations and CD markers. • Organization of lymphoid organs • MALT, GALT, SALT • **MODULE II – Defence Components: Constituents of immune system and response** • Theories of antibody formation and resolution of antibody structure • Humoral immunity: cells, antibody formation, primary and secondary response. • Immunoglobulins – structure, distribution and function. • Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics. • Immuno-diagnostics..the basis • Nature and biology of antigens and superantigens: haptens, adjuvants, carriers, epitopes, T dependant and T independent antigens. • Antigen elimination *in vivo* **MODULE III – Defence Strategies and Pitfalls: Effector mechanisms of immune responses**	12 hours 12 hours 12 hours

	• Complement system: mode of activation, classical, alternate and MBL pathways. Structures of key components. • Cell mediated immune responses: cell activation, cell-cell interaction and cytokines. • Cell-mediated cytoxicity: Mechanism of T cell and NK cell mediated lysis, antibody- dependant cell-mediated cytoxicity, and lectin-mediated cytoxicity. Phagocytosis: oxygen-dependant/ independent killing intracellularly. • Hybridoma technology and monoclonal antibodies. • Major histocompatibility complex…Structure of MHC molecules, basic organization of MHC in human , haplotype-restricted killing. • Hypersensitivity: An introduction to the different types. • Introduction to autoimmune diseases.	
References/ Reading	1. Essential Immunology (2005) Roitt I.M. and Delves P.J. 2. Essential Immunology (2011) Delves P J., Martin S. J.,. Burton D R, Roitt I.M. 3. Immunology (2001) Roitt I, Bostoff J. & Male D.6th edition 4. Immunology (2006) Luttmann M, Bratke K., Kupper M., & Myrtek D 5. Immunology (2007) Goldsby R.A,, Kindt T.J., Osbrne B.A and Kuby J.	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 186
Title: OCEANOGRAPHY & MARINE BIORESOURCES
Number of Credits: 3
Effective from 2019-2020

Course objectives	• Introduce students to marine environment and its physical features; • Introduce students to marine life, their habitats and adaptations.	
Learning Outcomes	Upon successful completion of this course, students should be able to: • Understand status and trends of major marine resources understand how oceans influence the climate • Familiarise with factors influencing primary and secondary production.	
Content:	**MODULE I (Marine life diversity and processes)** • Classification of marine environment • Marine bio resources. • Marine microbes (viruses, bacteria, archaea, protists, fungi) • Marine algae and plants (seaweeds, sea grasses, mangrove plants) • Invertebrates: sponges, cnidarians, polychaetes, crustaceans, marine worms, molluscs, echinoderms, arthropods, Non-craniate (non-vertebrate) chordates, • Adaptations of organisms to different habitats • Vertebrates ✓Marine fishes (bony, cartilaginous, jawless fishes) ✓Marine tetrapods (amphibians, reptiles, birds, mammals) • Plankton (phytoplankton and zooplankton) • Bio-communication in oceans, Microbe-microbe interaction, Quorum sensing, Microbe-metazoan interaction, Population connectivity, • Species abundance, richness and diversity indices, Biogeography, Recruitment, Growth, Mortality, Culture of microalgae and invertebrates; • Marine biomass and productivity - primary production, photosynthetic efficiency; secondary production, productivity distribution in ocean environment, Mechanism and factors affecting primary production, • Food web dynamics and ecosystem functioning, Microbial loop - Role of microbes in marine food web dynamics, – • Biogeochemical processes: Nutrient cycling, carbon cycle, Nitrogen cycle, Sulphur cycle, Iron cycling, Phosphorus cycling and other cycles. **MODULE II (Physical Oceanography)**	12 hours 12 hours

	• Ocean atmosphere interface • Circulation: Coriolis effect, Ekman transport, Langmuir circulation. • Planteray waves: Kelvin and Rossby waves. • Climate variability: Pacific decadal oscillation, North Atlantic oscillation, and Arctic oscillation, thermohaline circulation • El Niño-Southern Oscillation: El Niño & La Niña and its effect on global climate • Ocean currents: Antarctic Circumpolar Current, Deep ocean (density-driven), Western boundary currents (Gulf Stream, Kuroshio Current, Labrador Current, Oyashio Current, Agulhas Current, Brazil Current, East Australia Current); Eastern Boundary currents (California Current, Canary Current, Peru Current, Benguela Current) • Ocean gyres: Major gyres, Tropical gyres, Subtropical gyres, Subpolar gyres • Tides, Tsunamis, Wind waves and its effects **MODULE III (Chemical Oceanography)** • Seawater composition and its properties • Characterization of sediments:constituents, texture and mass properties • Types of Biogeochemical cycles in oceans • Isotope geochemistry • Oceanic anoxic events and dead zones • Biological pump • Ocean acidification and its significance • Plate tectonics, Mid-oceanic ridge spreading and convection.	12 hours
References/ Reading	1. Carl E. Bond (1996) Biology of Fisheries, 2nd Edition , W.B. Saunders Company. Philadelphia 2. Heywood V.H. , (1995) Global Bio Diversity Assessment. UNEP, Cambridge University Press PP.1140 3. Kortzinger, (2004). The Ocean takes a Breath, Science 4. Agarwalk et. al., (1996) Biodeversity and Environment. APH, pp351 5. Naskar K. and Mandal R., (1999) Ecology and Biodeveristy of Indian Mangroves . Daya.pp361. 6. Jeffrey S. Levinton, CD(2001).Marine Biology: Function, Biodiversity . Ecology (515pp) 7. Bertness, M. D., Bruno, J. F., Silliman, B. R., & Stachowicz, J. J. (Eds.). (2014). Marine community ecology and conservation. Sinauer Associates, Incorporated. 8. Chambers, R. C., & Trippel, E. A. (Eds.). (2012). Early life history and recruitment in fish populations (Vol. 21). Springer Science & Business Media. 9. Pickard, G. L., & Emery, W. J. (2016). Descriptive physical oceanography: an introduction Elsevier.	

	10. Knauss, J. A., & Garfield, N. (2016). Introduction to physical oceanography. Waveland Press. 11. Beer, T. (2017). Environmental oceanography. CRC Press.	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 187
Title of the course: CELL BIOLOGY
Number of Credits; 2
Effective from: 2019-2020

Course Objectives	The cells being "the fundamental building blocks of all organisms", a comprehensive understanding of the cell and cellular function is essential for all biologists. This course will hence provide a conceptual overview of cellular system and functioning in animals and plants.	
Learning Outcomes	Understand major concepts in cell biology with an awareness of experimental approaches and how they are applied in cell biology research.	
Content	**MODULE I** • Biochemical organization of the cell; diversity of cell size and shape; cell theory, the emergence of modern Cell Biology. • Principles underlying microscopic techniques for study of cells : Light, Phase contrast and interference, Fluorescence, Confocal, Electron (TEM and SEM), Electron tunneling and Atomic Force Microscopy.Flow cytometry • Structure and diversity of biological membranes; mechanisms of membrane transport. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane assembly. • Cell lysis and subcellular fractionation • Mitochondria and chloroplasts: ultrastructure and functional compartmentalization, biogenesis and organellar genome • Structure and function of microbodies, Golgi apparatus, Lysosomes and Endoplasmic Reticulum; • Nucleus – Structure and function of nuclear envelope, lamina and nucleolus; Macromolecular trafficking. • Cellular junctions and adhesions in animal cells; structure and functional significance of plasmodesmata. **MODULE II** • 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. • Protein localization – synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast and peroxisomes, receptor- mediated endocytosis. • The plant cell wall; extracellular matrix in plants and animals • The eukaryotic cell cycle and its regulation • Molecular aspects of cell division • Cell signaling • Cell fusion techniques • Molecular chaperones: types, characteristics and functional significance • Proteosomes; structure and function	12 hours 12 hours

	• Differentiation of cancerous cells; role of growth factors, proto-oncogenes and signal transduction mechanisms in tumour formation • Oncogenes and tumour suppressor genes	
References/ Reading	1. Lodish et al., (2000) Molecular Cell Biology, (4th edition) , W.H.Freeman & Company 2. Smith & Wood (2005) Cell Biology, (2nd Edition), Chapman & Hall London 3. Introductory Biophysics , V. Pattabhi & N. Gautham, Narosa Publications 4. Ionic Channels of Excitable Membranes, Third Edition. Bertil Hille. Sinauer Associates. Sunderland, MA. 2001. 5. Physical Biology of the Cell by Rob Phillips, Jane Kondev and Julie Theriot, Garland Science, Taylor & Francis Group, New York, 2009. 6. Handbook of Molecular Biophysics- Methods and applications by H.G. Bohr Wiley-VCH Verlag GmbH & Co, KGaA, Weinheim (2009) 7. The Physiology of Excitable Cells, Aidley, D. J. (1998). Cambridge University Press. 8. Principles of Neural Sciences Ed: E. Kandel, J. Schwarts and T. Jessel. 4th edition (2000) McGraw Hill 9. Textbook of Medical Physiology Ed: Guyton and Hall 9th edition (1998) W. B. Saunders Company 10. Molecular Neurobiology Ed: J.B.Martin (1998) Scientific American 11. Elements Of Molecular Neurobiology C.U.M. Smith,J Wiley and Sons Publishers, N.Y. 12. An Introduction to Molecular Neuro Biology Z.W. Hallsinauer Associates Inc. Publishers	

Programme:M.Sc. Marine Biotechnology
Course Code: MBC 188
Title of the course: BIOSTATISTICS
Number of Credits: 2
Effective from: 2019-2020

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.	
Learning Outcomes	Upon completing 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.	
Content	**MODULE I** 1.Scope of Biostatistics 2.Brief description and tabulation of data and its graphical representation, frequency distributions 3.Measures of Central Tendency and dispersion: mean, median, mode, range, standard deviation, variance, coefficient of variation, skewness, kurtosis 4.Displaying data: Histograms, stem and leaf plots, box plots 5.Probability analysis: axiomatic definition, axioms of probability: addition theorem, multiplication rule, conditional probability and applications in biology. **MODULE II** 1.Counting and probability, Bernoulli trials, Binomial distribution and its applications, 2.Poisson distribution 3.Normal distribution, z, t and chi square tests, levels of significance 4.Testing of hypotheses: null and alternative hypothesis, Type I and Type II errors 5.Simple linear regression and correlation 6.Analysis of variance	12 hours 12 hours
References/ Reading	1.Jaype Brothers, (2011), Methods in Bioastatistics for Medical Students and Research Workser (English), 7th Edition. 2.Norman T.J. Bailey, (1995), Statistical Methods in Biology, 3rd Edition, Cambridge University Press 3.P.N. Arora and P.K. Malhan, (2006), Bioastatistics, 2nd Edition , Himalaya Publishing House. 4.Samuels, JA Witmer (2003) Statistics for the Life Sciences, 3rd edition. Prentice Hall	

Programme: Programme:M.Sc. Marine Biotechnolgy
Course Code: MBC 189
Title: LAB I -TECHNIQUES IN MICROBIOLOGY, MARINE BIOLOGY AND CHEMISTRY
Number of Credits: 3
Effective from 2019-2020

Content	**MODULE I** • Preparation of solid & liquid media, Differential and Selective media: Isolation of bacteria from seawater /sediments samples, Enumeration: serial dilution methods, plating. • Maintenance of organisms: Streaking, slants and stabs cultures • Study of morphology and cultural characteristics. • Gram staining. • Motility • Antimicrobial sensitivity test and demo of drug resistance. • Cultivation of fungi: Slide, chunk and coverslip techniques. **MODULE II** • Samplers: water samplers, dredges , grabs, snappers. • Sampling (Field trips) and identification: • Phytoplankton & Zooplankton • Nekton • Benthos Estimations: • Chlorophyll • Nutrients: nitrates/nitrites, phosphates/silicates • Dissolved oxygen • Salinity, pH & alkalinity	36 hours 36 hours
References / Reading	1. Brock's Biology of microorganisms. (2006). Madigan, M., Martinko & Parker, J. 2. General Microbiology. (1987). Stanier, R.Y., Ingraham, Wheelis and Painter 3. Marie and Estuarine Microbiology Laboratory Manual. (1975). Colwell, R. et al. 4. Microbiology Methods. (1975). Collins, C.H. and Lyne, P.M. 5. Laboratory Methods in Microbiology. (1973). Harrigan, W.F. & McCance, M.E. 6. Source book of Experiment for the teaching of Microbiology. (1982). Primrose, .B. and Wardlaw, A.C. 7. Methods of Sea Water Analysis. (1995). Grasshoff, K., Ehrhardt, M. & Kremling,K. 8. Quantitative Ecology Ecology & Marine Biology. (1990). Bakus,G.J. 9. Methods of study of Marine Benthos. (1984). Holme,N.A. & McIntyre, A.D. 10. Methods in Marine Zooplankton Ecology. (1984). Omori,W &; Ikeda,T.	

	11. Standard Methods for the Examination of Water and Wastewater (2011, 22 nd Edition). Ed. Laura Bridgewater, American Public Health Association, American Water Works Association, Water Environment Federation. 12. Handbook of water analysis (2011, 3rd Edition). Ed. Leo M.L. Nollet, Leen S. P. De Gelder. CRC Press. Taylor and Francis Group, LLC. 13. Water Quality Concepts, Sampling, and Analyses (2010). Ed. Yuncong Li, Kati Migliaccio. CRC Press. Taylor and Francis Group, LLC. 14. Essentials of Practical Microbiology (2018). Ed. Apurba Sankar Sastry, Bhat Sandhya K. Jaypee brothers medical publishers (P) Ltd. 15. Practical Microbiology (2009). Ed R. Vasanthakumari. BI Publications Pvt Ltd.	

Programme: M.Sc. Marine Biotechnology
Course Code: MBC 190:
Title of the course: AQUACULTURE TECHNOLOGY
Number of Credits: 3
Effective from 2019-2020

Course Objectives	This course is aimed to teach sustainable use of aquatic resources with various approaches in biotechnology.	
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.	
Content	**MODULE I** 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; 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. Molecular Tools in Conservation of Fisheries Resources: Artificial Hybridization: Heterosis, Control of fish diseases by selection; selective breeding of disease resistant fish. 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 and brine shrimp. **MODULE II** Male and female of finfish and shellfish; Primary and secondary sex characters; Process of Oogenesis & Spermatogenesis, metabolic changes during gametogenesis; neuroendocrine system in crustacean & molluscs & its role in control of reproduction; mechanism of hormone synthesis, release, transport & action; Pheromones & reproductive behaviour; environmental factors influencing reproduction; Advances in Fish Breeding: Hypophysation, cryopreservation technique,	12 hours 12 hours

	genetic basis of determination of sex; chromosome manipulation: ploidy induction, sex reversal; gynogenesis and androgenesis; Broodstock management; Application of cross breeding in aquaculture; Selective breeding: qualitative and quantitative traits for selection, methods of selection; Inbreeding and heterosis in various economic characters; hormone induced ovulation; Synthetic hormones for induced breeding- GnRH analogue structure and function. **MODULE III** Bio-floc technology; Aquaponics; Zero water exchange aquaculture system; Aqua mimicry; Hydroponics; Raceway system of aquaculture; Bioremediation in Aquaculture systems: Genetically modified organisms in waste water treatment; Bioremediation for soil and water quality improvement; Micro-algae- indoor and mass-culture methods, Biotechnological approaches for production of important microalgae and other commercial important products.	12 hours
References/ Reading	1. Se-kwon Kim , (2015) Handbook of Marine Biotechnology, Springer 2. Felix,S,(2010) Handbook of Marine and Aquaculture Biotechnology AGROBIOS INDIA 3. Ramchandran, V, Aquaculture Biotechnology, Black Prints 4. Gautam, N,C, (2007) Aquaculture Biotechnology, Shree Publishers and Distributors	

Programme :M.Sc. Marine Biotechnology
Course Code: MBC 281
Title of the course: BIOPROCESS TECHNOLOGY
Number of Credits: 3
Effective from : 2019-2020

Course Objectives	The objective 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.	
Learning Outcomes	On completing 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 techniques for bio-based products; • calculate yield and production rates in biological production process, and also interpret data; • Give an account of important microbial/enzymatic industrial processes in the industry.	
Content	**MODULEI** Basic Principles of Biochemical Engineering and Fermentation Processes: • Isolation, screening, and preservation of industrially important microbes • Bioreactor designs • Types of fermenters • Concepts of basic modes of fermentation: batch, fed-batch and continuous • Scale up fermentation processes • Media formulation • Air and media sterilization. • Aeration & agitation in bioprocess. • Measurement and control of bioprocess parameters. **MODULE II** Industrial production of chemicals: • Strain improvement for increased field & other desirable characteristics • alcohol (beer) • organic acids (citric acid) • antibiotics (Penicillin) • amino acids (lysine) • Application of microbes in food processing:	12 hours 12 hours

	manufacture of cheese and monosodium glutamate **MODULE III** Downstream Processing: • introduction, removal of microbal cells & solids • bioseparation, filtration, centrifugation sedimentation. • flocculation, cell disruption, liquid-liquid extraction, • Purification by chromatographic techniques • Drying, crystallization. • Storage & Packaging • Effluent treatment & disposal. • Immobilization of microbial cells & their applications • Bioprocess for the production of biomass: yeast and mushrooms	12 hours
References/ Reading	1. Kuila, A., & Sharma, V. (Eds.). (2018). Principles and Applications of Fermentation Technology. John Wiley & Sons. 2. Dordick, J. S. (Ed.). (2013). Biocatalysts for industry. Science & Business Media. 3. Najafpour, G. (2015). Biochemical engineering and biotechnology. Elsevier. 4. Prasad, K. K., & Prasad, N. K. (2010). Downstream process technology: a new horizon in biotechnology. PHI Learning Pvt. Ltd. 5. Fomina, M., & Gadd, G. M. (2014). Biosorption: current perspectiveson concept, definition and application. Bioresource technology, 160, 3-14.	

Programme:M.sc. Mrine Biotechnology
Course Code: MBC 282
Title of the course: POTENTIAL OF MARINE BIOTECHNOLOGY
Number of Credits: 2
Effective from 2019-2020

Course Objectives	The objective of this course is to impart knowledge of biotechnological applications of marine organisms, important processes and impacts on the marine ecosystems and ways to control them.	
Learning Outcomes	On completion of the course, students should be able to comprehend the uses of marine organisms, their significances, interactions, impacts and management technologies to come-up with solutions for their control.	
Content	**MODULE I** **Applications of Marine Organisms** • Marine viruses and Giruses • Giant bacteria and their significance • Unculturable bacteria : occurrence ,characteristics and exploitation • Barophilic organisms & their applications • Seaweeds for removal of metal pollutants • GFP, RFP characteristics and their applications • Green mussel adhesive protein • Chitosan : products and applications • Biomimetics **MODULE II** **Management** • Marine pollution • Biofouling and corrosion • Ballast water • Red tides • Bacterial & viral pathogens in aquaculture • Aquaculture diseases in finfish and shellfish	12 hours 12 hours
References/ Reading	1. Le Gal, Y., Ulber, R., & Antranikian, G. (2005). Marine Biotechnology (Vol. 96). 2. Munn, C. (2011). Marine microbiology: Ecology & applications. 3. Osborn, M. (2005). Molecular microbial ecology. 4. Rainey, F., Oren, A. (2006). Extremophiles, Volume 35, 1st Edition. 5. Nabti, E. (2017). Biotechnological Applications of Seaweeds. 6. Day, R., Davidson, M. (2014). The Fluorescent Protein Revolution. 7. Hicks, B. (2002). Green Fluorescent Protein. 8. Ahmed, S., Ikram, S. (2017). Chitosan.	

	9. Bar-Cohen, Y. (2006). Biomemetics. 10. Naik, M., Dubey, S. (2017). Marine pollution and microbial bioremediation. 11. Flemming, H.-C., Murthy, P.S., Venkatesan, R., Cooksey, K.E. (2009). Marine and Industrial Biofouling. 12. Liengen, T., Basséguy, R., Féron, D., Beech, I.B. (2015). Understanding Biocorrosion. 13. Okaichi, T. (2003). Red Tides. 14. Pillay, T. V. R. (2001). Aquaculture. 15. Swain (2006). Fish and Shellfish Immunology. 16. Farch, D. (2015). Diseases of fish. 17. Evans et al. (2000). Environmental Biotechnology-Theory and Application. 18. Evams, G et al. (2003). Environmental Biotechnology.	

OPTIONAL COURSES

Programme: M.Sc. Marine Biotechnology
Course Code: MBO 183
Title of the course: LAB IV - BIOPROCESS TECHNOLOGY
Number of Credits: 2
Effective from 2019-2020

Course Objectives	The objectives of this laboratory course are to provide hands-on training to students in upstream and downstream unit operations.	
Learning Outcomes	Students should: • Gain ability to investigate, design and conduct experiments, analyze and interpret data, and apply laboratory skills to solve complete bioprocess technology problems. • Use acquired skills and knowledge in solving problems typical of bio-industry and research.	
Contents	1. Microbial production of ethanol using yeast sp. 2. Estimating ethanol concentration by Cerric Ammonium nitrate method. 3. Microbial production and estimation of organic acids: Citric acid using *Aspergillus* sp. 4. Microbial production of antibiotics. 5. Immobilization of microbial cells: use of alginate. 6.Fermentation: Batch,Fed-Batch and Continuous 7. Use of fermenter with special reference to scale-up operations. 8. Microfiltrations: separation of cells from broth 9. Bioseperations: Chromatography and extractions (organic acid & antibiotics) 10. Manufacture of ginger ale and estimating the alcohol content. 11. Solid State Fermentation: Mushroom cultivation. 12. Food Microbiology: Preparation of an edible fermented product	48 hours
References/ Reading	1.Khramtsov, N., McDade, L., Amerik, A., Yu, E., Divatia, K., Tikhonov,A., ... & Henck, S. (2011). Industrial yeast strain engineered to fermentethanol from lignocellulosic biomass. Bioresource technology, 102(17), 8310-8313. 2.Moser, A. (2012). Bioprocess technology: kinetics and reactors. Springer Science & Business Media. 3.Tamang, J. P. (Ed.). (2015). Health benefits of fermented foods and beverages. CRC Press. 4.Ray, B., & Bhunia, A. (2013). Fundamental food microbiology. CRC press. 5.Korzybski, T., Kowszyk-Gindifer, Z., & Kurylowicz, W. (2013). Antibiotics: origin, nature and properties. Elsevier. 6.Ngo, T. T. (Ed.). (2013). Molecular interactions in bioseparations. Springer Science & Business Media.	

Programme: M.Sc. Marine Biotechnology
Course Code: MBO 184:
Title of the course: LAB VI - BIOINFORMATICS
Number of Credits: 1
Effective from: 2019-2020

Course Objectives	The aim is to provide practical training in bioinformatics and statistical methods including accessing major public sequence databases	
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 the 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.	
Content	**MODULE I** 1. Using NCBI and Uniprot web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results. 5. Multiple sequence alignment using ClustalW. 6. Phylogenetic analysis of protein and nucleotide sequences. 7. Use of gene prediction methods (GRAIL/Genscan,/Glimmer). 8. Use of various primer designing and restriction site prediction tools. 9. Use of different protein structure prediction databases (PDB, SCOP, CATH). 10. Construction and study of protein structures using RASMOL/Deepview/PyMol. 11. Homology modelling of proteins. 12. Use of tools for mutation and analysis of the energy minimization of protein structures.	24 hours
References/ Reading	1. Bioinformatics:concepts skills and applications (2004).S.C. Rastogi, N. Mendiratta and P. Rastogi. 2. Bioinformatics: A modern approach . (2005) V.R. Srinivas. 3. Essential Bioinformatics (2006). J. Xiong. 4. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant 5. Bioinformatics: A Practical Approach 2007 Shui Qing (Chapman & Hall/CRC Mathematical and Computational Biology)	

	6. Bioinformatics, 3ed Paperback – 2009 by Andreas D. Baxevanis, B.F. Francis Ouellette Wiley Student Edition 7. Practical Bioinformatics Garland Science 1st Edition (2012) Michael Agostino 8. Bioinformatics Practical Manual (2015) by Mohammed Iftekhar , Mohammed Ghalib. Createspace Independent Pub	

Programme : M.Sc. Marine Biotechnology
Course Code: MBO 185 :
Title of the course : LAB VII - IMMUNOLOGY & MARINE PATHOGENESIS
Number of credits: 3
Effective from: 2019-2020

Course Objectives	This course involves learning techniques to identify reactions in the lab that form the basis for application in immunodiagnostics and also to gain an insight into the evaluation marine	
Learning Outcomes	Key hands-on experience of converting and applying theoretical knowledge to laboratory. Students become familiar with techniques involved in immunology as well as in the study of marine pathogens	
Contents	1. Determination of antibody titer using double immunodiffusion 2. Assesment of similarity between antigens using Ouchterlony's double diffusion test 3. Estimation of antigen concentration using radial immunodiffusion 4. Quantitative precipitation assay 5. DOT ELISA 6. Latex agglutination 7. Immunoelectrophoresis 8. Rocket immunoelectrophoresis 9. Sampling of fish and shellfish for disease diagnosis 10. Identification of bacteria- staining techniques and biochemical techniques 11. Observation of cellular components of fish blood and shrimp hemolymph 12. Isolation and characterization of fungi from fish & slide culture of fungi 13. SDS-PAGE analysis of fish proteins 14. Fish/shrimp cell culture. 15. Identification of fish pathogens using various techniques.	72 hours
References/ Reading	1. Edward J. Noga, (2010). Fish Disease: Diagnosis and treatment, Wiley Blackwell. 2. R.lan Froshney, Culture of Animal Cells, (3rd edition), Wiley-Liss. 3. Thanwal. R., (2014)A Handbook of Diseases, Astha Publisers & Distributors. 4. Bullock, G.L.,(2014) Diseases of Fisheried . Narendra Publishing House . 5. Inglis, V.,(2013) Bacterial Diseases of Fish , Wiley Publications	

Programme: M.Sc. Marine Biotechnology
Course Code: MBO 187
Title of the course: IPR, BIOSAFETY AND BIOETHICS
Number of credits: 2
Effective from: 2019-2020

Course Objectives	• To provide basic knowledge on intellectual property rights and their implications in biological research and product development; • To become familiar with India's IPR Policy; • To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products; • To become familiar with ethical issues in biological research. This course will focus on consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing	
Learning Outcomes	On completion of this course, students should be able to: • understand the rationale for and against IPR and especially patents; • understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; • understand different types of intellectual property rights in general and protection of products derived from biotechnology research and issues related to application and obtaining patents; • gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms, national and international regulations.	
Contents	**MODULE I** Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO, India); analysis and report formation. 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;	12 hours

	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. **MODULE II** Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan; risk assessment of transgenic crops *vs* cisgenic plants or products derived from RNAi, genome 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). Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.	12 hours
References/	1. A User's Guide to Patents (2007) Trevor M. Cook. Tottel Publishing.	

Reading	2. Biosafety and bioethics (2006) Rajmohan Joshi. Gyan Publishing House. 3. Biotechnology and Patent laws:patenting living beings (2008) Sreenivasulu, N.S. and Raju C.B. Manupatra Publishers. 4. *Complete Reference to Intellectual Property Rights Laws*. (2007). Snow White Publication Oct. 5. Craig, W., Tepfer, M., Degrassi, G., &Ripandelli, D. (2008). *An Overview of General* divisions/csurv/geac/annex-5.pdf 6. F. (2009). *Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants*. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9 7. *Features of Risk Assessments of Genetically Modified Crops*. Euphytica 8. Ganguli, P. (2001). *Intellectual Property Rights: Unleashing the Knowledge Economy*. New Delhi: Tata McGraw-Hill Pub. 9. Intellectual property law (2008) Lionel Bently, Brad Sherman. Oxford University Press. 10. International Union for the Protection of New Varieties of Plants. http://www.upov.int 11. Karen F. Greif and Jon F. Merz, *Current Controversies in the Biological Sciences - Case Studies of Policy Challenges from New Technologies*, MIT Press 12. Kuhse, H. (2010). *Bioethics: an Anthology*. Malden, MA: Blackwell. 13. National Biodiversity Authority. http://www.nbaindia.org 14. *National IPR Policy*, Department of Industrial Policy & Promotion, Ministry of Commerce GoI, National Portal of India. http://www.archive.india.gov.in 15. 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/ 16. Patents for Chemicals, Pharmaceuticals a nd Biotechnology:Fundamentals of Global Law, Practice and Strategy (2010) Grubb P. W. Grubb, P. L. Thomsen, P. R. Oxford University Press. 17. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ 18. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J. W., Burachik, M., Gray, A., Wu, World Intellectual Property Organisation. http://www.wipo.int 19. World Trade Organisation. http://www.wto.org	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 188:
Title of the course: BIOENTREPRENEURSHIP
Number of credits: 2
Effective from: 2019-2020

Course Objectives	Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with the understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.	
Learning Outcomes	Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.	
Contents	MODULEI Finance and Marketing • Taking decision on starting a venture; Assessment of feasibility of a given venture/new venture; • Approach a bank for a loan; Sources of financial assistance; Making a business proposal/Plan for seeking loans from financial institution and Banks; Funds from bank for capital expenditure and for working; Statutory and legal requirements for starting a company/venture; Budget planning and cash flow management; Negotiations/Strategy With financiers, bankers etc.; With government/law enforcement authorities; With companies/Institutions for technology transfer • Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/ Advertising; Services Marketing Dispute resolution skills. MODULE II	12 hours 12 hours

	• Fundamentals of Entrepreneurship • Support mechanism for entrepreneurship in India Role of knowledge centre and R&D • Knowledge centres like universities and research institutions; Role of technology and upgradation; Assessment of scale of development of Technology; Managing Technology • Transfer; Regulations for transfer of foreign technologies; Technology transfer agencies. E-business setup, management. Human Resource Development (HRD) Leadership skills; • Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up. External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking.	
References/ Reading	1. Ramsey David (2011). EntreLeadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books 2. Byrne John A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin. 3. Lynn Jacquelyn (2007). The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc.	

Programme: M.Sc. Marine Biotechnology
Course code MBO 189
Title of the course: CELLULAR BIOPHYSICS
Number of credits: 3
Effective from: 2019-2020

Course Objectives	The course will provide 1) knowledge of the fundamental physical principles for the electrical properties of living cells and models describing membrane and action potentials. 2) an understanding of how potentials are generated across the membranes of cells and what these potentials do.	
Learning Outcomes	It will equip the student with a broad perspective of integrating physics with biology at the cellular level with detailed information to pursue a career in newly evolving and dynamic fields of Neurobiology	
Contents	MODULE I 1) Overview of the Cellular organization of the nervous system: • Typical nerve cell • Types of cells: Neuronal, Glial cells, ependymal cells and Schwann cells. • Classification and types of neurons , cytons and axons • Function of nerve cells 2) Ion Channels • Sodium channels • Potassium channels • Calcium channels 3) Potentials of excitable cells Biophysics of nerve cells: • Electrical properties of the axon, ion fluxes, potentials of nerve cell membrane Resting membrane potential • Chemical –to- electrical transduction • Signal summation • Action Potential and propagation(a) Hodgkin and Huxley's model, voltage clamp experiment and the derivation and propagation of Action Potential • Compound Action potential • Sodium and Potassium ionic currents • Nernst's potential, Goldman's equation, Sodium–potassium pump. • Transmission of nerve impulse MODULE II	12 hours 12 hours

	Communication between neurons: • Types of synapses and synaptic transmission (electrical and chemical) • Synaptic transmission through second messenger (including mechanism of signal transduction, Neuromodulation and synaptic inhibition . • Electrical- to- chemical Transduction (a) Graded potential (b) Synaptic potential and synaptic integration [Electrical and Chemical Synaptic Potential, Excitatory Post Synaptic Potential (EPSP) Inhibitory Post Synaptic Potential (IPSP), Neuro- muscular junctions, Summation and facilitation. Spike potential • Neurotransmitter –physiological role, pharmacological significance, (example of one agonist and one antagonist for a neurotransmitter) Acetylcholine (Nicotinic and muscarinic receptors) MODULE III • Muscle- structure and electro-physiology of contraction. Spike potential Muscle contraction…Cross-bridge theorey. Calcium channels. Repolarisation. • Visual system: Vertebrate eye and retina. • Morphology and arrangement of photoreceptors, Electrical response to light. Concept of receptive fields. Colour vision. • Organisation of the nervous system in Marine organisms: • Structure of nerve net, neural plexus, an ganglionated nervous system e.g. hydra, starfish, and*Aplysia* . • Type study in behavior of *Aplysia*: elementary behavior, neuroendocrine reflexes, complex behavior; higher grade and learned behavior. Synaptic plasticity.	12 hours
References/ Reading	1. Introductory Biophysics , V. Pattabhi & N. Gautham, Narosa Publications 2. Ionic Channels of Excitable Membranes, Third Edition. Bertil Hille. Sinauer Associates. Sunderland, MA. 2001. 3. Physical Biology of the Cell by Rob Phillips, Jane Kondev and Julie Theriot, Garland Science, Taylor & Francis Group, New York, 2009. 4. Handbook of Molecular Biophysics- Methods and applications by H.G. Bohr Wiley-VCH Verlag GmbH & Co, KGaA, Weinheim (2009) 5. The Physiology of Excitable Cells, Aidley, D. J. (1998). Cambridge University Press. 6. Principles of Neural Sciences Ed: E. Kandel, J. Schwarts and T. Jessel. 4th edition (2000) McGraw Hill 7. Textbook of Medical Physiology Ed: Guyton and Hall 9th edition (1998) W. B. Saunders Company 8. Molecular Neurobiology Ed: J.B.Martin (1998) Scientific	

	American 9. Elements Of Molecular Neurobiology C.U.M. Smith,J Wiley and Sons Publishers, N.Y. 10. An Introduction to Molecular Neurobiology Z.W. HallSinauer Associates Inc. Publishers	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 191
Title of the course: SCUBA DIVING
Number of credits: 2
Effective from: 2019-2020

Content	**MODULE I**: Dive Theory • Introduction • Diving equipment • Physics • Physiology • Planning dives • Executive dives • The underwater world • Scuba experience and beyond **MODULE II:** Practicals • 2 sessions of pool training for skills • 2 days of sea dives- repeating pool skills and pleasure • Dives – Total 4 dives.	24 hours 24 hours
References/ Reading	www.barracudadiving.com	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 192
Title of the course: LAB II - BIOCHEMICAL & ANALYTICAL TECHNIQUES
Number of credits: 3
Effective from: 2019-2020

Course Objectives	The objective of this laboratory course is to introduce students to experimentation in biochemistry. The course is designed to teach the utility of these experimental methods in a problem-oriented manner.	
Learning Outcomes	Students should be able to: • Elaborate concepts of biochemistry with easy-to-run experiments. • Familiarize with basic laboratory instruments and understand principles underlying measurements using those instruments for experiments in biochemistry.	
Contents	1. Principles of colorimetry and experimental significance of the Beer-lambert Law 2. Estimation of proteins by the Lowry's method 3. Spectral characteristics of coloured solutions and UV absorption of proteins 4. Estimation of reducing sugars. 5. Titration curves of di- and tri- protic amino acids 6. Paper chromatography. 7. Ammonium sulphate precipitation and dialysis 8. Protein subunit molecular weight determination by SDS-PAGE 9. Column chromatographic techniques 10. Analysis of a biological specimen by SEM 11. Fluorescence microscopy 12. Demonstration of fluorescence spectroscopy 13. Demonstration of mass spectrometry 14. Demonstration of FT-IR/XRD	72 hours
References/ Reading	1. Modern Experimental Biochemistry (2003). Boyer, R. 2. Principles and Techniques of Biochemistry and MolecularBiology (2005). Wilson, K. & Walker, J. 3. An Introduction to Practical Biochemistry.(2005). Plummer,D.T. 4. Laboratory Manual of Biochemistry.(1998). Jayaraman, J. 5. Physical Chemistry: Principles and Applications in the Biological Sciences. Tinoco, Sauer, Wang, and Puglisi. (2013) Prentice Hall, Inc.	

	6. Physical Chemistry for the Life Sciences (2nd Edition). Atkins, de Paula. (2015) Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular, Friedrich Lottspeich, Joachim W. Engels, (2018). Wiley-VCH publisher. 7. Laboratory Protocols in Applied Life Sciences, (2014), Prakash S. Bisen, Taylor and Francis Publisher	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 193
Title of the course: LAB III - MOLECULAR BIOLOGY & GENETIC ENGINEERING
Number of credits: 3
Effective from: 2019-2020

Course Objectives	The objectives of this course are to provide students with the experimental knowledge of molecular biology and genetic engineering.	
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.	
Contents	1. UV mutagenesis to isolate amino acid auxotroph. 2. Transduction 3. Phage titre with λ phage/M13. 4. Genetic Transfer-Conjugation, gene mapping. 5. Plasmid DNA isolation and DNA quantification. 6. Restriction Enzyme digestion of plasmid DNA. 7. Genomic DNA and RNA isolation 8. Polymerase Chain reaction. 9. Cloning of insert in to a plasmid vector 10. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency. 11. Confirmation of the insert by Colony PCR and Restriction mapping 12. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis 13. Purification of His-Tagged protein on Ni-NTA columns 14. Southern hybridization.	72 hours
References/ Reading	1) Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN VENNISON PHI Learning 2) Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set 4th Edition (2012) by Michael R. Green , Joseph Sambrook	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 280
Title of the course: GENETIC ENGINEERING
Number of credits: 3
Effective from: 2019-2020

Course Objectives	To explain the various tools that are used in genetic engineering to create recombinants and its applications in biological research as well as in biotechnology industries	
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.	
Content:	**MODULE I** • Enzymes used in Molecular biology: restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; nucleases, Topoisomerase, thermostable polymerase, Terminal deoxynucleotide polymerase and others. • 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. • 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. **MODULE II** • 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	12 hours 12 hours

	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. • 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. **MODULE III** • 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*),Frog (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	**12 hours**
References/ Reading	1. Brown, T. A. (2006). *Genomes* (3rd ed.). New York: Garland Science Pub 2. S. Primrose, R. Twyman, B. Old, and G. Bertola (2006). *Principles of Gene* 3. *Manipulation and Genomics*, Blackwell Publishing Limited; 7th Edition 4. Green, M. R., & Sambrook, J. (2012). *Molecular Cloning:*	

	A Laboratory Manual. 5. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press. 6. Selected papers from Scientific Journals, particularly Nature & Science. *7.* Technical Literature from Stratagene, Promega, Novagen, New England Biolab. 8. Introduction to Biotechnology and Genetic Engineering (2008)A.J. Nair Laxmi Publications Pvt. Ltd 9. From Genes to Genomes: Concepts and Applications of DNA Technology 2011by Jeremy W. Dale, Malcolm von Schantz , Nicholas Plant Wiley-Blackwell publisher 10. Textbook of Biotechnology Paperback – 2017 by H.K. Das Wiley Publisher 11. Gene Cloning and DNA Analysis: An Introduction 2016 T. A. Brown Wiley-Blackwell; 7th edition 12. Applied Molecular Biotechnology: The Next Generation of Genetic Engineering (2016)Muhammad Sarwar Khan, Iqrar Ahmad Khan, Debmalya Barh. CRC press 1st Edition	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 282
Title of the course: BIOINFORMATICS
Number of credits: 2
Effective from: 2019-2020

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	
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.	
Contents	**MODULE I** • Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • 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, Clustal, Muscle; Scoring matrices, Distance matrices. • 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). **MODULE II** • 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	12 hours 12 hours

	CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally similar proteins). • 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. • 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. • Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement ad quantification); Analysis of differentially expressed genes; Experimental designs.	
References/ Reading	1. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*, John Wiley and Sons. 2. D.W. Mount, (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press. 3. Jones &Peuzner, (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India. 4. DovStekel, (2003); *Microarray Bioinformatics*; Cambridge University Press. 5. Introduction to Bioinformatics (2006)1st Edition Anna Tramontano Chapman & Hall/CRC Mathematical and Computational Biology. 6. Essential Bioinformatics Paperback – 2007 by Jin Xiong Cambridge University Press; First edition. 7. Understanding Bioinformatics (2007) 1st Edition Marketa J Zvelebil, Jeremy O. Baum. Garland Science 8. Introduction to Bioinformatics (2013) Lesk Oxford University Press; 4th Revised ed.	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 283
Title of the course: LAB V-CELL AND TISSUE CULTURE
Number of credits: 2
Effective from: 2019-2020

Contents	1. Preparation of starting material (Biosafety cabinet, solutions, media, cell sample etc.): Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, contamination and precautions 2. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell like HEK293, COS-7 3. Transfection and co-transfection: Calcium-phosphate method and Lipofection 4. Cell fixation and staining: Immunolabeling, mounting, fluorescence imaging 5. Tissue culture medium, contamination and precautions in plant tissue culture 6. Callus induction and plantletregeneration 7. Single cell suspension and Protoplast isolation	48 hours
References/ Reading	1. Animal cell culture (2000) – A Practical Approach John R.W. Masters 2. Culture of animal cells – A manual of Basic techniques (2005) R.I. Freshney 3. Plant tissue culture, 3rd edition(2012) –Techniques and experiment, R. Smith	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 284
Title of the course: MARINE FOOD TECHNOLOGY
Number of credits: 2
Effective from: 2019-2020

Course Objectives	The objectives of this course are to teach the principles of food preservation, processing and packaging and quality management practices for food of marine origin.	
Learning Outcomes	On completion of this course, students should be able to acquire practical knowledge of food technology for marine foods.	
Content	**MODULE-I** 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. Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer. **MODULE-II** 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. 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.	12 hours 12 hours
References/ Reading	1. Drugs from sea. (2000). Fusetani, N. 2. Microbiology of deep sea hydrothermal vents. (1995). Karl, D.M. 3. The search from bioactive compounds from microorganisms. (1992). Omum, S. 4. Biotechnology and Biodegradation (1990). Kamely, D. Chakraborty, A. & Omenn, G.S. 5. Recent Advances in Marine Biotechnology. Vol.2 (1998) Fingerman, M., Nagabushanam, R., Thompson, M. 6. Biotechnology in the marine sciences: Proceedings of the first	

	annual MIT sea grant lecture & seminar. (1984). Colwell, R.D.(Ed)Recent articles from various journals such as Journal of Marine Biotechnology, Nature and Science will be covered. 7. 1. Environmental Biotechnology: Theory and Application Gareth G. Evans, Judy Furlong John Wiley and Sons, 2011 8. Recent Advances in Marine Biotechnology Volume 3 – Milton fingerman et al., 1999. 9. Cynobacterial and Algal Metabolisms and Environment Biotechnology – TasneemFatma, 1999. 10. Environmental Biotechnology Theory and applications – Evans et al., 2000. 11. Environmental Biotechnology – Gareth M.Evams et al., 2003 12. Biotechnology, Recombinant DNA Technology, Environmental Biotechnology – 13. S.Mahesh et al., 2003. 14. A.S. Ninawe & K. Rathnakumar, (2008) Fish Processing Technology and Product Development, Narendra Publishing House, New Delhi 15. Fereidon Shahidi et al., (2014) Seafood Safety, Processing and Biotechnology. Taylor and Francis. A CRC press book 16. K.C. Badapanda (2012. Fish Processing and Preservation Technology. VolIV NPH Narendra Publishing House, New delhi	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 285
Title of the course: NANOBIOTECHNOLOGY
Number of credits: 2
Effective from: 2019-2020

Course Objectives	The course aims at providing general and broad introduction to the multi- disciplinary field of nanotechnology.	
Learning Outcomes	On successful completion of this course, students should be able to describe the basic science behind the properties of materials at a nanometre scale.	
Content	**MODULE I** 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. Thin films; Colloidal nanostructures; Self assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation. 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. **MODULE II** Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development. Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. 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.	12 hours 12 hours

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

Programme: M.Sc. Marine Biotechnology
Course code: MBO 286
Title of the course: DEVELOPMENTAL BIOLOGY
Number of credits: 2
Effective from: 2019-2020

Course Objectives	This course will provide a conceptual overview of how developmental patterns arise. Using examples from different model systems regulatory networks involved are highlighted, aiming to project the molecular basis of developmental patterns.	
Learning Outcomes	Understanding of major ideas in developmental biology; familiarization with experimental approaches and how they are applied to specific problems in developmental biology.	
Contents	**MODULE I** • Germ cells and fertilization; embryogenesis as modelled through *Xenopus.* • Cell fate & commitment – potency- concept of embryonic stem cells, differential gene expression, terminal differentiation, transdetermination. • Lying of body axis planes; cellular polarity: differentiation of germ layers. Morphogens, gradients, concept of compartmentalization and fate mapping. • Cellular movements and gastrulation (sea urchin as model system); mammalian development (mouse/rat model). • Neurulation. • Cell lineages and pattern formation- *Caenorhabditis* as a model system; concept of positional values; heterochronic genes and effects of their mutations. • Apoptosis : concept, mechanism and physiological significance. The role of programmed cell death in developmental processes. • Cell-cell communication in development; induction and competence; cascades of induction; paracrine factors. • Signal transduction cascades; Fibroblast growth factor and the RTK pathway; the Hedgehog family; the Wnt family; the TGF-β superfamily. • Juxtacrine signaling; the Notch pathway; cross-talk between pathways. Maintenance of the differentiated state. **MODULE II** • Organizational and functional hierarchy of developmental control genes; maternal and zygotic gene effects. • Homeotic selector genes in *Drosophila*; concept of the homeobox and homeotic mutations; conceptual	12 hours 12 hours

	extrapolation to mammalian systems. • Complications in mammalian development; extraembryonic structures; twins and embryonic stem cells; production of chimeric mice. • The unique development of the human brain; adult neural stem cells. • Post-embryonic development: metamorphosis, regeneration and aging; significance of Imaginal discs in *Drosophila*. • Embryogenesis and early pattern formation in plants; 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. • Role of nuclear–cytoplasmic interactions in development. Medical implications of developmental biology. • Overview of developmental mechanisms of evolutionary change.	
References/ Reading	1. Gilbert, S.F. Developmental Biology. (1997). 2. Schneider, E.L. & Rowe, J.W.(Eds.) (1990). Handbook of the Biology of Aging. 3. Cooper G. ( ) The Cell. 4. Alberts et al. The Molecular Biology of the Cell. (2002).	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 287
Title of the course: GENOMICS AND PROTEOMICS
Number of credits :2
Effective from : 2019-2020

Course Objectives	The objectives of this course are to provide introductory knowledge concerning genomics & proteomics and their applications.	
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.	
Content	**MODULE I** Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. 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. Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. 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. **MODULE II** Aims, strategies and challenges in proteomics; proteomics technologies: 2D-PAGE, isoelectric focusing, mass spectrometry, MALDI-TOF, yeast 2-hybrid system, proteome databases. 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.	12 hours 12 hours
References/ Reading	1. Primrose, S.B. Twyman, R.M. Primrose S.B., & Primrose, S.B.(2006) . Principles of Gene Manipulation and Genomics, Malden, MA:Blakwell Pub. 2. Liebler, D.C. (2002), Introduction of Prteomics: Tools for the new Biology. Totowa, NJ:Humana Press.	

	3. Cambel, A.M. & Heyer , L.J.(2003). Discovering Genomics, Proteomics, and Bioinformatics. Scan San Franscisco: Benjamin Cummings. 4. Structural Proteomics: High-Throughput Methods (Methods in Molecular Biology) (2008)- B. Kobe, M. Gussand T. Huber 5. Campbell AM &Heyer LJ, Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings 2007	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 288
Title of the course: ENZYMES: CHEMISTRY & APPLICATIONS
Number of credits: 3
Effective from: 2019-2020

Course Objectives	This course will provide a comprehensive view of enzyme chemistry and kinetics, methods and strategies for enzyme purification and characterization. One section also deals with the biotechnological significance of enzyme functions.	
Learning Outcomes	A thorough understanding of the essential concepts of enzymology, with an awareness of the biotechnological potential of enzymes in various fields of application.	
Content	**MODULE I** • Classification and nomenclature of enzymes. • Effect of pH, temperature, ions, etc. on enzyme activity., the Arrhenius Plot • Enzyme extraction strategies; choice of systems for production of enzymes for biotechnological applications. • General methods for quantitative assay of enzymes. • Enzyme purification: principles and techniques of salting in and out, molecular • sieving, ion exchange and affinity chromatography, gel electrophoresis, isoelectric • focusing, 2-D electrophoresis. • Fold purification and enzyme recovery, setting up of a purification table. **MODULE II** • Isozymes ;*in situ* localization of enzymes in gels. • Catalytic mechanisms: mechanism of action of lysozyme, chymotrypsin etc. • Cofactors and Coenzymes: physiological significance and contributions to enzyme activity measurements. • Reaction kinetics, order and molecularity; steady state kinetics; analysis of kinetic • data of single-substrate reactions. • Kinetics and mode of action of allosteric enzymes. • Enzyme inhibition: types and significance • Multisubstrate reactions and their kinetic parameters. • Enzyme activation. • Biological regulation of enzyme activity. **MODULE III** • Role of covalent modification in enzymatic activity; zymogens. • Significance and applications of enzyme modifications through the use of PEG, etc. • Clinical and industrial applications of hydrolytic enzymes.	12 hours 12 hours 12 hours

	• Ribozymes: types, structure and significance. • Catalytic antibodies: concept and applications. • Enzyme fusion and its biotechnological significance. • Development and applications of biosensors.	
References/ Reading	1. Bioseparations: Principles & Techniques (2005). Sivasankar B. 2. Enzymes- a practical introduction to structure mechanism and data analysis (2000). Copeland, R.A. 3. Enzymes: Biochemistry, Biotechnology & clinical chemistry (2004). Palmer, T.	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 289
Title of the course: MOLECULAR IMMUNOLOGY
Number of credits: 3
Effective from: 2019-2020

Course Objectives	The focus is on the key characteristics of immune system to recognize non-self from self…to remember structures and produce molecules that are highly specific to the foreign molecules. The course addresses in detail the different mechanisms that generate very large number of specific receptors that the immune system generates in response at the molecular level.	
Learning Outcomes	Will be theoretically equipped to develop strategies to manipulate the immune system, and its components to benefit the patient and design vaccines. It will prepare the students to engage further in this rapidly evolving field.	
Content	**MODULE I** **Recognition of antigens** 1. The major histocompatibility complex: • Discovery and its role in immune response • Structure of MHC molecules • Binding of peptides to MHC molecules • Genomic organization of the MHC 2. Recognition of antigens by T Lymphocytes • Antigen processing and presentation to $CD4^+$ and $CD8^+$ T Lymphocytes. • Antigen receptors and accessory molecules of T Lymphocytes • Effector molecules of T lymphocytes **MODULE II** **Maturation, activation and regulation of Lymphocytes** 1. Maturation of Lymphocytes • General features of Lymphocyte maturation • Formation of functional antigen receptor genes in B & T lymphocytes. • Maturation of B lymphocytes. • Maturation of T lymphocytes. 2. Activation of T lymphocytes • Signal transduction by the T lymphocyte receptor complex – Ras and Rac, Calcineurin and Protein Kinase C signaling. • Activation of transcription factors in T cells 3. Activation of B cells • Signal transduction by the B cell antigen receptor complex • CD40 and its role in T-B cooperation	12 hours 12 hours

	• Bidirectional molecular interactions between T-B cells **MODULE III** **Effectors mechanisms of immune response** Immunologic tolerance • General features & mechanisms of immunologic tolerance • T Lymphocyte tolerance • B Lymphocyte tolerance • Homeostasis in the immune system: termination of normal immune response • Cytokines – regulating innate and adaptive immunity and stimulate hematopoiesis • Cell mediated immunity • Humoral immunity • evasion of mechanisms by bacteria and virus Diseases caused by immune response: hypersensitivity and autoimmunity • Mechanisms of autoimmunity • Types of hypersensitivity diseases • Immunosuppression • Evasion of immune responses by pathogens	12 hours
References/ Reading	1. Cellular and Molecular Immunology (2017) Abbas A.K. Lichtman A.H. & Pober, J.S. 9th Edition 2. Practical Immunology (2008) Frank C.Hay & O.M.R. Westwood 3. Immunology (2007) Goldsby R.A,, Kindt T.J., Osbrne B.A and Kuby J. 4. Essential Immunology (2011) Delves P J., Martin S. J.,. Burton D R, Roitt I.M. 5. Immunology (2006) Luttmann M, Bratke K., Kupper M., & Myrtek D, Manual of Molecular and Clinical Laboratory Immunology (2016) Detrick B., Hamilton R.G. & Folds J.D. ASM Press.	

Programme: M.Sc. Marine Biotechnology
Course code: MBO 290
Title of the course: STEM CELL BIOLOGY
Number of credits: 1
Effective from: 2019-2020

Course Objectives	The aim of the course is to bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells to a coherent picture in an experimental and clinical context.	
Learning Outcomes	On completion of the course, students should be aware of basics of stem cell function in the body and their usage in the medical context.	
Content	**MODULE I** Definition,stem cell origins and plasticity,classification and source of stem cells; Stem cell differentiation; Stem cells cryopreservation, iPS technology; microRNAs and stem cell regulation, Tumor stem cells, Overview of embryonic and adult stem cells for therapy. Human stem cells research: Ethical considerations; Stem cell based therapies: Pre-clinical regulatory consideration and patient advocacy.	12 hours
References/ Reading	1. Stem cells: From basic to advanced principles, John Collins, (2017). Hayle Medical 2. Essential of Stem cell Biology, Robert lanza, (2013) Elsiver publisher. 3. Principle of Tissue Engineering, Robert lanza, (2011), AP publisher 4. Essential stem cell methods, (2009), Robert Lanza, Elsivier. 5. Developmental Biology. (1997). Gilbert, S.F. 6. Handbook of the Biology of Aging. (1990). Schneider,E.L. & Rowe,J.W.(Eds.) 7. Robert Lanja (2006) Essential of Stem Cell Biology, 2 nd Edition, Academic Press. 8. A.D. Ho. R. Hoffiman, (2006) Stem Cell Transplantation Biology Process Therapy, Willy-VCH	