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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/91/2 Date:31.05.2023

Ref: GU/Acad –PG/BoS -NEP/2022/339/32 dated 20.08.2022

CIRCULAR

In supersession to the above referred Circular, the updated approved Syllabus with revised Course Codes of the **Master of Sciences in Marine Biotechnology** Programme is enclosed.

The Dean/ Vice-Deans of the School of Biological Sciences and Biotechnology is requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.05.31 11:06:18 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, School of Biological Sciences and Biotechnology, Goa University.
2. The Vice-Deans, School of Biological Sciences and Biotechnology, Goa University.

Copy to:

1. The Chairperson, Board of Studies in Marine Biotechnology.
2. The Programme Director, M.Sc. Marine Biotechnology, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University

ANNEXURE II

M.Sc. Marine Biotechnology

Preamble

The M.Sc. Marine Biotechnology is supported by the DBT, New Delhi, Govt. of India, and was started at Goa University in 1988 with the objective of developing manpower in the field of Marine Biotechnology. The students are imparted training and skills in Marine Biotechnology and empowering them to undertake the challenges in BLUE biotechnology.

The eligibility for the program is B.Sc. Degree under 10+2+3 in any branch of sciences such as Physical, Chemical Biological, Agricultural, Fisheries, Pharmaceutical Medicine Engineering, or Technology with 55% marks. Admission to the program is through a Graduate Aptitude Test - Biotechnology (GAT-B) 2021 entrance examination that is conducted at the national level.

Proposed Scheme For

M.Sc. Marine Biotechnology (1455)

(Applicable from 2022-23)

SEMESTER I		
Course Codes	**Course Titles**	**Credits**
Discipline-specific Core courses (16 credits)		
MBT-500	Marine Microbiology & Ecology	3
MBT-501	Lab I: Techniques in Microbiology, Marine Biology and Chemistry	3
MBT-502	Immunology and Marine pathogenesis	3
MBT-503	Lab II: Immunology & Marine Pathogenesis	2
GBT-504	Biophysical Principles & Analytical Techniques	2
GBT-505	LAB III: Biochemical and analytical techniques	3
Discipline-specific Elective courses (Any 4 credits)		
GBT-521	Concepts in Biochemistry	2
GBT-522	Biostatistics	2
GBT-523	Mathematics for Biologists	2
GBT-524	Biology of the Extremophilic Organisms	2
Semester II		
Discipline-specific Core courses (16 credits)		
MBT-504	Oceanography and Marine Bioresources	3
MBT-505	Aquaculture Technology	3
GBT-508	Genetics and Molecular Biology	3
GBT-509	Lab IV: Genetics and Molecular Biology	2
GBT-510	Cell and Developmental Biology	3
GBT-512	Lab V: Plant and Animal Tissue Culture	2
Discipline-specific Elective courses (Any 4 credits)		
MBT-521	Bioinformatics	2
GBT-526	Lab VI: Lab in Bioinformatics	2
GBT-527	Nanotechnology	2
GBT-528	Vaccine Technology	2

Semester III		
Research specific Elective courses (Any 8 credits)		
GBT-600	Recombinant DNA Technology	3
GBT-601	Lab VII: Recombinant DNA Technology	2
GBT-602	Bioprocess Technology	3
GBT-603	Lab VIII: Bioprocess technology	2
MBT-600	Marine Food Technology	2
Generic Elective courses (Any 12 credits)		
GBT-623	Virology	2
MBT-621	IPR, Biosafety & Bioethics	3
MBT-622	Potential of Marine Biotechnology	2
GBT-624	Genomics & Proteomics	2
GBT-621	Solid Waste Management	3
MBT-652	Summer/Winter Internship	2
Semester IV		
Research specific Elective courses (Any 4 credits)		
GBT-605	Research Methodology	2
GBT-606	Synthetic Biology	2
GBT-607	Plant and Animal Biotechnology	2
MBT-601	Field Trip	2
MBT-602	Scuba Diving	2
Discipline-specific dissertation		
MBT-651	Dissertation	16

SEMESTER I

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-500

Title of the Course: MARINE MICROBIOLOGY & ECOLOGY

Number of Credits: 3

Effective from AY: 2022 - 23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The objective of this course is 1. to provide information about the microbes available in the aquatic environment, 2. understand their role, and their interaction with the marine environment	
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: actinomycetes anaerobes. • Extremophiles: barophiles, thermophiles, psychrophiles, halophiles, polyextremophiles, • An overview of the organization and cell structure of prokaryotes and Archaea: cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups.	**No. of hours** 15
	MODULE II • Techniques in Marine Microbiology: • Sampling: Water, Sediments. • Direct observation and enumeration of microbes: Light and • Electron microscopy to study the morphology and	15

	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 • 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 movements in microbes, Quorum sensing, Chemotaxis, Phototaxis, Bioluminescence and indicator species, and Biological rhythms.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. C.B. Munn, Marine Microbiology: Ecology and Applications, CRC Press, 2020. 2. D. Surajit, D. Hirak Ranjan, Microbial Diversity in the Genomic era, Elsevier, 2018. 3. D.L. Kirchman, J.M. Gasol, Microbial ecology of the Oceans. Wiley-Blackwell, New York, 2018. 4. J. Paul, Methods in Microbiology: Marine microbiology, Academic Press, 2001 5. K. Horikoshi, G. Antranikian, A. Bull, T. Robb, F. T. Stetter, K. O, Extremophiles handbook, Springer, 2011. 6. L. Gram, Microbial Spoilage of Fish and Seafood, Springer, 2009 7. M.T. Madigan, D.H. Buckley, W.M. Sattley, D.A. Stahl, Brock Biology of Microorganisms, Pearson Publisher, 2021. 8. M.J. Pelczar, E.C.S. Chan and N.R. Kreig, Microbiology, CBS Publishers, 2001.	
Course		

Outcomes:	1. The course explains the different features of marine ecosystems and the microbial diversity in oceans. 2. The students will get an overview of the concepts and techniques used in Marine Microbiology. 3. The students will be able to understand the morphology, nutrition and classification of various microbes and analyze their growth characteristics. 4. They will be able to discuss marine microbes in terms of physiological capability and their biogeochemical role.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-501

Title of the Course: LAB I: TECHNIQUES IN MICROBIOLOGY, MARINE BIOLOGY AND CHEMISTRY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	1) To introduce the students to various methods to isolate and culture bacteria using different media, learn marine sampling methods. 2) measure the physical and chemical parameters of the marine aquatic system.	
Content:	1. Preparation of solid & liquid media, Differential and Selective media: Isolation of bacteria from seawater /sediments samples, Enumeration: serial dilution methods, plating. 2. Maintenance of organisms: Streaking, slants and stabs cultures. 3. Study of morphology and cultural characteristics. 4. Gram staining. 5. Motility 6. Antimicrobial sensitivity test and demo of drug resistance. 7. Cultivation of fungi: Slide, chunk and cover slip techniques.	**No. of hours** 45
	8. Samplers: water samplers, dredges, grabs, snappers. 9. Sampling (Field trips) and identification: i. Phytoplankton & Zooplankton. ii. Nekton iii. Benthos 10. Estimations: i. Chlorophyll ii. Nutrients: nitrates, nitrites, phosphates, silicates iii. Dissolved oxygen iv. Salinity, pH & alkalinity.	45

Pedagogy:	Hands-on experiments in the laboratory, learning skills in sampling techniques.
References/ Readings:	1. A. Eleftheriou and A. McIntyre, Methods for the Study of Marine Benthos, Wiley Publisher, 2005. 2. A. Sastry, Essentials of Practical Microbiology, India: Jaypee Brothers Medical Publishers Pvt. Limited, 2021. 3. G. J. Bakus, Quantitative Analysis of Marine Biological Communities: Field Biology and Environment, Wiley publisher, 2007 4. K. Grasshoff, K. Kremling, M. Ehrhardt, Methods of Seawater Analysis, Wiley Publisher, 2009. 5. L. Yuncong, M. Kati , Water Quality Concepts, Sampling, and Analyses. CRC Press LLC, 2019. 6. M.L. Leo Nollet, S. P. Leen, Gelder, Handbook of Water Analysis, CRC Press, 2013. 7. M. E. McCance, W. F. Harrigan, Laboratory Methods in Microbiology. Elsevier Science, 2014. 8. M. Omori, T. Ikeda, Methods in Marine Zooplankton Ecology. Krieger Publisher, 1992. 9. R. Baird, A. Eaton, E.W. Rice, L. Bridgewater, Standard methods for the examination of water and wastewater. American Public Health Association, 2017. 10. R. Vasanthakumari, Practical Microbiology, India: B.I. Publications Pvt. Limited, 2009. 11. W. Sattley, M. Madigan, K. Bender, D. Stahl, D. Buckley, Brock Biology of Microorganism, Pearson Education, 2017.
Course Outcomes:	Upon completion of the course, the student will be able to 1. Use appropriate media to isolate bacteria from different ecosystems. 2. Study and group bacteria on the basis of morphological and biochemical tests. 3. Understand the various techniques used for marine sampling. 4. Estimate the plankton and the elemental composition in seawater.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-502

Title of the Course: IMMUNOLOGY AND MARINE PATHOGENESIS

Number of Credits: 3

Effective from AY: 2022 - 23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	1) To provide basic knowledge and 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. 4) To introduce the common fish/shellfish pathogens, understand their growth characteristics and control and preventive measures.	
Content:	**<u>MODULE I</u> – Concepts and Basics** • Introduction – History and scope of immunology • Innate immunity: - factors, features and 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 • Phagocytosis: oxygen-dependent/ independent killing intracellularly. • Major histocompatibility complex…Structure of MHC molecules, basic organization of MHC in human, haplotype-restricted killing. • Nature and biology of antigens and superantigens: haptens, adjuvants, carriers, epitopes, T-dependant and T-independent antigens.	**No. of hours** 15

	<u>MODULE II</u> – Defense Components: Constituents of the immune system and effector mechanisms of immune responses • Humoral immunity: cells, antibody formation, primary and secondary response. • Immunoglobulins – structure, distribution and function. • Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics. • The basics of Immuno-diagnostics. • 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. • Hybridoma technology and monoclonal antibodies. • Hypersensitivity: An introduction to the different types. • Introduction to autoimmune diseases.	15
	<u>MODULE III</u> – Marine Pathogens and Disease Control • Introduction to finfish and shellfish diseases: bacterial, fungal, parasitic, nutritional, environmental and their control. • Prevention of Fish diseases. • Human bacterial Pathogens associated with fishes and their products - *Aeromonas* spp., *Clostridium* spp., *Listeria* spp., *Plesiomonas*, *Salmonella* spp., *Staphylococcus aureus*, *Vibrio* spp. and common *Enterobacteriaceae.* • Marine Biotoxins as biological hazards associated with fish and fishery products.	15
Pedagogy:	Lectures, tutorials, assignments	
	1. D. Male, J. Brostoff, D. Roth, I. Roitt, Immunology. Elsevier Saunders	

References/ Readings:	publication, 2013. 2. D.R. Ward and C.A. Hackney. Microbiology of marine food products. Springer Science, 2012. 3. F. Parthiban, S. Felix, Microbiology of Fish and Fishery Products. Daya Publishing House, 2018. 4. I.M. Roitt, P.J. Delves, S. J. Martin, D. R. Burton, I.M. Roitt, Essential Immunology. Wiley-Blackwell, 2017. 5. J. Punt, S. Stranford, P. Jones et al., Kuby Immunology W.H. Freeman, 2018. 6. P. T. K. Woo, D. W. Bruno. Fish diseases and disorders. Volume 3: viral, bacterial and fungal infections. CABI Publishing, 2011. 7. W. Luttman, K. Bratke, M. Kupper, D. Myrtek, Immunology. Academic Press, 2009.
Course Outcomes:	1. The course will enable students to understand the fundamentals of basic immunological processes in the human system. 2. Knowledge of principles of immunodiagnostics would enable them to upskill effectively for research and development, in the field. 3. The basic overview of Immunology strengthens their foundations for a career in Biotechnology. 4. The Marine Biotechnology students will get an overview of the different marine pathogens and disease control.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-503

Title of the Course: LAB II: IMMUNOLOGY AND MARINE PATHOGENESIS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	This course involves 1) learning techniques to identify reactions in the lab that form the basis for application in immunodiagnostics 2) to gain an insight into the evaluation of marine pathogens.	
Content:		**No. of hours**
	1. Determination of antibody titer using the double immunodiffusion. 2. Assessment 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	30
	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.	30
Pedagogy:	Lectures/ tutorials-assignments/hands-on practical	

References/ Readings:	1. G.L. Bullock, Diseases of Fisheries. Narendra Publishing House, 2014. 2. J. Edward J, Fish Disease: Diagnosis and treatment. Wiley Blackwell, 2010. 3. I. R. Freshney, Culture of Animal Cells. Wiley-Blackwell, 1998. 4. V. Inglis, Bacterial Diseases of Fish. Wiley Publications, 2013. 5. C.A. Janeway, P. Travers, M. Walport, M. Shlomchik, Immunobiology: The Immune System in Health and Disease. Garland Publishing, USA, 2001. 6. K.R. Joshi, N.O. Osama, Immunology. 5th Edition, Agrobios Ltd, India, 2012. 7. G.P. Talwar, S.K Gupta. A Handbook of Practical and Clinical Immunology Vol I CBS Publishers, 2017. 8. R. Thanwal, A Handbook of Diseases. Astha Publishers & Distributors, 2014.
Course Outcomes:	1. Key hands-on experience in converting and applying theoretical knowledge to the laboratory. 2. Students will become familiar with immunologic techniques that are used in clinical medicine as well as immunology research laboratories. 3. Students will be able to understand and develop interest towards functionality of various immunodiagnostic kits and its application in health and disease related research. 4. Students become familiar with techniques involved marine pathogen identification, characterization, cell culture, analysis of fish blood cells and proteins.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-504

Title of the Course: BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	The course is designed to 1) provide broad exposure to basic techniques used in Modern Biology research. 2) impart a basic conceptual understanding of the principles of these techniques and emphasize the biochemical utility of the same. 3) have a clear understanding of all analytical techniques such that the barrier to implementing the same is abated to a great extent.	
Content:	**MODULE I** • Description of Macromolecular Structure, Intermolecular and Intramolecular forces in protein, DNA and other biomolecules. • Diffusion, Brownian motion and sedimentation, determination of molecular weight from sedimentation and diffusion. • Concept and application of Chemical and Physical equilibria in biological system. • Nature and Role of Ionic, Covalent and Noncovalent Interaction in molecular confirmation, scaffolding and packaging of protein and DNA • Thermodynamics of protein folding: Protein folding kinetics, Misfolding and aggregation. • 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, • Biochemical and biophysical characterizations of	**No. of hours** 15

	biomolecules: 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. protein 15 hours 11 diffusion, dynamics by fluorescence correlation spectroscopy.	15
	MODULE II • Spectroscopy: Electromagnetic radiations in spectroscopic techniques. Beer-Lambert law, UV/Visible spectroscopy, Fluorescence spectroscopy, Emission, excitation, Quenching, Quantum Yield. Nuclear magnetic resonance Spectroscopy. Electron spin resonance spectroscopy. • Centrifuge: Basic concepts of centrifugation. Calculation of g value from RPM. Types of rotors used, Differential centrifugation, Density gradient centrifugation. Rate-zonal centrifugation, Isopycnic centrifugation. • Microscopy: Abbey's law, Resolution, Magnification, Phase-contrast microscopy, Confocal microscopy, High resolution microscopy, • Nanoscopy: Atomic force Microscopy, Scanning tunneling Microscopy, Scanning electron microscopy, Transmission electron microscopy and Cryo-electron microscopy X-ray diffraction.	
Pedagogy:	Lectures/ tutorials/assignments.	
References/ Readings:	1. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry (Part1-3), 2nd Edn., 1982. 2. M.A. Subramaniam, Biophysics: Principle and techniques. MJP Publishers, 2021. 3. K. Salman, and Z. Diaz, Principal and Techniques of Bioinstrumentation. Intelliz Publisher, 2016. 4. J. Frank, Three Dimensional Electron Microscopy of Macromolecular Assemblies. Academic Press., 2006. 5. I. Tinoco, K. Sauer, J. Wang, and J. Puglisi, Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc. 2013 6. P. Atkins, Physical Chemistry for the Life Sciences (2nd Revised Edition), 2015.	

	7. A. Cooper, Biophysical Chemistry. Royal Society of Chemistry, 2011. 8. K. E. Van-Holde, C. Johnson, Principles of Physical Biochemistry, 3rd ed. Prentice Hall, 2010.
Course Outcomes:	1. Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell. 2. This course will offer them broad idea of instruments/techniques used in biological science laboratories. 3. Student will achieve knowledge that will be helpful to use and handle research lab instruments. 4. After completion of this course student will have a clear idea of the industrial applications of bioinstrumentations that will be advantageous for them to find a job /research scope in Industries and academics.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-505

Title of the Course: LAB III: BIOCHEMICAL AND ANALYTICAL TECHNIQUES

Number of Credits: 3

Effective from AY: 2022 - 23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	The objective of this laboratory course is 1) to introduce students to experimentation in Biochemistry. 2) to teach the utility of these experimental methods in a problem-oriented manner.	
Content:	1. UV-Visible spectroscopic analysis 2. Estimation of proteins by Lowry/Bradford's method 3. Estimation of reducing sugars 4. Enzyme assay 5. Ammonium sulfate precipitation and dialysis 6. Specific activity, fold purification, percentage yield of enzyme 7. Protein subunit molecular weight determination by SDS-PAGE 8. Thin-layer chromatography	**No of hours** 45
	9. Column chromatographic techniques: ion exchange/Affinity/Gel filtration 10. Biochemical assays using ELISA plate reader. 11. Compound and Fluorescence microscopy demonstration 12. Analysis of a biological specimen by SEM. 13. Fluorescence imaging of fixed stained and live cells. 14. Demonstration of fluorescence spectroscopy. 15. Density gradient ultracentrifugation.	45
Pedagogy:	Hands-on experiments in the laboratory, Demonstrations, videos, tutorials	

References/ Readings:	1. A. de Paula. Physical Chemistry for the Life Sciences (2nd Edition). W.H. Freeman, 2011. 2. A. de Paula., Physical Chemistry for the Life Sciences (3rd Edition). W. H. Freeman, 2015. 3. R. Boyer, Modern experimental biochemistry. Pearson Education India, 2000. 4. L. Friedrich and J. W. Engels, Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH publisher, 2018. 5. J.F. James , An Introduction to practical laboratory optics, Cambridge University press, 2017. 6. J. Jayaraman, Laboratory Manual of Biochemistry. New Age International Private Limited, 2011. 7. G. John Biological Centrifugation CRC Press, 2020. 8. K. E. van Holde, C. Johnson, P. S. Ho., Principles of Physical Biochemistry, 2nd Edn., Prentice Hall, 2005. 9. P. Mu, & D. T. Plummer, Introduction to practical biochemistry. Tata McGraw-Hill Education, 2001. 10. B. S. Prakash, Bisen, Laboratory Protocols in Applied Life Sciences., Taylor and Francis Publisher, 2014. 11. S. W. Tinoco, and Puglisi. Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc., 2013. 12. K. Ulrich, Fluorescence microscopy: From Principle to application, Wiley Int., 2017. 13. K. Wilson, J. Walker, (Eds)., Principles and techniques of biochemistry and molecular biology. Cambridge university press, 2010.
Course Outcomes:	1. Students will be able to understand and apply the biochemistry knowledge gained to analyze biochemical samples. 2. Students will get familiarize with basic laboratory instruments and understand principles underlying measurements and using those instruments for experiments in biochemistry. 3. Students will be able to use various instruments to analyze structure of biochemical molecules. 4. Students will be able to use the experimental methods to design biochemical experiments for the research purpose.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-521

Title of the Course: CONCEPTS IN BIOCHEMISTRY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The primary objective of this course is to 1)build upon the knowledge of basic biochemical principles with an emphasis on different metabolic pathways and their integration. 2)understand the structure-function relationships of biomolecules.	
Content:	**MODULE I** • Biochemistry: the molecular logic of life. • Amino acids, proteins, nucleic acids, carbohydrates, and lipids. • Vitamins and hormones. • Forces that stabilize biomolecules: electrostatic and Vander Waal's interaction, hydrogen bonding. Interactions with solvents, Hydrophobic effect. • Basic Thermodynamics: Laws of thermodynamics. Concepts of ΔG, ΔH, and ΔS. • Chemical kinetics: Concepts of Order and molecularity of a chemical reaction. Derivation of first and second-order rate equation, measurement of rate constants. Concept of activation energy. • Enzymology: Introduction and classification of enzymes. Types of enzymatic reaction mechanisms, Enzyme kinetics, enzyme inhibition, Regulatory enzymes. Isozymes, Zymogen and Ribozyme. Examples of enzymatic reactions.	**No. of hours** 15

	MODULE II ● Basic concepts and design of metabolism - glycolysis, gluconeogenesis. ● Pyruvate oxidation, Citric acid cycle ● Oxidative phosphorylation; the importance of electron transfer in oxidative phosphorylation; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation, inhibitors of electron transport chain. ● Glyoxylate cycle ● The pentose phosphate pathway ● Fatty acid synthesis, β-oxidation; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and the mevalonate pathway. ● Amino acid metabolism; nucleotide metabolism ● Photosynthesis and photorespiration	15
Pedagogy:	Lectures, tutorials, assignments.	
References/ Readings:	1. E. E. Abali, S. D. Cline, D. S. Franklin, S. M. Viselli, Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher, 2021. 2. R. L . Miesfeld, M. M. McEvoy, Biochemistry. Worldwide publisher, 2020. 3. R.K. Murray, et al. Harper's Illustrated Biochemistry McGraw Hill publisher, 2022. 4. D.L. Nelson, Lehninger Principles of Biochemistry. W.H. Freeman & Co., 2017. 5. D. Papachristodoulou, A. Snape, W. H. Elliott, and D. C. Elliott, Biochemistry and Molecular Biology. Oxford University publisher, 2018. 6. L. Stryer, J. Berg, J. Tymoczko, G.Gatto. Biochemistry New York, Freeman publisher.,2019. 7. D. Voet, J.G. Voet, W.P.Charlotte, Principles of Biochemistry. Wiley publisher, 2012. D. Voet, J.G. Voet, W.P.Charlotte, Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher, 2018.	

Course Outcomes:	The students will be able to: 1. gain fundamental knowledge in Biochemistry 2. draw molecules and reaction mechanisms perfectly. 3. acquire knowledge of biomolecules and their significance. 4. understand the role of enzymes in the regulation of metabolic pathways.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-522

Title of the Course: BIOSTATISTICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	This course aims to introduce students 1) to statistical methods and help them understand underlying principles 2) to understand underlying practical guidelines of "how to do it" and "how to interpret" statistical data.	
Content:	**MODULE I** ● Scope of Biostatistics ● Brief description and tabulation of data and its graphical representation, and frequency distributions. ● Measures of Central Tendency and dispersion: mean, median, mode, range, standard deviation, variance, coefficient of variation, skewness, kurtosis. ● Displaying data: Histograms, stem and leaf plots, box plots. ● Probability analysis: axiomatic definition, axioms of probability: addition theorem, multiplication rule, conditional probability, and applications in biology.	**No. of hours** 15
	MODULE II ● Counting and probability, Bernoulli trials, Binomial distribution, and its applications, ● Poisson distribution ● Normal distribution, z, t, and chi-square tests, levels of significance ● Testing of hypotheses: null and alternative	15

	hypotheses, Type I and Type II errors ● Simple linear regression and correlation ● Analysis of variance	
Pedagogy:	Lectures, tutorials, assignments.	
References/ Readings:	1. P.N. Arora and P.K. Malhan, Biostatistics. Himalaya Publishing House., 2006. 2. C. R. Kothari, Quantitative Techniques, Vikas Publishing House, 2013. 3. B.K. Mahajan, Methods in Biostatistics: for Medical Students and Research Worker. Jaype Brothers, 2018. 4. S. Rao K, Biostatistics for Health and Life Sciences, Himalaya Publishing House, 2010. 5. V. B Rastogi, Fundamentals of Biostatistics. Ane Books Pvt Ltd., 2009. 6. S. J.A. Witmer, Statistics for the Life Sciences. Prentice Hall, 2016.	
Course Outcomes:	Upon completing this course, students would be able to – 1. understand how to summarize statistical data; 2. apply appropriate statistical tests based on an understanding of the study question, type of study, and type of data; 3. organize and interpret the results of statistical tests. 4. use the theoretical statistics knowledge to apply it to statistical software	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-523

Title of the Course: MATHEMATICS FOR BIOLOGISTS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	1) To give conceptual exposure to essential contents of mathematics 2) To enable them to perform quantitative analysis in biology.	
Content:	**MODULE I** • Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; • Constructing linear models in biological systems. • Quadratic equations (solving, graphing, features of, interpreting quadratic models, etc.) • Introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, • Basics of trigonometric functions, Pythagorean theory. • Graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, • Basics of vectors, introduction to matrices.	**No of hours** 15
	MODULE II • Images as 2D/3D Functions, Functions and its derivatives, Computing Derivatives of Curves, Rules for Calculating Derivatives. • Curvature and Second Derivative Plotting Curves, Numerical Calculation of Derivatives., Function, Derivatives and Series Expansion Differential calculus (limits, derivatives), integral calculus (integrals, sequences, and series, etc.). • Population dynamics; oscillations, circadian rhythms, developmental patterns, • Symmetry in biological systems, fractal geometries,	15

	size limits & scaling in biology, • Modelling chemical reaction networks and metabolic networks.	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. S.K. Aggarwal, Bio Mathematics. Alps Book Publishers, 2008. 2. M. Aitken, B. Broadhursts, S. Haldky, Mathematics for biological scientists. Garland Science, 2009. 3. N. Bairagi, Introductory Mathematical Biology. U. N. Dhur and Sons Private Limited Publisher, 2021. 4. P.C. Foster, Easy mathematics for biologists. Taylor and Francis, 1999. 5. R. Robeva, Mathematical concepts and methods in modern,Biology using Modern Discrete Models. Academic Press, 2013. 6. K. A. Stroud, D. J. Booth. Foundation Mathematics. Palgrave Macmillan, 2009.	
Course Outcomes:	1. Will be able to apply the concepts of mathematics in Biology 2. Will recognize the importance and value of mathematical thinking. 3. Use of mathematics to describe biological processes and their use in problem-solving. 4. Able to apply math skills to understand the diverse phenomena that exist in biological system.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-524

Title of the Course: BIOLOGY OF THE EXTREMOPHILIC ORGANISMS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisites required	
Course Objectives:	1) To obtain knowledge regarding the existence of extreme habitats. 2) To understand how the strategies are adopted to overcome extreme conditions.	
Content:	**MODULE I** • Thermophiles: Tree of life. • Types of Extreme habitats based on environmental variables/sources: • Low Temperatures: Polar regions (Antarctica and Arctic). • High temperatures: Deserts, Hot springs, hydrothermal vents, Deserts. • Pressure: Deep-sea environments, Subsurface rocks, Mariana Trench. • Vacuum: Space station, space habitation. • Desiccation: extreme hypersaline environments, deserts. • Hypersaline: coastal lagoons, salt and soda lakes, salterns, deep-sea brine pools, brine channels in sea ice, and fermented foods and pickling brines. • pH: Acidic [Solfataric fields (sulfuric volcanic fields), geysers, sulfuric acid pools, acid minedrainages from coal and metal mining waste] or Alkaline (Soda lakes and soda deserts). • Low oxygen: Low or depleted oxygen level in water bodies (anthropogenic activities, pollution, eutrophication, algal growth) • Methane: Natural wetlands, freshwater lakes, streams, rivers, estuarine and coastal areas, termite, and wild	**No of hours** 15

	ruminant guts, terrestrial and marine seeps, volcanoes, geothermal vents, gas hydrates, and methane produced from biomass combustion (i.e., wildfires). Anthropogenic sources agriculture, with cattle and rice cultivation as the largest contributors, fossil fuels, waste (ex. landfills, sewage), and biomass/biofuel burning. • Categories of extremophiles: Thermophile, Halophile, Psychrophile, Alkaliphile, Acidophile, Piezophile or barophile, Xerophiles, Anaerobic, methanogenic, metal resistant, radiation resistant, endoliths.	
	MODULE II • Homeostasis, enantiosis (physiological/biochemical) • Thermogenesis, exothermic, endothermy molecular mechanisms (stability of proteins, catalytic rates) Stress proteins: heat shock, chaperonins, SAPKs • Freeze avoidance/tolerance: antifreeze proteins, ice nucleation, frost (cold) hardiness, Membrane structures, and temperature. • Life under pressure: barophilic bacteria, metazoan, Deep diving penguins, mammals • Energy metabolism – the role of oxygen (normoxia, hypoxia, anoxia) physiological adaptations (hibernation, torpor, estivation) • Photosynthesis - physiological and biochemical adaptations to extreme light and temperature • Ionizing radiation - mechanism of radiation resistance • Life with limited water - arthropods, reptiles • Hot, dry environments - mammalian physiological adaptations • Mechanisms to avoid osmotic stress acid and alkaline environments • Overcoming heavy metal and toxin tolerances, • Biotechnological application of extremophiles	15
Pedagogy:	Lectures, tutorials, assignments	

References/ Readings:	1. R.P. Anitori, Extremophiles: Microbiology and Biotechnology. Caister Academic Press, 2012. 2. R.V. Durvasula, and D.V. Subba Rao, Extremophiles: From Biology to Biotechnology. CRC Press, 2018. 3. J. Elster, G. Prisco, A.H.L Huiskes, H.G.M. Edwards, Life in Extreme Environments., Insights in Biological Capability. Cambridge University Press, 2020. 4. N. Gunde-Cimerman, A. Oren, A. Plemenitaš (ed) Adaptation to Life at High Salt Concentrations in Archaea, Bacteria, and Eukarya. Springer Publisher, 2005. 5. S. Richa and S. Vivek, Physiological and Biotechnological Aspects of Extremophiles. Academic Press, 2020. 6. V. Singh Om, Extremophiles: Sustainable Blackwell, 2012. 7. D.A. Wharton. Life at the Limits: Organisms in Extreme Environments Cambridge Press, 2002.
Course Outcomes:	1. Students will be able to understand and distinguish between various types of extreme environments. 2. Students shall gain knowledge about specialized features exhibited by extremophilic organisms. 3. Students shall be able to understand the mechanisms of adaptation adopted by different organisms in extreme habitats. 4. Students shall be able to understand the bioprospecting of the extremophiles for biotechnological applications.

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SEMESTER II

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT- 504

Title of the Course: OCEANOGRAPHY AND MARINE BIORESOURCES

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	Introduce students to 1. the marine environment and its physical features; 2. to marine life, their habitats and adaptations.	
Content:	**MODULE I: (Marine life diversity and processes)** • Classification of the marine environment • Marine bioresources. • Marine microbes (viruses, bacteria, archaea, protists, fungi) • Plankton (phytoplankton and zooplankton) • Marine algae and plants (seaweeds, sea grasses, mangrove plants) • Invertebrates: sponges, cnidarians, polychaetes, crustaceans, marine worms, molluscs, echinoderms, arthropods, Non-craniate (non-vertebrate) chordates, • Vertebrates: - Marine fishes (bony, cartilaginous, jawless fishes) - Marine tetrapods (amphibians, reptiles, birds, mammals) • Adaptations of organisms to different habitats • Marine biomass and productivity - primary production, photosynthetic efficiency; secondary production, productivity distribution in ocean environment, Mechanism and factors affecting primary production. • Bio-communication in oceans, Quorum sensing, Microbe-microbe interaction, Microbe-seaweed	**No. of hours** 15

	interaction, Microbe-metazoan interaction, Population connectivity • Species abundance, richness and diversity indices, Biogeography, Recruitment, Growth, Mortality. • 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. • Culture of microalgae and invertebrates.	
	<u>MODULE II:</u> (Physical Oceanography) • Ocean atmosphere interface • Circulation: Coriolis effect, Ekman transport, Langmuir circulation. • Planetary 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 • Plate tectonics, Mid-oceanic ridge spreading and convection	15
	<u>MODULE III:</u> (Chemical Oceanography) • Seawater composition and its properties • Characterization of sediments: constituents, texture	15

	and mass properties • Types of Biogeochemical cycles in oceans (trace elements) • Isotope geochemistry • Oceanic anoxic events and dead zones • Biological pump • Ocean acidification and its significance	
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings:	1. Agarwalk et. al., Biodiversity and Environment. APH Publishing Corporation, 1996. 2. T. Beer, Environmental Oceanography. CRC Press Heywood V.H. Global Biodiversity Assessment. UNEP, Cambridge University Press, 1995. 3. M. D. Bertness, J. F. Bruno, Silliman, B. R., & J. J. Stachowicz,, Eds., Marine community ecology and conservation. Sinauer Associates, Incorporated, 2014. 4. R. C. Chambers, & E. A. Trippel, (Eds.). Early life history and recruitment in fish populations (Vol. 21). Springer Science & Business Media, 2012. 5. J. S. Levinton, C. D., Marine Biology: Function, Biodiversity, Ecology. OUP, USA publication, 2001. 6. J. A. Knauss & N. Garfield, Introduction to physical oceanography. Waveland Press, 2016. 7. Kortzinger, The Ocean takes a Breath, Science 306 (5700):1337, 2004. 8. K. Naskar and R. Mandal, Ecology and Biodiversity of Indian Mangroves. Daya Publishers, 1999. 9. G. L Pickard & W. J Emery, Descriptive physical oceanography: an introduction. Elsevier, 2016. 10. A. P and Thurman, H. V., Essentials of Oceanography. Pearson Publisher, 2017.	
Course Outcomes:	At the end of this course, students will be able to: 1. understand the status and trends of major marine resources 2. understand how oceans influence the climate. 3. familiarise with marine life and factors influencing primary and secondary production. 4. apply their knowledge to understand the climate change.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-505

Title of the Course: AQUACULTURE TECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	MBT-501	
Course Objectives:	1) This course is aimed at teaching the sustainable use of aquatic resources with various approaches in Biotechnology. 2) It also provides a deep insight into the modern techniques used to promote the breeding and growth of aquatic species.	
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.	**No. of hours** 15

	• 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, genetic basis of determination of sex; chromosome manipulation: ploidy induction, sex reversal; gynogenesis and androgenesis; Brood stock 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.	15
	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 the production of important microalgae and other commercial important products.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. S. Felix, Handbook of Marine and Aquaculture Biotechnology. Agrobios India, 2010. 2. N.C. Gautam, Aquaculture Biotechnology. Shree Publishers and Distributors, 2007.	

	3. G. Krishnaveni and K. Veeranjaneyulu, Recent Technologies in Fish and Fisheries Rigi Publications, 2016. 4. M.N. Kutty and T.V. Pillay, Aquaculture: Principles and Practices. Wiley Blackwell, 2005. 5. A. Patel and S.N. Pathak, Textbook of Aquaculture. Pacific Book Internationals, 2010. 6. E. Kim, Handbook of Marine Biotechnology, Springer. 2015. 7. R.R. Stickney, D. Gatlin, Aquaculture: An Introductory Text. CABI Publishing, 2022. 8. R.R. Stickney, Encyclopedia of Aquaculture. Wiley InterScience, 2000.
Course Outcomes:	On completion of this course, students will: 1. be able to explain the fundamental principles of aquaculture Biotechnology. 2. be able to identify the role of aquaculture in society. 3. be able to understand the concept of selective breeding, hypophysation, artificial insemination, artificial hybridization required in recent aquaculture. 4. learn the basics of aquaponics, biofloc technology, bioremediation and other modern techniques in aquaculture.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-508

Title of the Course: GENETICS AND MOLECULAR BIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The aim of this course is to 1) obtain and understand the fundamental knowledge of molecular and cellular processes such as RNA transcription, protein synthesis, mutation, epigenetic modification and gene regulation. 2) Understand the organization of the genome and gene transfers in prokaryotes	
Content:	**MODULE I** • Mendelian Genetics and Population genetics • 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 initiator tRNA), 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	**No of hours** 15
	MODULE II • Prokaryotic and eukaryotic transcription -RNA polymerase/s and sigma factors,	15

	• 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, 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.	15
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings:	1. D. P. Clark, N. J. Pazdernik and M. R. McGehee, Molecular Biology (3rd) Elsevier Inc, 2019. 2. W. Klug, M. Cummings and C. Spencer, Concepts of Genetics (12th ed), Pearson publishers, 2019. 3. E. S. Goldstein, T. Stephen, J. Kilpatrick and J. Krebs, Lewin's genes XII,	

	Bartlett Publishers, 2017. 4. H. F. Lodish, A. Berk, C. Kaiser, M. Krieger and A. Bretscher, Molecular Cell Biology (8th ed) Freeman MacMillan publisher, 2016. 5. P. J. Russell, iGenetics: A Molecular Approach, (3rd ed), Pearson publisher, 2016. 6. G. Karp, J. Iwasa and W. Marshall, Karp's Cell and Molecular Biology: Concepts and Experiments, (8th ed) Wiley Publisher, 2016. 7. M. Strickberger, Genetics, (3rd ed) by Pearson publishers, 2015. 8. M. J. Simmons and P. Snustad, Principles of Genetics (7th ed), Wiley Student Edition, 2015. 9. J. D. Watson, T A Baker, S P Bell, A Gann, M Levine and R Losick, Molecular Biology of the Gene, (7 ed), Cold Spring Harbor Laboratory Press, New York, 2014. 10. R. F. Weaver, Molecular Biology (5th ed) McGraw Hill Higher Education publisher, 2012.
Course Outcomes:	1. 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. 2. Will be able to understand the various molecular mechanisms of gene regulation. 3. Will appreciate the role of noncoding RNA in regulation and their application in molecular biology 4. Understand the importance of repeat sequences and DNA repair systems

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-509

Title of the Course: LAB IV: GENETICS AND MOLECULAR BIOLOGY

Number of Credits: 2

Effective from AY: 2022-23

<table>
<tr><td>Pre-requisites for the Course:</td><td colspan="2">None</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">The objective of this course is to
1) provide students with experimental knowledge of molecular biology and genetic engineering.
2) understand the concept of mutation and gene transfer processes</td></tr>
<tr><td rowspan="2">Content:</td><td>1. UV/Chemical mutagenesis and survival curve.
2. Isolation of amino acid auxotroph by replica plating.
3. Phage infection and burst size; types of plaque formation
4. Transduction
5. Genetic Transfer-Conjugation, gene mapping.
6. Genomic DNA isolation</td><td>No of hours

30</td></tr>
<tr><td>7. DNA quantification and gel electrophoresis
8. RNA isolation
9. RNA denaturing gel electrophoresis.
10. Mitosis.
11. Meiosis</td><td>30</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">Hands-on experiments in the laboratory, video, online data</td></tr>
<tr><td>References/ Readings:</td><td colspan="2">1. R.K. Sharma and S.P.S Sangha, Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press, 2020.
2. S. K. Gakhar, M. Miglani and A Kumar, Molecular Biology: A Laboratory Manual. Rupa Publications, 2019.
3. Hofmann, Wilson and Walkers Principles and Techniques of Biochemistry and Molecular Biology, Cambridge University Press, 2018.
4. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set, 2012.
5. S. John Vennison, Laboratory Manual for Genetic Engineering 1st Edition, PHI Learning, 2009.</td></tr>
</table>

Course Outcomes:	Students will be able to 1. create mutants using mutagenesis and screen them 2. Purify and check DNA quality for molecular biology experiments. 3. Understand the concept of phage titer and screen phage infection 4. Understand the various stages of cell division

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT–510

Title of the Course: CELL AND DEVELOPMENTAL BIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
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 1) a conceptual overview of a cellular system and its functioning in animals. 2) a conceptual outline of developmental patterns using examples from different model systems regulatory networks involved are highlighted, aiming to project the molecular basis of developmental patterns.	
Content:	**MODULE I** • Biochemical organization of the cell; diversity of cell size and shape; cell theory, and the emergence of modern Cell Biology. • Principles underlying microscopic techniques for the study of cells. • Structure and diversity of biological membranes; mechanisms of membrane transport. Self-assembly of lipids, micelle, biomembrane organization - sidedness and function; membrane assembly. • The plant cell wall; extracellular matrix in plants and animals • Cell lysis and subcellular fractionation • Structural organization and functions of cell organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cytoskeletons structure and motility function • Cellular communication: General principles of cell	**No. of hours** 15

	communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, integrins, neurotransmission, and its regulation.	
	MODULE II • Protein localization – synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast, and peroxisomes, receptor-mediated endocytosis. • Proteasomes; structure and function • Cell division and cell cycle: Mitosis and meiosis, their regulation, Cell cycle, and its regulation, Apoptosis, Necrosis, and Autophagy. • Cell signaling • Cell fusion techniques • Molecular chaperones: types, characteristics, and functional significance • Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis.	15
	MODULE III • Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. • Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation, and formation of germ layers in marine animals. • Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post-embryonic development- larval	15

	formation, metamorphosis; environmental regulation of normal development; sex determination.	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. A. Amon, M. Krieger, H. Lodish, , A. Bretscher , C. A. Kaiser, A. Berk , K. C. Martin, H. Ploegh, Molecular Cell Biology. United Kingdom: W. H. Freeman, 2016. 2. C. Smith, Wood Cell Biology, Chapman Hall, 2005. 3. G. M. Cooper and R. E. Hausman, The Cell: A Molecular Approach. United States: Sinauer Associates, 2013. 4. S. F. Gilbert, Developmental biology. Sinauer Associates, Inc, 2010. 5. J.D. Watson, M. Levine, T. A. Baker, A. Gann, S. P. Bell, R.L. Watson, Molecular Biology of the Gene, Pearson Education, 2014. 6. G. Karp, J. Iwasa, W. Marshall, Cell Biology Global Edition. United States: Wiley, 2018. 7. S. T. Kilpatrick, Krebs, J. E., Goldstein, E. S., Lewin, GENES XII. Japan: Jones; Bartlett Learning, 2017. 8. H. Lodish, and B. Arnold, Molecular Cell Biology, W.H. Freeman & Company, 2000. 9. T. D. Pollard, , W. C. Earnshaw, J. Lippincott-Schwartz, G. Johnson , Cell biology E-book. Elsevier Health Sciences, 2016. 10. J. M. W. Slack, Essential Developmental Biology. Germany: Wiley, 2009. 11. Smith & Wood., Cell Biology, Chapman & Hall London, 2005. 12. M. A. Subramanian, Developmental Biology. India: MJP Publisher, 2022. 13. B. M. Turner, Chromatin and gene regulation: molecular mechanisms in epigenetics. John Wiley; Sons, 2008. 14. L. Wolpert, Developmental Biology: A Very Short Introduction. OUP Oxford, 2011.	
Course Outcomes:	1. Students will be able to understand major concepts in cell and Developmental biology with an awareness of experimental approaches and how they are applied in cell biology research. 2. Students will be able to understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. 3. Students will be able to summarise how these cellular components	

	are used to generate and utilize energy in cells. 4. Students will be able to summarize the molecular and genetic background of animal developmental biology.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-512

Title of the Course: LAB V: PLANT AND ANIMAL TISSUE CULTURE

Number of Credits: 2

Effective from AY: 2022-23

<table>
<tr><td>Pre-requisites for the Course:</td><td colspan="2">No prerequisite is required.</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">1) To gain a comprehensive understanding of the growth and development of plants in vitro.
2) To understand the fundamentals of animal cell culture, and the growth and maintenance of animal cells under aseptic conditions.</td></tr>
<tr><td rowspan="2">Content:</td><td>1. Preparation of starting material (Biosafety cabinet, solutions, media, cell sample etc.).
2. Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, contamination and precautions.
3. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell lines HEK293, COS-7.
4. Transfection and co-transfection: Calcium-phosphate method and Lipofection.
5. Cell fixation and staining: Immunolabeling, mounting, fluorescence imaging.</td><td>No. of hours

30</td></tr>
<tr><td>1. Tissue culture medium preparation, contamination and precautions in plant tissue culture.
2. Callus induction from different explants such as rice and carrot.
3. Plantlet regeneration.
4. Somatic embryogenesis
5. Single cell suspension.
6. Protoplast isolation</td><td>30</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">Hands-on experiments in the laboratory, online video and demonstrations</td></tr>
</table>

References/ Readings:	1. I.R. Freshney and A. Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, Wiley Blackwell Publisher, 2021. 2. I.R. Freshney and J.R.W. Masters, Animal cell culture – A Practical Approach Oxford University Press, 2000. 3. H. Sherathiya, Practical manual for Plant Tissue Culture: Basic Techniques of Plant Tissue Culture and Molecular Biology. Grin Verlag, 2013. 4. R. Smith, Plant tissue culture Techniques and experiment. Academic Press, 2012.
Course Outcomes:	1. The students will understand the basic concepts of pluripotency and totipotency in plant and animal tissue culture. 2. They will get a basic understanding about the media and growth parameters required for the culture of plant and animal tissues. 3. They shall learn to grow and maintain plant and animal cells/ explants under aseptic conditions. 4. The students will be exposed to modern techniques of plant propagation through Somatic embryogenesis and cell suspension culture.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-521

Title of the Course: BIOINFORMATICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	GBT-509	
Course Objectives:	The objectives of this course are 1)to provide students with theory and practical experience of the use of common computational tools and databases especially marine databases 2)To facilitate the investigation of molecular biology and evolution-related concepts.	
Content:	**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	**No. of hours** 15

	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 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.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. L. Arthur, Introduction to Bioinformatics. Oxford University Press, 2019.	

	2. A. D. Baxevanis, G. D. Bader and D. S. Wishart, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher, 2020. 3. N. Gautham, Bioinformatics databases and algorithms, 2007. 2. V.R. Srinivas, Bioinformatics: A modern approach, PHI Learning Pvt. Ltd., 2005. 3. S.C. Rastogi, N. Mendiratta and P. Rastogi, Bioinformatics: concepts skills and applications, 2004. 4. J. Xiong, Essential Bioinformatics, by Cambridge University Press, First edition, 2007. 5. S. Ignacimuthus, Basic Bioinformatics, Alpha Science International Ltd,2013. 6. J. Pevsner, Bioinformatics and Functional Genomics, Wiley Blackwell Publication, 2015. 7. P. S. Neelakanta, A Textbook of Bioinformatics: Information-theoretic Perspectives of Bioengineering and Biological Complexes, World Scientific Publisher, 2020. 8. W. Even and G. Grant, Statistical methods in Bioinformatics: An introduction, 2005. 9. J. Xiong, Essential Bioinformatics, Cambridge University Press, 2006.
Course Outcomes:	Students should be able to: 1. develop an understanding of the basic theory of these computational tools. 2. gain working knowledge of these computational tools and methods. 3. appreciate their relevance for investigating specific contemporary biological questions. 4. Understand the process of drug designing

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT–526

Title of the Course: LAB VI: LAB IN BIOINFORMATICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Nil	
Course Objectives:	The aim is 1) to provide practical training in bioinformatics and statistical methods 2) learn to access and search the major public databases for data retrieval.	
Content:	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.	**No. of hours** 30

	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. Whole-genome assembly from NGS raw data sequence 13. 16sRNA sequence analysis and use of Bioedit 14. Molecular docking	30
Pedagogy:	Hands-on experiments in the laboratory, video, online data	
References/ Readings:	1. A.D. Baxevanis, G.D. Bader, D.S. Wishart, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher, 2020. 2. S. Shui Qing, Bioinformatics: A Practical Approach (Chapman; Hall/CRC Mathematical and Computational Biology), 2007. 3. W. Even, and G. Grant, Statistical methods in Bioinformatics: An introduction, 2005. 4. N.C. Jones, and P.A. Pevzner; Introduction to Bioinformatics Algorithms; Ane Books, India, 2004. 5. D.W. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, 2001.	
Course Outcomes:	On completion of this course, students should be able to: 1. describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyze and discuss results in the light of molecular biology knowledge; 2. explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming; 3. predict secondary and tertiary structures of protein sequences; 4. perform various statistical tools available to analyze the data.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-527

Title of the Course: NANOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	1) To provide a general and broad introduction to the multi-disciplinary field of nanotechnology. 2) To study the application of nanotechnology	
Content:	**MODULE I** • Introduction, concepts, historical perspective; • Different formats of nanomaterials and applications with examples 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 characterization. • 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.	**No of hours** 15

	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 nano scaffolds in synthesis, 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 strata of the environment; Ecotoxicity models and assays; Life cycle assessment, containment.	15
Pedagogy:	Lectures/ video tutorials/assignments/self study	
References/ Readings:	1. K. Chittaranjan, D. S. Kumar, M. V. Khodakovskaya, Plant Nanotechnology Principles and Practices. Springer, 2016. 2. J. GeroDecher, B., Schlenoff., Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag, 2003. 3. D. S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley-Liss, 2004. 2. T. H. Grey, Bioconjugate Techniques, Elsevier, 2013. 3. M. Kuno, Introductory Nanoscience, Physical and Chemical Concepts. Garland Science, 2012. 4. N.H., Malsch,Biomedical Nanotechnology, CRC Press, 2005. 5. J.J. Ramsden, Nanotechnology: An Introduction. Elsevier Amsterdam,. 2012. 6. S. Sanmugam, Nanotechnology. MJP publisher, 2011.	

Course Outcomes:	1. Students will be able to describe the basic science behind the properties of materials at a nanometer scale. 2. Students will be able to use and apply knowledge gained to synthesize nanoparticles 3. Students will be able to analyze the properties of nanoparticles and decide on its application 4. Students will be able to understand the life cycle nanoparticles and their impact on environment.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-528

Title of the Course: VACCINE TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic concepts in Immunology	
Course Objectives:	1. To understand the conventional to the latest technology in vaccine production. 2. To understand the immunological effect and strategies for vaccine design.	
Content:	**MODULE I** • Protective immune response in bacterial; viral and parasitic infections; Primary and Secondary immune responses during infection; Antigen presentation and Role of Antigen-presenting cells: Dendritic cells in immune response; • Innate immune response; Humoral (antibody-mediated) responses; Cell-mediated responses: role of CD4+ and CD8+ T cells; • Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells Correlates of protection. • Epitopes, linear and conformational epitopes, characterization and location of APC, MHC, and immunogenicity. • History of vaccines, Conventional vaccines; Vaccination and immune response; • Different types of Vaccines: Inactivated Vaccine, Attenuated Vaccine, Toxoid Vaccine, Subunit Vaccine, Conjugate Vaccine, Valence Vaccine, Heterotypic Vaccine, mRNA vaccine with Examples. • Vaccines based on routes of administration: oral, intranasal, intramuscular. Subcutaneous, intravenous. Case examples of injectable vaccines, and combination vaccines.	**No. of hours** 15

	• Physical method of gene delivery: tattooing, gene gun, electroporation, ultrasound, and laser. • Maternal Immunization	
	MODULE II • Vaccines with and without adjuvants. Different types of adjuvants: oil-based adjuvants such as Freunds, aluminum hydroxide, aluminum phosphate, [AS04] aluminum potassium sulfate monophosphoryl lipid A (MPL) + aluminum salt, [MF59] Oil in water emulsion composed of squalene. [AS01] Monophosphoryl lipid A (MPL) and QS-21, a natural compound extracted from the Chilean soapbark tree, combined in a liposomal formulation, [cpG1018] Cytosine phosphoguanine (CpG), a synthetic form of DNA that mimics bacterial and viral genetic material. • Vaccine delivery systems (e.g., emulsion (water- in-oil-in-water multiple emulsions, microemulsions, or nanoemulsions) microparticles, immune-stimulating complexes ISCOMs liposomes, nanoparticles, dendrimer and micellar) with examples such as PLGA, Chitosans, polyphosphazene, polyanyhydrides, polymethacrylic acid, liposomes, and their derivatives, virosomes, polymeric nanoparticle delivery system, • New emerging diseases and vaccine needs (Ebola, Zika). • Quality control and regulations in vaccine research	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. C. Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009. 2. R.W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001. 3. C. A. Janeway, Travers, P., Walport, M.; Shlomchik, M. J. Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub, 2005. 4. S. H. Kaufmann, Novel Vaccination Strategies. Weinheim: Wiley-VCH,	

	2004. 5. T. J. Kindt, B. A. Osborne, R. A. Goldsby; Kuby, J. Kuby Immunology. New York: W.H. Freeman, 2013. 6. D. Male, et al., “Immunology”, Mosby Publication, 2007.
Course Outcomes:	1. Understanding the progress in the development of various types of vaccines. 2. Correlating the immunological responses with immunisation/vaccination. 3. Understanding of vaccine design and strategies for vaccine delivery. 4. Understand the significance of adjuvant, immunogens, and other ingredients for developing an effective vaccine.

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SEMESTER III

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-600

Title of the Course: RECOMBINANT DNA TECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	General concepts in genetics and molecular biology	
Course Objectives:	The students will understand the use of 1) various enzymes and techniques for manipulating DNA. 2) various DNA vectors and their use in creating recombinant DNA molecules 3) recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries.	
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;	**No. of hours** 15

	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; proofreading enzymes; ● PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; ● Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP. ● 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.	15
	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; ● Development of transgenic plants; debate over GM	15

	crops; introduction to methods of genetic manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans),Frog (Xenopus sp), 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.	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Wiley-Blackwell Publishers, 2016. 2. T. A Brown, Genomes, New York: Garland Science Publisher, 2017. 3. J. W. Dale, M. von Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology, Wiley-Blackwell publisher, 2011. 4. H. K. Das, Textbook of Biotechnology, Wiley Publisher, 2017. 5. M. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual.CSH Press, 2012. 6. V. Hunter and F. Strickland, Applications of Recombinant DNA Technology. ED-TECH Press, 2018. 7. A. J. Nair, Introduction to Biotechnology and Genetic Engineering. Laxmi Publications Pvt. Ltd, 2008. 8. S. Primrose and R. B. Twyman, Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited, 2006. 9. M. K. Sarwar, I. A. Khan and D. Barp, Applied Molecular Biotechnology: The Next Generation of Genetic Engineering CRC Press, 2016. 10. V. Singh and P Dhar, Genome Engineering via CRISPR-Cas9 System, Elsevier Publisher, 2020.	

Course Outcomes:	The students will be able to 1. create recombinant DNA molecules and evaluate their expression. 2. Exploit relevant tool/techniques as well as vector and host for cloning and expression. 3. Design experiments for generating applications for use in medical animal and plant biotechnology. 4. Devise strategies for creating transgenic and understand CRISPER technology

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-601

Title of the Course: LAB VII: RECOMBINANT DNA TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	A theory course in Recombinant DNA technology	
Course Objectives:	The students will learn 1) cloning strategies and expression of foreign genes 2) setting up reactions for DNA manipulation. 3) to interpret the results of DNA manipulation studies and use. 4) appropriate tools for the validation of recombinant DNA.	
Content:	**MODULE I** ● Plasmid DNA isolation (Alkaline lysis, Boiling method, column based method) ● Plasmid DNA quantification. ● Restriction Enzyme digestion of plasmid DNA. ● Polymerase Chain reaction (RAPD/RFLP). ● Real Time PCR. ● Reverse transcriptase PCR	**No. of hours** 30
	MODULE II ● Cloning of insert into a plasmid vector ● Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency. ● Confirmation of the insert by Colony PCR and Restriction mapping ● Expression of recombinant protein, the concept of soluble proteins and inclusion body formation in *E.coli*, SDS-PAGE analysis ● Purification of His-Tagged protein on Ni-NTA columns ● Southern blotting hybridization.	30
Pedagogy:	Hands-on experiments in the laboratory, online videos.	

References/ Readings:	1. S. Carson, Manipulation and expression of recombinant, DNA a laboratory manual Elsevier Academic Press, 2006. 2. M.R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual Three-volume CSH Press, 2012. 3. J.S. Vennison, Laboratory Manual for GENETIC ENGINEERING, PHI Learning, 2009.
Course Outcomes:	The student will be able to 1. create recombinant DNA molecules. 2. conceptualize the various steps in cloning DNA in an appropriate vector and evaluate gene expression. 3. apply and use the knowledge to create tools in diagnostics, medical and forensic science. 4. Apply and use PCR for diagnostic applications

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-602

Title of the Course: BIOPROCESS TECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	1) To educate students about fundamental concepts of Bioprocess technology 2) To study and understand related applications.	
Content:	**MODULE I** **Basic Principles of Biochemical Engineering and Fermentation Processes**: • Isolation, screening, and preservation of industrially important microbes • Bioreactor designs • Types of fermentors • 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.	**No. of hours** 15
	MODULE II **Industrial production of chemicals:** • Strain improvement for increased field and other desirable characteristics • Alcohol (beer) • Organic acids (citric acid) • Antibiotics (Penicillin) • Amino acids (lysine) • Application of microbes in food processing: manufacture of cheese and monosodium glutamate	15

	MODULE III **Downstream Processing:** • Introduction, removal of microbial cells, solids, bio-separation, filtration, centrifugation, sedimentation, flocculation, cell disruption, liquid-liquid extraction. • Purification by chromatographic techniques • Drying and crystallization. • Storage and Packaging. • Effluent treatment & disposal. • Immobilization of microbial cells, immobilized reactors & their applications • Bioprocess for the production of biomass: yeast and mushrooms	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. A. Kuila, V. Sharma (Eds.). Principles and Applications of Fermentation Technology. John Wiley & Sons, 2018. 2. A. Wiseman (Ed). Topics in enzyme Fermentation technology. Topics in enzyme and fermentation biotechnology. ACS Publications, 1984. 3. Fomina M., & Gadd G. M. Biosorption: current perspectives on concept, definition and application. Bioresource technology, 160, 3-14, 2014. 4. F. Stanbury, A. Whitaker, J.H. Stephan. Principles of fermentation technology. Butterworth Heinemann Books – Elsevier, 2003. 5. G. Najafpour, Biochemical engineering and biotechnology. Elsevier, 2015. 6. J.M. Coulson & J.F. Richardson. Chemical engineering. Elsevier, 2017. 7. J. S. Dordick (Ed.). Biocatalysts for industry. Science & Business Media, 2013. 8. M.C. Flickinger, Drew, S.W. Encyclopedia of Bioprocess technology. Vol 1-5, 1999. 9. M. M. Young (Ed) Comprehensive Biotechnology. Pergamon Press, 2019. 10. P. Prave, V. Fanst, W. Sitting & D.A. Sukatesh, Fundamentals of Biotechnology, 1987. 11. K. K. Prasad & N. K. Prasad, Downstream process technology: a new horizon in Biotechnology. PHI Learning Pvt. Ltd, 2010. 12. Trevan, M.D. Immobilized enzymes: An introduction & application in Biotechnology, 1980.	

Course Outcomes:	1. Students shall gain knowledge regarding various concepts related to biotechnological industrial aspects. 2. Students shall learn about the industrial production of biotechnologically important products. 3. Students shall be aware of how an industry functions from a biotechnological perspective. 4. Students shall be prepared to meet the challenges of new and emerging areas of Biotechnology industry

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-603

Title of the Course: LAB VIII: BIOPROCESS TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	The objectives of this laboratory course is/are: 1) To educate students about fundamental concepts of Bioprocess technology 2) To provide hands-on training to students in upstream and downstream unit operations.	
Content:	**MODULE I** • Microbial production of ethanol using yeast sp. • Estimating ethanol concentration by Cerric Ammonium nitrate method. • Microbial production and estimation of organic acids: Citric acid using *Aspergillus sp*. • Microbial production of antibiotics. • Immobilization of microbial cells: use of alginate. • Fermentation: Batch, Fed-Batch and Continuous.	**No. of hours** 30
	MODULE II • Use of fermentor with special reference to scale-up operations. • Microfiltrations: separation of cells from broth • Bio-separations: Chromatography and extractions (organic acid & antibiotics) • Manufacture of ginger ale and estimating the alcohol content. • Solid State Fermentation: Mushroom cultivation. • Food Microbiology: Preparation of an edible fermented product.	30
Pedagogy:	Hands-on experiments in the laboratory, online videos.	

References/ Readings:	1. A. Moser. Bioprocess technology: kinetics and reactors. Springer Science & Business, 2012. 2. A. Wiseman (Ed). Topics in enzyme & Fermentation technology. British Polymer Journal, Wiley Blackwell, 1984. 3. B. Ray, & A. Bhunia, Fundamental food microbiology. CRC press, 2013. 4. D. Behrens & P. Kramer (Ed), Bioprocess engineering: Downstream processing & recovery of bioproducts, safety in Biotechnology and regulations, 1990. 5. F. Stanbury & A. Whitaker, Principles of fermentation technology. Elsevier, 2016. 6. J.M. Coulson & J.F. Richardso. Chemical engineering. Elsevier, 2017. 7. J. P. Tamang (Ed.). Health benefits of fermented foods and beverages. CRC Press, 2015. 8. Khramtsov, N., McDade, L., Amerik, A., Yu, E., Divatia, K., Tikhonov,A., & Henck, S. Industrial yeast strain engineered to ferment ethanol from lignocellulosic biomass. Bioresource Technology, 102(17), 8310-8313, 2011. 9. L.E. Cassida, Industrial microbiology. New Age International Pvt Ltd Publishers, 1994. 10. M.C. Flickinger & S.W. Drew (Ed). Encyclopedia of bioprocess technology. Vol 1-5. Wiley Blackwell, 1999. 11. M.D. Trevan, Immobilized enzymes: An introduction & application in Biotechnology. Wiley Blackwell, 1980. 12. M. Young (Ed) Comprehensive Biotechnology. Vol 2- 4. Elsevier, 1985. 13. P. Prave, V. Fanst, W. Sitting, D.A. Sukatesh (Ed.) Fundamentals of Biotechnology. Saras Publications, 1987. 14. T. Korzybski, Z. Kowszyk-Gindifer, & W Kurylowicz. Antibiotics: origin, nature and properties. Elsevier, 2013. 15. T. T. Ngo (Ed.). Molecular interactions in bioseparations. Springer Science & Business, 2013.

Course Outcomes:	On completing the course, students should be able to: 1. appreciate relevance of microorganisms from industrial context; 2. carry out stoichiometric calculations and specify models of growth; 3. give an account of design and operations of various fermentors; 4. present unit operations together with fundamental principles for basic methods in production techniques for bio-based products; 5. calculate yield and production rates in biological production process, and also interpret data; 6. give an account of important microbial/enzymatic industrial processes in the industry.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT 600

Title of the Course: MARINE FOOD TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	The objectives of this course are 1) to teach the principles of food preservation, processing and packaging. 2) quality management practices for food of marine origin.	
Content:	**MODULE I** • Introduction; Importance; Applications of biotechnology in food processing • Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes- causative factors; Drying –conventional methods; Salt curing, pickling and smoking; Freezing and cold storage, Canning procedures; Role of preservatives in processing. • 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.	**No. of hours** 15
	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	15

	Authority (MPEDA), government policies, economic importance; nutrition promotion, consumer studies qualitative and quantitative research methods.	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. S. Omura, The search for bioactive compounds from microorganisms. Springer New York, 2011. 2. M. Fingerman, Recent Advances in Marine Biotechnology, Vol. 8: Bioremediation (1st ed.) CRC Press, 2003. 3. G. M. Evans, J. Furlong, G.G. Evans, Environmental Biotechnology: Theory and Application. United Kingdom: Wiley, 2011. 4. T. Fatma, Cyanobacterial and Algal Metabolism and Environmental Biotechnology. India: Narosa, 1999. 5. A.S. Ninawe, K. Rathnakumar, Fish Processing Technology and Product Development. India: Narendra Publishing House, 2008. 6. P. Galvez Raul, Berge Jean-Pascal (Eds.) Utilization of Fish Waste. United Kingdom: CRC Press, 2013. 7. W.C. Frazier, D.C. Westhoff, V.M. Vanitha, Food Microbiology. 5th Edition. McGraw Hill Education, 2017. 8. G.M. Hall, Fish Processing Technology. United Kingdom: Springer US, 2012. 9. D. Kitts, F. Shahidi, Y.M. Jones, Seafood Safety, Processing and Biotechnology. Taylor and Francis. A CRC press book, 2014. 10. K.C. Badapanda, Fish Processing and Preservation Technology. Vol IV NPH Narendra Publishing House, New Delhi, 2012.	
Course Outcomes:	On completion of this course, 1. Students shall learn the application of biotechnological concepts in the processing and production of marine food resources. 2. Students shall get familiarized with the basic techniques of processing, packaging and preserving marine food resources. 3. Students shall gain knowledge regarding various aspects of spoilage of marine foods and the associated seaborne pathogens. 4. Students shall learn about various quality management and regulations associated with marine food products and novel product development.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-623

Title of the Course: VIROLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge in Microbiology.	
Course Objectives:	Upon completion of this course the students will be able to 1) develop an understanding of how the perception of microbes (bacteria and viruses) is limited by technology: only metagenomic analyses allow to now start studying in depth the dark matter. 2) gain an appreciation for viruses as essential drivers of the evolution of life on Earth. 3) Gain theoretical knowledge in virology virus transmission processes, illness and etiology	
Content:	**MODULE I** ● General Virology ● The structure of virus particles: subunits, filamentous viruses, and nucleoproteins, isometric virus particles, Enveloped (membrane-bound) virus particles, Virus particles with head–tail morphology. ● Frequency of occurrence of different virus particle morphologies. ● Classification of viruses based on disease, host organism , virus particle morphology , viral nucleic acids , taxonomy. ● Satellites, Viroids, and prions ● Replication of Viral DNA and RNA ● Containment facilities, maintenance and handling of pathogenic viruses. ● Viral Enteric Diseases and Oncogenic viruses, Rotavirus diversity, emerging strains, ● Other viruses associated with diarrhoea and gastroenteritis: Adenoviruses, Astroviruses,	**No. of hours** 15

	Norwalk and Sapporo-like viruses and other enteroviral diseases, Polio; Non-polio Enteroviruses, hepatic viruses. ● Biology of Measles, mumps, rubella, Parvovirus B-Chicken pox and other viral pox diseases ● Viral respiratory diseases Biology and pathogensis of SARS, ● Metapneumovirus, Human rhino virus and Corona virus etc. ● Viral Haemorrhagic Fevers Yellow Fever, Kyasanur forest, disease, Chikungunya, Rift Valley Fever, Crimean Congo.	
	MODULE II ● Haemorrhagic fever, Hanta, Marburg and Ebola, and Rickettsial fevers. ● Viral encephalitis: Japanese encephalitis and West Nile viral infection, endemic areas. ● Biology of HIV viruses. ● Vaccines and antivirals. ● Methods of culturing viruses ● Human Virome, assembly, composition and host interaction ● Marine Virome. Ecological role of viruses in marine ecosystem. ● Lysogeny strategy adopted by marine viruses. ● Metagenomic methods to study the virome and the dark matter. ● Phage serotyping. ● Phage therapy for combating diseases, Case studies	15
Pedagogy:	Lectures, tutorials, Case studies, Assignments	
References/ Readings:	1. R. Ananthanarayan, Ananthanarayan and Paniker's, Textbook of Microbiology. Universities Press, 2020. 2. J. Carter and V. A. Saunders, Virology: principles and applications, Wiley, 2007. 3. N. Dimmock, A. Easton and K. Leppard, Introduction to Modern Virology, John Wiley and Sons, 2006.	

	4. J. Flint, L W Enquist, V.R. Racaniello and A.M. Skalka, Principles of Virology: Molecular Biology, Pathogenesis, and Control. ASM Press, 2000. 5. R. Khare, Guide to Clinical and Diagnostic Virology, ASM Books, 2019. 6. S. N. J Korsman, M. I Andersson, L. Nutt, G. Van Zyl and W. Preiser, Virology E-Book: An Illustrated Colour, Text. Elsevier Health Sciences, 2012. 7. G. Kudesia and T. Wreghitt, Clinical and Diagnostic Virology, Cambridge University Press, 2009. 8. B. Mishra, Textbook of Medical Virology, CBS, Publishers and Distributors, 2020. 9. D. D. Richman, F.G. Hayden and R. J. Whitley , Clinical Virology, Wiley, 2020. 10. A. M. Skalka, J. Flint, G. F. Rall, V. R. Racaniello and T. Hatziioannou, Principles of Virology, Wiley, 2020. 11. R. Warom, Virology, Titan Books, 2017. 12. D. O. White and F. J. Fenner, Medical Virology, Elsevier Science, 2016. 13. C.J. Woolverton, L. Sherwood and J. Willey, Prescott's Microbiology. McGraw-Hill Education, 2016.
Course Outcomes:	The student will be able to 1. identify the different viral diseases and correlate with the virus morphology, classification and containment facilities. 2. able to employ methodology to study the diversity of unculturable viruses. 3. devise applications such as phage therapy for combating infections 4. appreciate and understand the role virome in environment

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT 621

Title of the Course: IPR, Biosafety & Bioethics

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	1) To provide basic knowledge on intellectual property rights and their implications in biological research and product development; 2) To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products; 3) To become familiar with ethical issues in biological research. 4) Understand the consequences of biomedical research technologies such as cloning of whole organisms, genetic modifications, DNA testing.	
Content:	**MODULE I** • Different types of IP: patents, trademarks, copyright, industrial design, traditional knowledge, geographical indications, Trade Secrets. • Basics of patents: types of patents; • Concept of 'prior art': invention in context of "prior art"; • Precautions before patenting-disclosure/non-disclosure • Patent application- forms and guidelines, fee structure, time frames; • Types of patent applications: provisional and complete specifications; • PCT and conventional patent applications; procedure for filing a PCT application; role of a Country Patent Office; filing of a patent application; • Patent databases - IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; • WIPO Treaties; Budapest Treaty; Patent Cooperation	**No. of hours** 15

	Treaty (PCT) • International framework for the protection of IP • National Bio-diversity Authority (NBA) and other regulatory bodies, protection of new GMOs; • History of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; • Country-wise patent searches (USPTO, EPO, India); analysis and report formation. • International patenting-requirement, procedures and costs; financial assistance for patenting • 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	15

	characterization and development of analysis plan; risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. • 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).	
	MODULE III • 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	15
Pedagogy:	Lectures, tutorials, Case studies, assignments	
References/ Readings:	1. L. Bently and B. Sherman, Intellectual property law . Oxford University Press, 2008. 2. L. Bently, Intellectual property law Oxford University Press., 2008.	

3. Complete Reference to Intellectual Property Rights
4. T. M. Cook, A User's Guide to Patents Tottel Publishing., 2007.
5. W. Craig, M. Tepfer, G. Degrassi, & D. Ripandelli, An Overview of General divisions/csurv/geac/annex-5.pdf F, 2009.
6. 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. D. O. Fleming, D. L. Hunt, Biological safety: principles and practices ASM Press., 2000.
8. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub., 2001.
9. Grubb P. W. Grubb P. L. Thomsen, P. R., Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy Oxford University Press., 2010.
10. http://www.wipo.int
11. International Union for the Protection of New Varieties of Plants. http://www.upov.int
12. J. Rajmohan. Biosafety and bioethics Gyan Publishing House., 2006.
13. F. Karen . Greif and Jon F. Merz, Current Controversies in the Biological Sciences – Case Studies of Policy Challenges from New Technologies, MIT Press
14. Keith F, CRC handbook of laboratory safety. A.CRC Press.,2000.
15. H. Kuhse, Bioethics: An Anthology. Malden, MA: Blackwell., 2010.
16. Laws. Snow White Publication Oct., 2007.
17. National Biodiversity Authority. http://www.nbaindia.org
18. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI.
19. National Portal of India.http://www.archive.india.gov.in
20. 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/
21. Recombinant DNA Safety Guidelines, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, 2017. Retrieved from https://dbtindia.gov.in/
22. K. Singh. Intellectual property rights in Biotechnology. A status report New Delhi Biotech Consortium, India, 1993.
23. N.S. Sreenivasulu, and C.B. Raju, Biotechnology and Patent laws: patenting living beings Manupatra Publishers, 2008.
24. Wegner H. Patent law in Biotechnology, chemicals &

	pharmaceuticals. Stockton Press, 1994. 25. Wolt, J. D., Keese, P., Raybould, A., Fitzpatrick, J.W., Burachik, M., Gray, A., Wu, World Intellectual Property Organisation. World Health Organization. Laboratory biosafety manual. WHO press, 2004. 26. World Trade Organisation. http://www.wto.org
Course Outcomes:	On completion of this course, students should be able to: 1. understand the rationale for and against IPR and especially patents; 2. understand why India has adopted an IPR Policy and be familiar with broad outline of patent regulations; 3. understand different types of intellectual property rights 4. gain knowledge national and international regulations of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of GMOs 5. describe the major competing ethical theories and apply ethical theory to contemporary moral issues that arise out of recent developments in the life sciences that affect public policy. 6. analyze and clarify moral beliefs about abortion, human reproduction, decisions of life and death, mental illness and other related issues.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-622

Title of the Course: POTENTIALS OF MARINE BIOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge about Microbiology/Oceanography/Aquaculture	
Course Objectives:	1) To impart knowledge of biotechnological applications of marine organisms, important processes and 2) To impacts on the marine ecosystems and ways to control them.	
Content:		**No. of hours**
	MODULE I • 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	15
	MODULE II • Marine pollution • Biofouling and corrosion • Ballast water • Harmful algal blooms • Bacterial & viral pathogens in aquaculture • Aquaculture diseases and diagnosis	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. S. Ahmed, S. Ikram, Chitosan:Derivatives, composites and applications. Wiley, Scrivener Publishing, 2017. 2. Y. Bar-Cohen, Biomemetics: Biologically Inspired Technologies. CRC Press, 2006. 3. R. Day, M. Davidson, The Fluorescent Protein Revolution. CRC Press, 2014. 4. G. Evams et al., Environmental Biotechnology. John Wiley & sons,	

	Ltd., 2003. 5. Evans et al, Environmental Biotechnology, Theory and Application. Wiley- Blackwell, 2000. 6. H.C. Flemming, P.S. Murthy, R. Venkatesan, K.E. Cooksey. Marine and Industrial Biofouling. Springer, 2009. 7. B. Hicks (Ed.) Green Fluorescent Protein. Humana Press, 2002. 8. Gal Y., Ulber R., & Antranikian G. Marine Biotechnology. Springer, 2005. 9. T. Liengen, R. Basséguy, D. Féron, I.B. Beech, Understanding Biocorrosion. Elsevier Ltd, 2015. 10. C. Munn, Marine microbiology: Ecology & applications. Garland Science, 2011. 11. E. Nabti, Biotechnological Applications of Seaweeds. Springer, 2017. 12. M. Naik, M. Dubey 2017). Marine pollution and microbial bioremediation. Springer. 13. T. Okaichi, Red Tides. Terra Scientific Publishing company, Tokyo and Kluwer Academic Publishers, Boston, 2003. 14. Osborn M. and Smith C., Molecular microbial ecology. Taylor & Francis, 2005 15. T. V. R. Pillay, Aquaculture: Principles and Practices. Blackwell Pub., Oxford, UK, 2001. 16. Rainey F., Oren A. Extremophile Microorganisms and the Methods to Handle Them. Methods in Microbiology. Elsevier, Academic Press, 2006. 17. Swain, P. el al., Fish and Shellfish Immunology. Elsevier, 2006.
Course Outcomes:	On completion of the course, students will 1. be able to comprehend the uses and significance of marine organisms. 2. gain a deep insight about the potential applications of marine organisms in the field of Biotechnology. 3. acquire knowledge about the threats associated with marine bioresources. 4. get an overview about aquaculture diseases and their diagnosis.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT 624

Title of the Course: GENOMICS AND PROTEOMICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge in Molecular Biology/Biochemistry.	
Course Objectives:	1) To develop required knowledge and skills in the students so that they are able to acquire the following competency in genomics and proteomics which aims to look into the genome and protein properties from a global perspective. 2) To provide basic knowledge about sample preparation, mass spectrometry workflow, different chromatography technologies and quantitative proteomics.	
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.	**No. of hours** 15

	MODULE II ● Introduction to Proteomics ● Proteomics technologies- Sample preparation, Protein extraction and quantification, Gel-based proteomics: 2D-PAGE, isoelectric focusing. ● Mass spectrometry-based proteomics: mass spectrometry, MALDI-TOF, sample preparations, liquid chromatography, and quantitative proteomics techniques such as iTRAQ, SILAC and TMT using mass spectrometry. ● Protein-protein interaction, protein-DNA interactions, yeast 2-hybrid system, protein chips and functional proteomics. ● Proteome databases. ● Clinical and biomedical applications of proteomics; Challenges in proteomics. ● Introduction to metabolomics, lipidomics, metagenomics, translational research and systems biology.	15
Pedagogy:	Lectures, tutorials, assignments, demonstration	
References/ Readings:	1. A. Batiza, Bioinformatics, genomics, and proteomics: getting the big picture. Infobase Publishing, 2005. 2. B. Cummings, Bioinformatics, 2nd Edition, 2007. 3. B. R. Glick & J.J. Pasternak, Molecular Biotechnology, 3rd Edition, ASM Press, 1998. 4. B. Kobe , M. Gussand, T. Huber, A.M. Campbell & L. J. Heyer, Structural Proteomics: High-Throughput Methods (Methods in Molecular Biology) Discovering Genomics and Proteomics, Humana Press, 2008. 5. D.C. Liebler, Introduction of Proteomics: Tools for the new Biology. Totowa, NJ: Humana Press, 2002. 6. S.C. Suhai, Genomics and proteomics: functional and computational aspects Springer, 2000.	
Course Outcomes:	Students will be able to 1. acquire knowledge and gain understanding of the fundamentals of genomics and proteomics, transcriptomics and metabolomics. 2. analyse various analytical problems based on techniques of proteomics like 2D and MALDI and methods of protein separation,	

	detection and quantitation. 3. evaluate various applications of genomics and proteomics in agriculture, human health and industry. 4. have the necessary learning to radically advance their understanding of life and transform medicine.

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-621

Title of the Course: SOLID WASTE MANAGEMENT

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic Knowledge of Microbiology and Environmental Science/ Environmental Technology.	
Course Objectives:	1) To develop required skills in Plan segregation, collection, transportation, recycling and disposal of municipal solid waste 2) To give an overview of municipal solid waste management, Methods of processing, basic disposal facilities, treatment options, and the environmental issues of solid waste management. 3) Provide relevant information about municipal solid waste reduction and on hazardous waste management.	
Content:	**MODULE I** • Introduction, Sources and Composition of Municipal Solid Waste, Sources of solid waste, Types of solid waste, Composition of solid waste and its determination, Types of materials recovered from MSW. • Properties of Municipal Solid Waste: Physical, Chemical, and Biological properties of Municipal Solid Waste, Transformation of Municipal Solid Waste. • Solid Waste Generation and Collection: Quantities of Solid Waste, Measurements and methods to measure solid waste quantities, Solid waste generation and collection, Factors affecting solid waste generation rate, Quantities of materials recovered from MSW.	15
	MODULE II • Handling, Separation and Storage of Solid Waste:	15

	- Handling and separation of solid waste at site. Material separation by pick in, screens, float and separator magnets and electromechanical separator and other latest devices for material separation. - Waste handling and separation at Commercial and industrial facilities. - Storage of solid waste at the sources. • Processing of Solid Waste: - Processing of solid waste at residence e.g. Storage, conveying, compacting, Shredding, pulping, granulating etc. Processing of solid waste at Commercial and industrial site.	
	MODULE III • Treatment of the Municipal Solid Waste: - Biochemical processes and advanced methods: Methane generation by anaerobic digestion, composting, Mechanical-biological treatment (MBT) and other biochemical Processes. - Treatment of solid waste at wastewater treatment plants: Advanced methods - Anaerobic co-digestion of the sewage sludge with liquid wastes such as septage, Novel composting methods (such as terra-preta of the sludge (biomass). - Combustion and energy recovery of municipal solid waste, effects of combustion, undesirable effects of Combustion. - Landfill: Classification, planning, sitting, permitting, landfill processes, landfill design, landfill operation, use of old landfill. - Differentiate sanitary land fill and incineration as final disposal system for solid waste. • Hazardous Solid Waste: - Definition, sources, identification, classification and characterization of hazardous solid waste. - Hazardous waste toxicity, reactivity,	15

	infectiousness, flammability, radioactivity, corrosiveness, irritation, bio-concentration, genetic activity, explosiveness. - Bio-medical waste, its sources, generation, storage, transportation and Disposal. - Solid waste management and sustainable development: Case studies	
Pedagogy:	Lectures, tutorials, Case studies, assignments.	
References/ Readings:	1. A. K. Chaterjee, Introduction to environmental biotechnology. PHI, India, 2011. 2. M. L. Davis, A. David , Environmental Engineering. McGraw Hill Education, 2017. 3. T. George, T. Hillary, and V. Samuel, Integrated solid waste management . McGraw Hill Publisher, 2014. 4. M.E. Henstock, Disposal and recovery of municipal solid waste Butterworths publication, 1983. 5. R. B. King, J. K. Sheldon, and G. M. Long, Practical Environmental Bioremediation: The Field Guide, Lewis Publishers., 1998. 6. M. Prabhu, Resource recovery from wastewaters for sustainable development,2016. shodhganga.inflibnet.ac.inhttp://hdl.handle.net/10603/84904 7. T. Satyanarayana, B. Johri, and T. Anil, Microorganisms in Environmental Management, Springer Publishers., 2012. 8. A. Scragg, Environmental Biotechnology. Pearson Education Limited, 2007. 9. H. J. Rehm and G. Reed, Biotechnology, a comprehensive treatise, VCH Verleg, 1999.	
Course Outcomes:	At the end of this course, the students will be able to: 1. explain solid waste management systems with respect to its physical properties, and associated critical considerations in view of emerging technologies. 2. outline sources, types and composition of solid waste with methods of handling, sampling and storage of solid waste. 3. select the appropriate method for solid waste collection, transportation, redistribution, disposal and treatment. 4. describe methods of disposal of hazardous solid waste.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT 652

Title of the Course: Summer/Winter Internship

Number of Credits: 02

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	The primary objectives is 1. To understand the agency as a system, and to develop an understanding and skills in working with specialized organization (preferably those working in marine related areas). 2. To impart student with "hands-on" experiences at a qualified place of employment (non-profit or governmental agency or private organizations) 3. To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Content:	• The Internship course is designed to permit students to apply their skills and knowledge of the discipline gained in the classroom setting and apply it in actual industrial/academic environment. Students are required to observe and participate in a job-related capacity under supervision of the employer. • The students are expected to follow the work schedule of the agency/organization where he/she is placed with reference to working days and working hours. • The student has to submit a internship report duly signed by the head of the organization and submit it to the program Director for evaluation	60 hrs
Pedagogy:	Theory, practical demonstrations, documentation, etc.	
Course Outcomes:	At the end of this course, students will be able to: 1. gain "hands-on" experiences at a qualified place of employment (non-	

	profit or governmental agency) the daily expectations of employment within the agency. 2. Students engaged in the activities which are supervised by an agency employee, will acquire the skills and knowledge base necessary to become successfully employed within the agency or a similar occupational or professional environment. 3. Expose the student to various work forces and get a broader perspective on available opportunities. 4. Develop a personal relationship with the employer and enhancing the experience for mentor as well as mentee

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SEMESTER IV

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT 605

Title of the Course: RESEARCH METHODOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	1) To develop required skills in the students so that they are able to acquire following competency: Plan research, Write research proposal, carry out data collection and analysis and write scientific communication. 2) The course will give the student an overview of research methods.	
Content:	**MODULE I** ● Conduct of Research ● Good Laboratory Practices, Ethics in research ● Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process. ● Problem Identification & Experimental Design– Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance. ● Project proposal writing, Literature survey- tools for literature survey. Defining the Aims and Objectives, Work Plan – Time-bound Frame. ● Making a reading list, Citation, Bibliography and its management software. ● Research Design: Concept and Importance in Research – Features of a good research design –	**No. of hours** 15

	Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. ● Sampling: Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample-Practical considerations in sampling and sample size. ● Data collection, Analysis and Interpretation: Types of data, Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis – Cross tabulations and Chi-square test including testing hypothesis of association.	
	MODULE II ● Importance of communicating research, Ethical aspects in academic writing, Plagiarism and software to detect plagiarism. ● Types of scientific writing and Research manuscript writing: reports, short communication, manuscript/original articles, review articles, thesis writing. ● Fundamentals of scientific paper: Drafting titles and framing abstracts, Authorship, Keywords, Introduction, Material and methods, Results and Discussion, Conclusion, Acknowledgement, Conflicts of Interest, Scientific Objectivity and Bibliography. ● Selection of journal for publication: Tools for suggesting journals for publishing research, Open access and predatory journals, cloned journals. ● Publication/Research metrics - Impact factor, citation count, cite score, h-Index, g-Index. ● Research evaluation: Peer review, Viva Voce. ● Benefits of publishing data. Science and social	15

	responsibility.	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. M. Alley, The Craft of Scientific Writing, Springer Science and Business Media, 1996. 2. G. Barbara and R.A. Day, How to write and publish a scientific paper. Greenwood, 2016. 3. P.G. Cooray, Guide to Scientific and Technical Writing. P.G. Cooray, Hindagala, Sri Lanka, 1992. 4. C. R. Kothari, Research Methodology Methods and Techniques, New Age International, 2004. 5. R. C. Kumar, Research Methodology. APH Publisher Corporation, New Delhi, 2008. 6. A. E. Shamoo, and D.B. Rasnik, Responsible conduct of research. Oxford, 2021.	
Course Outcomes:	At the end of this course, students will be able to 1. Understand basic elements of scientific research, including research methods, planning, writing the research proposal, data collection and analysis, and writing scientific communications. 2. Demonstrate the ability to choose methods appropriate to research aims and objectives 3. Understand the limitations of particular research methods 4. Develop skills in qualitative and quantitative data analysis and presentation 5. Develop advanced critical thinking skills 6. Explain key research concepts, read, comprehend, and explain research articles in their academic discipline.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-606

Title of the Course: SYNTHETIC BIOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	The objective of the course is to 1) redesign organisms for useful purposes by engineering them to have new abilities. 2) harness the power of nature to solve problems in medicine, manufacturing and agriculture.	
Content:	**MODULE I** • Synthetic biology: Introduction, History, Top down and Bottom up approach. • Enabling technologies 1. Emerging tools for DNA synthesis: artificial DNA synthesis, synthetic genomics. 2. Genome modularity concepts: Biobricks, Assembly method: 3 Antibiotic (3A) Assembly, Amplified Insert Assembly, Gibson Scarless Assembly, Methylase-assisted (4R/2M) Assembly Golden gate cloning 3. Synthetic biological circuits: oscillators, bistable switches, logical operators, analog tuners 4. Circuit design 5. Modeling 6. Microfluidics 7. Synthetic transcription factors	**No. of hours** 15
	MODULE II ● Genome editing: CRISPR technologies, gene	

	therapy, synthetic immunology ● Artificial cells, Synthetic genomics, Mycoplasma laboratorium, Protocell ● Computational method for protein engineering, pathway engineering, circuit designs using biological parts for creating synthetic biological constructs and strain design ● Xenobiology using nucleic acid analogues, xenonucleic acids, unnatural base pairs and expanded genetic code ● Applications of synthetic biology in biosensors, biological computers, organoids, bio-printed organs, space explorations. ● Ethics on creation of life and ethical support for synthetic biology	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. M. M. Andrea, Introduction to Synthetic Biology, Springer Verlag, 2018. 2. M. W. Covert, Fundamentals of Systems Biology From Synthetic Circuits To Whole-Cell Models, Taylor & Francis, 2018. 3. J. A. Davies, Synthetic Biology: A Very Short Introduction, Oxford, 2018. 4. G. E. Kaebnick, T. H. Murray, A. Lustig and J. Boldt, Synthetic Biology and Morality Artificial Life and the Bounds of Nature MIT Press Ltd, 2013. 5. M. A. Marchisio, Computational Methods in Synthetic Biology Springer, 2021. 6. V. Singh and P.K. Dhar, Systems and Synthetic Biology, Springer, 2015.	
Course Outcomes:	The students will be able to 1. apply the concepts of synthetic biology for the design of biological systems. 2. understand how the limits of existing technology be overcome by DNA synthesis technology 3. identify the biological problems that have limitations for industrial use and to analyze how synthetic biology can be applied as a solution. 4. Apply the concepts in creating various applications	

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: GBT-607

Title of the Course: PLANT AND ANIMAL BIOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge of molecular biology and recombinant DNA Technology	
Course Objectives:	1) The provide a comprehensive exposure to advances in animal and plant Biotechnology. 2) Student is expected to have a clear understanding of basic Biotechnology techniques to learn recent advances in the field.	
Content:		**No. of hours**
	MODULE I General features of eukaryotic expression and vector systems. Gene transfer to animal cells. Transgenic mice methodologies, Transgenic poultry, Transgenic Fish, Embryo transfer technology, Gene targeting, Cloning live stock by nuclear transfer, Transgenic livestock, Ethics of cloning Disease resistant transgenics, animal models for disease study, Pharming, improving milk quality, improving traits, Xenografts, Toxological applications, knock outs.	15
	MODULE II Strategies for Introducing Biotic and Abiotic Stress Resistance/Tolerance Bacterial resistance; Viral resistance; Fungal resistance; Insects and pathogens resistance; Herbicide resistance; Drought, salinity, thermal stress, flooding and submergence tolerance Genetic Engineering for Plant Architecture and Metabolism Seed storage proteins; Protein engineering; Vitamins and other value addition compounds; Source-sink relationships for yield increase; Post-harvest bioengineering; Plant architecture; Flowering behaviour Plants as Biofactories: Concept of biofactories; Fermentation and production of industrial enzymes,	15

	vitamins and antibiotics and other biomolecules; Cell cultures for secondary metabolite production; Production of pharmaceutically important compounds; Bioenergy generation	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. A. Bongso and E.H. Lee, Stem cells from bench to bed side World Scientific publisher, 2004. 2. A. Slater, N. Scott, and Fowler, Plant Biotechnology: The genetic manipulation of plants. Oxford University Press, 2003. 3. B. D. Singh, Plant Biotechnology. Kalyani Publisher, 2015. 4. B.R Jordan. The Molecular Biology and Biotechnology of Flowering, CABI Publication, 2006. 5. M. Denis, Plant Breeding and Biotechnology: Societal Context and the Future of Agriculture,Cambridge University Press, 2007. 6. P. K. Gupta, Plant Biotechnology. Rastogi Publication, 2015. 7. W. Neil. Phytoremediation: Methods and Reviews, Humana Press, 2007.	
Course Outcomes:	1. Students will be familiar with the principles and applications of different techniques used in plant and animal transformation. 2. Students will learn to compare the pros and cons of transgenic plants in the environment. 3. They will understand the role of rDNA technology in evolving plants for resistance to pest and disease, tolerance to herbicides and abiotic factors. 4. They will learn about the different mechanisms of disease resistance, stress tolerance and products produced using genetic engineering in plants and animals.	

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Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT-601

Title of the Course: Field trip

Number of Credits: 02

Effective from AY: 2022-23

Pre-requisites for the Course:	Theoretical and practical knowledge of Marine Microbiology, Marine pathogenesis, Oceanography and Aquaculture	
Course Objectives:	The primary objectives of the group learning are as follows: 1. To provide first-hand experience, 2. To stimulate interest and motivation in science, 3. To add relevance to learning and inter-relationships, 4. To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Content:	• Visit to any Central Scientific Research and Development institute or Science laboratory (including those carrying out marine related research: National Institute of Oceanography or ICAR-Fisheries Department or TERI). • Visit to a pharmaceutical industry to learn about industrial manufacturing processes. • Visit to 3-4 Biotechnology industrial unit such as beverage production unit, dairy industry, fish processing unit, food processing unit, waste processing unit, etc. • Visit to 1-2 fish or shrimp or mussel or crab culture farm/ Fish breeding unit/ Ornamental fish hatchery/ Small-scale aquaponics systems. Boat cruise and sample collection techniques • Preparation of report, Group discussion and individual presentation	**No of hours** 8 8 10 20 14
Pedagogy:	Field visit,	
Course Outcomes:	At the end of this course, the students will be able to: 1. connect between the field trip learning with prior experiences and knowledge from the classroom. 2. sharpen their skills of observation and perception. 3. understand experiential learning discussed during field trips. 4. Appreciate the art of commercial fish culture methods and get motivated to become entrepreneurs	

Name of the Programme: M.Sc. Marine Biotechnology

Course Code: MBT - 602

Title of the Course: SCUBA DIVING

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Students must know to swim 200 meters (any style) and be able to float 10 minutes	
Course Objectives:	Skill-based course with an objective to: 1. Familiarize divers with knowledge, procedures, techniques, and problems of underwater diving. 2. Appreciate and preserve marine life .	
Content:	**MODULE I** Dive Theory 1. Introduction 2. Diving equipment 3. Physics 4. Physiology 5. Planning dives 6. Executing dives 7. The underwater world 8. Scuba experience and beyond	**No. of hours** 15
	MODULE II Practicals (Total 4 dives) ● 2 sessions of pool training for skills ● 2 days of 2 sea dives each - skills and pleasure dives	15
Pedagogy:	Lectures, tutorials, practical onsite training	
References/ Readings:	1. PADI Open Water Diver Manual PADI publisher, 2015. 2. D. Graver, Scuba Diving. Human Kinetics Publishers, 2016. 3. S. Cole, and M. Brandon, Reef Life: A Guide to Tropical Marine Life Firefly Books Ltd, 2013.	
Course	1. The students will be able to study the marine biodiversity.	

Outcomes:	2. They will be able to carry out underwater surveying and understand the human and environmental impact on marine life. 3. Collection of underwater marine samples. 4. Students will become licensed divers and can enrol for the advanced scuba diving course.

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