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 national level.

Proposed Scheme

For

M.Sc. Marine Biotechnology (1455)

(Applicable from 2022-23)

SEMESTER I			
Course Codes	**Course Titles**	**Credits**	**Course Level**
Discipline-specific Core courses (16 credits)			
MBTC-401	Marine Microbiology & Ecology	3	100
MBPC-401	Lab I: Techniques in Microbiology, Marine Biology and Chemistry	3	100
MBTC-402	Immunology and Marine pathogenesis	3	100
MBPC-402	Lab II: Immunology & Marine Pathogenesis	2	100
MBTC-403	Biophysical Principles & Analytical Techniques	2	100
MBPC-404	Lab III: Biochemistry and analytical techniques	3	100
Discipline-specific Elective courses (Any 4 credits)			
MBTE-401	Concepts in Biochemistry	2	100
MBTE-402	Biostatistics	2	100
MBTE-403	Mathematics for Biologists	2	100
MBTE-404	Biology of the Extremophilic Organisms	2	100
Semester II			
MBTC-405	Oceanography and Marine Bioresources	3	100
MBTC-406	Aquaculture Technology	3	200
MBTC-407	Genetics and Molecular Biology	3	100
MBPC-407	Lab IV: Genetics and Molecular Biology	2	200
MBTC-408	Cell and Developmental Biology	3	100
MBPC-409	Lab V: Plant and Animal Tissue Culture	2	100
Discipline-specific Elective courses (Any 4 credits)			
MBTE-405	Bioinformatics	2	200
MBPE-405	Lab VI: Lab in Bioinformatics	2	200
MBTE-406	Nanobiotechnology	2	200
MBTE-407	Vaccine Technology	2	200
Semester III			
Research specific Elective courses (Any 8 credits)			
MBTR-501	Recombinant DNA Technology	3	300
MBPR-501	Lab VII: Recombinant DNA Technology	2	300
MBTR-502	Bioprocess Technology and Marine	3	300

	Bioprocessing		
MBPR-502	Lab VIII: Bioprocess technology and Marine Bioprocessing	2	300
MBTR-503	Marine Food Technology	2	200
Elective Generic courses (Any 12 credits)			
MBTG-501	Virology	2	200
MBTG-502	IPR, Biosafety & Bioethics	3	100
MBTG-503	Potential of Marine Biotechnology	3	300
MBTG-504	Genomics & Proteomics	2	200
MBTG-505	Solid Waste Management	3	300
MBIG-501	Summer/Winter Internship	2	200
Semester IV			
Research specific Elective courses (Any 4 credits)			
MBTR- 509	Research Methodology	2	200
MBTR-510	Synthetic Biology	2	200
MBTR-511	Plant and Animal Biotechnology	2	300
MBFR-501	Field Trip	2	200
MBSR-501	Scuba Diving	2	200
Discipline-specific dissertation			
MBPD- 501	Dissertation	16	400

Course level 100: No prerequisite for the course.
Course level 200: At least one prerequisite course is required.
Course level 300: More than two prerequisite courses are required.
Course level 400: Courses from Semester I, II, and III are prerequisites.

SEMESTER- I

Course Code	MBTC-401	
Title of the Course	MARINE MICROBIOLOGY & ECOLOGY	
Credits	3	
Course Objectives	The objective of this course is to provide information about the microbes available in the aquatic environment, their role and interaction with the marine environment	
Learning Outcomes	• Explain the different features of marine ecosystems and the microbial diversity in oceans; • Describe and discuss marine microbes in terms of physiological capability and their biogeochemical role.	
Contents:	**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: i) cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups.	15 hours

	MODULE II • Techniques in Marine microbiology: • Sampling: Water, Sediments. • Direct observation and enumeration of microbes: Light and • electron microscopy to study morphology and structure of microbes. • Culture-base methods for isolation and identification of microbes. Phenotypic and Genotypic testing, polyphasic methods of identification. Chemotaxonomy, Metagenomics. •Bergey's manual & identification of marine bacteria.	15 hours
	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 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Gram, L., (2009) Microbial Spoilage of Fish and Seafood, Springer 2. Horikoshi K., Antranikian G., Bull A. T, Robb F. T. and Stetter, K. O., (2011) Extremophiles handbook, Springer 3. Kirchman, D.L, Gasol, J.M., (2018), Microbial ecology of the Oceans. Wiley-Blackwell, New York. 4. Madigan. M.T., Buckley, D.H., Sattley, W.M., Stahl, D.A.(2021) Brock Biology of Microorganisms, Pearson Publisher. 5. Munn, C.B., (2020) Marine Microbiology: Ecology and Applications. CRC	

	Press 6. Paul, J., (2001) Methods in Microbiology: Marine microbiology, Academic Press. 7. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R. (2001) Microbiology. CBS Publishers. 8. Surajit D., Hirak Ranjan D., (2018) Microbial Diversity in the Genomic era, Elsevier

Course Code:	MBPC-401	
Title	LAB I-TECHNIQUES IN MICROBIOLOGY, MARINE BIOLOGY AND CHEMISTRY	
Credits	3	
Course Objectives	• To introduce the students to various methods to isolate and culture bacteria using different media, learn marine sampling methods and measure the physical and chemical parameters of the marine aquatic system.	
Learning Outcomes	Upon completion of the course, the student will be able to • Use appropriate media to isolate bacteria from different ecosystems. • Study and group bacteria on the basis of morphological and biochemical testing. • Understand the various techniques used for marine sampling. • estimate the planktons and elemental composition in seawater.	
Contents:	• Preparation of solid & liquid media, Differential and Selective media: Isolation of bacteria from seawater /sediments samples, Enumeration: serial dilution methods, plating. • Maintenance of organisms: Streaking, slants and stabs cultures • Study of morphology and cultural characteristics. • Gram staining. • Motility • Antimicrobial sensitivity test and demo of drug resistance. • Cultivation of fungi: Slide, chunk and cover slip techniques.	45 hours

	• Samplers: water samplers, dredges, grabs, snappers. • Sampling (Field trips) and identification: • Phytoplankton & Zooplankton • Nekton • Benthos Estimations: • Chlorophyll • Nutrients: nitrates, nitrites, phosphates, silicates • Dissolved oxygen • Salinity, pH & alkalinity.	45 hours
Pedagogy	Hands-on experiments in the laboratory, learning skills in sampling techniques.	
References/ Reading	1. Baird R., Eaton A. D., Rice E. W., Bridgewater L. (2017) Standard methods for the examination of water and wastewater. American Public Health Association 2. Bakus, G. J., Bakus, G. J. (2007). Quantitative Analysis of Marine Biological Communities: Field Biology and Environment. Wiley publisher. 3. Eleftheriou A, and McIntyre A., (2005) Methods for the Study of Marine Benthos.Wiley Publisher. 4. Grasshoff K., Kremling K.,Ehrhardt, M., (2009) Methods of Seawater Analysis, Wiley Publisher . 5. Leo M.L. Nollet, Leen S. P. Gelder De (2013) Handbook of Water Analysis. CRC Press. 6. McCance, M. E., Harrigan, W. F. (2014). Laboratory Methods in Microbiology. Elsevier Science. 7. Omori, M., Ikeda, T. (1992). Methods in Marine Zooplankton Ecology. Krieger Publisher 8. Sastry, A. (2021). Essentials of Practical Microbiology. India: Jaypee Brothers Medical Publishers Pvt. Limited. 9. Sattley, W., Madigan, M., Bender, K., Stahl, D., Buckley, D. (2017). Brock Biology of Microorganism. Pearson Education. 10. Vasanthakumari R., (2009) Practical Microbiology. (2009). India: B.I. Publications Pvt. Limited. 11. Yuncong Li, Kati M., (2019) Water Quality Concepts, Sampling, and Analyses. CRC Press LLC.	

Course Code	MBTC-402	
Title of the Course	IMMUNOLOGY AND MARINE PATHOGENESIS	
Credits	3	
Course Objectives:	• To provide a basic knowledge and appreciate the components of the human immune response that work together to protect the host. • To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity • To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders and immune deficiencies. • To introduce the common fish/shellfish pathogens, understand their growth characteristics and control and preventive measures.	
Learning Outcomes	• The mode of continuous assessment and formulation of tests enables students to handle competitive entrance exams. The basic overview of Immunology and Marine Pathogenesis strengthens their foundations for a career in Biotechnology and Marine Biotechnology.	
Contents:	MODULE I – 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	15 hours

	molecules, basic organization of MHC in human, haplotype-restricted killing. • Nature and biology of antigens and super antigens: haptens, adjuvants, carriers, epitopes, T-dependant and T-independentt antigens	
	<u>MODULE II – Defence Components: Constituents of immune system and effector mechanisms of immune responses</u> • 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 hours
	<u>MODULE III – Marine Pathogens and Disease Control</u> • 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 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Readings	1. Luttmann W., Bratke K., Kupper M., and Myrtek D (2009). Immunology. Academic Press 2. Male D., Brostoff J., Roth D., Roitt I., (2013) Immunology. Elsevier Saunders publication 3. Parthiban F., Felix S. (2018) Microbiology of Fish and Fishery Products, Daya Publishing House. 4. Punt, J., Stranford, S., Jones, P., Owen, J.A.,(2018) Kuby Immunology W.H. Freeman 5. Roitt I.M. Delves P.J. Martin S. J., Burton D R, Roitt I.M. (2017) Essential Immunology Wiley-Blackwell 6. Ward, D.R. and Hackney, C.A., (2012). Microbiology of marine food products. Springer Science 7. Woo, P. T. K., Bruno, D. W (2011). Fish diseases and disorders. Volume 3: viral, bacterial and fungal infections. CABI Publishing.	

Course Code	MBPC-402
Title of the course	Lab II: IMMUNOLOGY AND MARINE PATHOGENESIS
Credits	2
Course Objectives	This course involves learning techniques to identify reactions in the lab that form the basis for application in immunodiagnostics and also to gain an insight into the evaluation of marine pathogens.
Learning Outcomes	• Key hands-on experience in converting and applying theoretical knowledge to the laboratory. Students become familiar with techniques

	involved in immunology as well as in the study of marine pathogens	
Contents:	1. Determination of antibody titer using 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 hrs
	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 hrs
Pedagogy	Hands-on experiments in the laboratory, video, online data	
References/ Reading	1. Bullock, G.L.,(2014) Diseases of Fisheries . Narendra Publishing House . 2. Edward J. Noga, (2010). Fish Disease: Diagnosis and treatment, Wiley Blackwell. 3. Freshney. I.R., (1998). Culture of Animal Cells. Wiley-Blackwell 4. Inglis, V.,(2013) Bacterial Diseases of Fish , Wiley Publications 5. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2001) Immunobiology: The Immune System in Health and Disease, Garland Publishing, USA. 6. Joshi, K.R., Osama, N.O. (2012) Immunology, 5th Edition, Agrobios Ltd, India. 7. Talwar G.P ., Gupta S.K (2017) A Handbook Of Practical And Clinical	

	Immunology Vol I CBS Publishers. 8. Thanwal. R., (2014) A Handbook of Diseases, Astha Publishers & Distributors.

Course Code	MBTC-403	
Title of the course	BIOPHYSICAL PRINCIPLES AND ANALYTICAL TECHNIQUES	
Credits	2	
Course Objectives	The course is designed to provide a broad exposure to basic techniques used in Modern Biology research. The goal is to impart a basic conceptual understanding of the principles of these techniques and emphasize the biochemical utility of The students are expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.	
Learning Outcomes	Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.	
Contents:	**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 Non-covalent Interaction in molecular conformationon, 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,	15 hours

	• Biochemical and biophysical characterizations of 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 diffusion, dynamics by fluorescence correlation spectroscopy. **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**	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Anders L. et al. (2016) Textbook of Structural Biology. World Scientific. 2. Atkins, de P. (2011) Physical Chemistry for the Life Sciences. W.H. Freeman. 3. Bhavna P., Fulekar, M.H (2019), Bioinstrumentation, Wiley Int. 4. Branden C., and Tooze J., (1998) Introduction to Protein Structure, Garland Science. 5. Rodney C., (2017). Biophysics: An IntroductionWiley Int. 6. Salman K., and Diaz, Z., (2016) Principal And Techniques of	

	Bioinstrumentation, Intelliz Publisher 7. Schulz GE and Schirmer RH, (1998) Principles of Protein Structure, Springer Verlag. 8. Stout G.H., and Jensen L.H., (1989) X-ray Structure Determination: A practical guide. John Wiley and Sons Inc., New York. 9. Subramaniam, M. A (2021) Biophysics: Principle and techniques, MJP Publishers. 10. Tinoco Jr. I. Sauer K., Wang J.C., Puglisi J. D., Harbison G., Rovnyak D. (2013) Physical Chemistry: Principles and Applications in Biological Sciences Pearson Publishers 11. Van Holde K. E., Johnson, C. Ho P. S. (2005) Principles of Physical Biochemistry. Prentice Hall.

Course code	MBPC-404	
Title of the course	LAB III: BIOCHEMICAL AND ANALYTICAL TECHNIQUES	
Credits	3	
Course Objectives	The objective of this laboratory course is to introduce students to experimentation in biochemistry. The course is designed to teach the utility of these experimental methods in a problem-oriented manner.	
Learning Outcomes	Students should be able to: • Elaborate concepts of biochemistry with easy-to-run experiments. • Familiarize with basic laboratory instruments and understand principles underlying measurements using those instruments for experiments in biochemistry.	
Contents:	1. UV-Visible spectroscopic analysis. 2. Estimation of proteins by the 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.	45 hours

	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 hours
Pedagogy	Hands-on experiments in the laboratory, video, online data	
References/ Reading	1. Atkins, de Paula. (2011) Physical Chemistry for the Life Sciences (2nd Edition). W.H. Freeman. 2. Atkins, de Paula. (2015), Physical Chemistry for the Life Sciences (2nd Edition). W. H. Freeman 3. Boyer, R. (2000). Modern experimental biochemistry. Pearson Education India. 4. Friedrich L., Engels, J. W. (2018) Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH publisher 5. James J.F. (2017), An Introduction to practical laboratory optics, Cambridge University press. 6. Jayaraman, J. (2011). Laboratory Manual of Biochemistry. New Age International Private Limited 7. John G., (2020), Biological Centrifugation CRC Press. 8. K. E. van Holde, C. Johnson, P. S. Ho (2005) Principles of Physical Biochemistry, 2nd Edn., Prentice Hall. 9. Mu, P., & Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education. 10. Prakash S. Bisen, (2014), Laboratory Protocols in Applied Life Sciences., Taylor and Francis Publisher 11. Tinoco, Sauer,Wang, and Puglisi. (2013) Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc. 12. Ulrich K., (2017) Fluorescence microscopy: From Principle to application, Wiley Int. 13. Wilson, K., Walker, J. (Eds.). (2010). Principles and techniques of biochemistry and molecular biology. Cambridge university press.	

Course Code	MBTE-401	
Title of the course:	CONCEPTS IN BIOCHEMISTRY	
Credits	2	
Course Objectives	• The major objective of this course is to build upon the knowledge of basic biochemical principles with emphasis on different metabolic pathways and their integration. Attention is drawn to the structure-function relationships of biomolecules.	
Learning Outcomes	• Gain fundamental knowledge in biochemistry and understand the role of enzymes in the regulation of metabolic pathways.	
Contents:	**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 van der 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.	15 hours
	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 hours
Pedagogy	Lectures, tutorials, assignments.	
References/ Reading	1. Abali E. E., Cline S. D., Franklin D. S., Viselli S. M., (2021) Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher 2. Miesfeld R. L., McEvoy M. M., (2020) Biochemistry. Worldwide publisher 3. Murray, R.K. et al (2022). Harper's Illustrated Biochemistry McGraw Hill publisher. 4. Nelson D.L. (2017) Lehninger Principles of Biochemistry. W.H. Freeman & Co. 5. Papachristodoulou D., Snape A., Elliott W. H., and Elliott D. C. (2018). Biochemistry and Molecular Biology. Oxford University publisher. 6. Stryer L; Berg J., Tymoczko J., Gatto G. (2019). Biochemistry New York, Freeman publisher. 7. Voet, D., Voet, J.G., Charlotte W.P. (2018). Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher.	

Course Code	MBTE-402
Title of the course	BIOSTATISTICS
Credits	2
Course Objectives	The objective of this course is to introduce students to statistical methods and to understand underlying principles, as well as practical guidelines of "how to do it" and "how to interpret it" statistical data.
Learning	Upon completing this course, students should be able to –

<table>
<tr><td>Outcomes</td><td colspan="2">• understand how to summarize statistical data;
• apply appropriate statistical tests based on an understanding of the study question, type of study, and type of data;
• Interpret results of statistical tests.</td></tr>
<tr><td rowspan="2">Contents:</td><td><u>MODULE I</u>
• 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.</td><td>15 hours</td></tr>
<tr><td><u>MODULE II</u>
• 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 hypotheses, Type I and Type II errors
• Simple linear regression and correlation
• Analysis of variance</td><td>15 hours</td></tr>
<tr><td>Pedagogy</td><td colspan="2">Lectures, tutorials, assignments</td></tr>
<tr><td><u>References/ Reading</u></td><td colspan="2">1. Arora P.N. and Malhan, P.K. (2006), Biostatistics. Himalaya Publishing House. House.
2. Kothari, C. R.,(2013) Quantitative Techniques, Vikas Publishing
3. Mahajan B.K., (2018), Methods in Biostatistics: for Medical Students and Research Worker. Jaype Brothers,
4. Rao K. Surya (2010), Biostatistics for Health and Life Sciences, Himalaya Publishing House.</td></tr>
</table>

	5. Rastogi, V. B. (2009). Fundamentals of Biostatistics. Ane Books Pvt Ltd. 6. Samuels, JA Witmer (2016) Statistics for the Life Sciences. Prentice Hall

Course Code	MBTE-403	
Title	MATHEMATICS FOR BIOLOGISTS	
Credits	2	
Objectives	• To give conceptual exposure to essential contents of mathematics • To enable them to perform quantitative analysis in biology.	
Learning outcomes	• Gain a broad understanding of mathematics • Recognize the importance and value of mathematical thinking, understand the use of mathematics to describe biological processes and their use in problem-solving, and understand the diverse phenomena that exist in biological systems.	
Contents	<u>Module I</u> • 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.	15 hours
	<u>Module II</u> • 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	15 hours

	(limits, derivatives), integral calculus (integrals, sequences, and series, *etc*.). • Population dynamics; oscillations, circadian rhythms, developmental patterns, • Symmetry in biological systems, fractal geometries, size limits & scaling in biology, • Modelling chemical reaction networks and metabolic networks	
Pedagogy	Lectures, tutorials, assignments	
References/Reading	1) Aggarwal, S.K., (2008) Bio Mathematics. Alps Book Publishers. 2) Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for biological scientists. Garland Science. 3) Bairagi N., (2021) Introductory Mathematical Biology. U. N. Dhur and Sons Private Limited Publisher 4) Foster, P.C. (1999) Easy mathematics for biologists. Taylor and Francis 5) Robeva R (2013) Mathematical concepts and methods in modern biology using Modern Discrete Models. Academic Press 6) Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. Palgrave Macmillan.	

Course Code	MBTE-404	
Title	BIOLOGY OF THE EXTREMOPHILIC ORGANISMS	
Credits	2	
Objectives	• To obtain knowledge regarding the existence of extreme habitats. • To understand how the strategies are adopted to overcome extreme conditions.	
Learning outcomes	• Understands the mechanisms of adaptation adopted by different organisms in extreme habitats. • Bioprospecting of the extremophiles for biotechnological applications	
Contents	<u>Module I</u> • 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 mine drainages 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 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.	15 hours
	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 hours
Pedagogy	Lectures,tutorials, assignments	
References/Reading	1) Anitori, R.P., (2012) Extremophiles: Microbiology and Biotechnology. Caister Academic Press. 2) Durvasula, R.V., and Subba Rao.D.V. (2018). Extremophiles: From Biology to Biotechnology. CRC Press. 3) Elster J., Prisco, G.di, Huiskes, A.H.L, Edwards, H.G.M., (2020) Life in Extreme Environments., Insights in Biological Capability. Cambridge University Press. 4) Gunde-Cimerman N, Oren, A., Plemenitaš a.,(Ed) (2005)Adaptation to Life at High Salt Concentrations in Archaea, Bacteria, and Eukarya. Springer Publisher. 5) Richa, S. and Vivek S., (2020) Physiological and Biotechnological Aspects of Extremophiles. Academic Press. 6) Singh Om V.(2012) Extremophiles: Sustainable Blackwell 7) Wharton D.A., (2002) Life at the Limits: Organisms in Extreme Environments Cambridge Press.	

SEMESTER II

Course Code	MBTC-405	
Title of the Course	OCEANOGRAPHY AND MARINE BIORESOURCES	
Credits	3	
Course Objective:	• Introduce students to the marine environment and its physical features; Introduce students to marine life, their habitats and adaptations.	
Learning Outcomes	At the end of this course, students will be able to: • Understand the status and trends of major marine resources • Understand how oceans influence the climate. • Familiarise with marine life and factors influencing primary and secondary production.	
Contents:	<u>Module 1: (Marine life diversity and processes)</u> • 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	15 hours

	distribution in ocean environment, Mechanism and factors affecting primary production. • Bio-communication in oceans, Quorum sensing, Microbe-microbe interaction, Microbe-seaweed 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 2: (Physical Oceanography)</u> •Ocean atmosphere interface • Circulation: Coriolis effect, Ekman transport, Langmuir circulation. • Planteray waves: Kelvin and Rossby waves. • Climate variability: Pacific decadal oscillation, North Atlantic oscillation, and Arctic oscillation, thermohaline circulation • El Niño-Southern Oscillation: El Niño & La Niña and its effect on global climate • Ocean currents: Antarctic Circumpolar Current, Deep ocean (density-driven), Western boundary currents (Gulf Stream, Kuroshio Current, Labrador Current, Oyashio Current, Agulhas Current, Brazil Current, East Australia Current); Eastern Boundary currents (California Current, Canary Current, Peru Current, Benguela Current) • Ocean gyres: Major gyres, Tropical gyres, Subtropical gyres, Subpolar gyres • Tides, Tsunamis, Wind waves and its effects • Plate tectonics, Mid-oceanic ridge spreading and convection	15 hours
	<u>Module 3: (Chemical Oceanography)</u> • Seawater composition and its properties	15 hours

	• Characterization of sediments: constituents, texture 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., (1996) Biodiversity and Environment. APH Publishing Corporation. 2. Beer, T. (2017). Environmental Oceanography. CRC Press Heywood V.H. (1995) Global Biodiversity Assessment. UNEP, Cambridge University Press 3. Bertness, M. D., Bruno, J. F., Silliman, B. R., & Stachowicz, J. J. (Eds.). (2014). Marine community ecology and conservation. Sinauer Associates, Incorporated. 4. Chambers, R. C., & Trippel, E. A. (Eds.). (2012). Early life history and recruitment in fish populations (Vol. 21). Springer Science & Business Media 5. Jeffrey S. Levinton, C. D., (2001). Marine Biology: Function, Biodiversity , Ecology . OUP, USA publication 6. Knauss, J. A., & Garfield, N. (2016). Introduction to physical oceanography. Waveland Press. 7. Kortzinger, (2004). The Ocean takes a Breath, Science 306(5700):1337 8. Naskar K. and Mandal R., (1999) Ecology and Biodiversity of Indian Mangroves. Daya Publishers 9. Pickard, G. L., & Emery, W. J. (2016). Descriptive physical oceanography: an introduction. Elsevier. 10. Trujillo A. P., and Thurman H. V., (2017) Essentials of Oceanography. Pearson Publisher	

Course Code	MBTC-406	
Title of the course	AQUACULTURE TECHNOLOGY	
Credits	3	
Prerequisites	MBTC-401	
Course Objectives	• This course is aimed to teach sustainable use of aquatic resources with various approaches in biotechnology.	
Learning Outcomes	On completion of this course, students should be able to: • Explain fundamental principles of aquaculture biotechnology; • Identify the role of aquaculture biotechnology in society.	
Content	**MODULE I** • Importance of coastal aquaculture; Aqua farms; Design and construction; Criteria for selecting cultivable species; Culture systems and management practices – extensive, semi-intensive and intensive culture practices. Seed production in controlled condition; Types; Design and management of hatchery –induced spawning; Mass production of seeds; feed formulation; Artificial insemination - *in vitro* fertilization; • Fish Feed Technology: Types of feed, conventional feed *vs* functional feeds; Principles of feed formulation and manufacturing, diets suitable for application in different aquaculture systems; feed formulation ingredients; Use of natural and synthetic carotenoids; feed additives; Role of additives; Feed processing: Gelatinization, extrusion Technology, pellet dressing with heat liable nutrients; Feed evaluation; Feeding schedule to different aquatic organisms, check tray operation and feed management, Biomass calculation based on feed intake; Post-harvest Biotechnology: Fundamental aspects of freezing, methods of freezing; Delaying of spoilage. Molecular Tools in Conservation of Fisheries Resources: Artificial Hybridization: Heterosis, Control of fish diseases by selection; selective breeding of disease resistant fish.	15 hours

	• 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.	15hours
	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	15 hours

	commercial important products.	
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Felix,S,(2010) Handbook of Marine and Aquaculture Biotechnology AGROBIOS INDIA. 2. Gautam, N,C, (2007) Aquaculture Biotechnology, Shree Publishers and Distributors 3. Krishnaveni, G., and Veeranjaneyulu, K., (2016) RECENT TECHNOLOGIES IN FISH AND FISHERIES Rigi Publications 4. Kutty, M.N., and Pillay T.V., (2005) Aquaculture: Principles and Practices (Wiley Blackwell) 5. Patel, A., and Pathak S.N., (2010) Textbook of Aquaculture. Pacific Book Internationals. 6. Se-kwon Kim , (2015) Handbook of Marine Biotechnology, Springer 7. Stickney R.R., Gatlin D., (2022) Aquaculture: An Introductory Text CABI Publishing 8. Stickney, R.R., (2000) Encyclopedia of Aquaculture Wiley InterScience	

Course Code:	MBTC-407	
Title of the Course:	GENETICS AND MOLECULAR BIOLOGY	
Credits	3	
Course Objective:	The aim of this course is to obtain and understand the fundamental knowledge of molecular and cellular processes such as RNA transcription, protein synthesis, mutation, epigenetic modification and gene regulation.	
Learning Outcomes	The students should be able to explain and summarize the scientific principles of the molecular biology of DNA, RNA and understand the role played in overall functioning of the cell.	
Contents:	**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	15 hours
	MODULE II • Prokaryotic and eukaryotic transcription -RNA polymerase/s and sigma factors, • Transcription unit, Prokaryotic and eukaryotic promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent) • Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac*, *trp*operons, attenuation, anti-termination, stringent control, translational control. • Eukaryotic transcription - RNA polymerase I, II and III mediated, General eukaryotic transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs. ; Silencers, insulators, enhancers, mechanism of silencing and activation.	15 hours
	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 hours
Pedagogy	Lectures/tutorials/assignments	
References/Reading	1. Clark D.P. Pazdernik, N.J., McGehee, M.R. (2019) 2. Goldstein E.S. , Stephen T. Kilpatrick J Krebs J. (2017) Lewin's GENES XII . Bartlett Publishers 3. Karp G., Iwasa J., Marshall W., (2016) Karp's Cell and Molecular Biology: Concepts and Experiments, (8 ed) Wiley Publisher 4. Klug, W., Cummings, M, Spencer.C . (2019) Concepts of Genetics (12ed). Pearson publishers 5. Lodish H.F; Berk A ; Kaiser C ; Krieger M ; Bretscher A . (2016). Molecular Cell Biology (8 ed) Freeman MacMillan publisher 6. Russell P.J, iGenetics: A Molecular Approach. (2016) (3 ed) Pearson publisher. 7. Simmons M. J., Snustad P. (2015). Principles of Genetics (7 ed). Wiley Student Edition. 8. Strickberger, M. (2015) Genetics, (3 ed) by Pearson publishers 9. Watson J.D, Baker T.A, Bell S.P, Gann A, Levine M & Losick R (2014) Molecular Biology of the Gene, Cold Spring Harbor Laboratory Press, New York 10. Weaver R.F (2012) Molecular Biology (5th ed) McGraw Hill Higher Education publisher.	

Course Code:	MBPC-407
Title of the Course	LAB IV: GENETICS AND MOLECULAR BIOLOGY
Credits	2
Prerequisite	MBTC-407

Objective:	• The objective of this course is to provide students with experimental knowledge of molecular biology and genetic engineering.	
Learning Outcomes	• Students should be able to gain hands-on experience on gene cloning, protein expression and purification. This experience would enable them to begin a career in industry.	
Contents:	1. UV/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	30 hrs
	7. DNA quantification and gel electrophoresis 8. RNA isolation 9. RNA denaturing gel electrophoresis. 10. Mitosis. 11. Meiosis	30 hrs
Pedagogy	Hands-on experiments in the laboratory, video, online data	
References/Readings	1. Gakhar S.K., Miglani M., Kumar A., (2019) Molecular Biology: A Laboratory Manual. Rupa Publications. 2. Green R. , Sambrook J. (2012) Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set 3. Hofmann A. (2018) Wilson and Walkers Principles And Techniques Of Biochemistry And Molecular Biology. Cambridge University Press 4. Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN Vennison PHI Learning 5. Sharma R.K., Sangha S.P.S (2020) Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press.	

Course Code	MBTC-408	
Title of the course	CELL AND DEVELOPMENTAL BIOLOGY	
Credits	3	
Course Objectives	The cells being "the fundamental building blocks of all organisms", a comprehensive understanding of the cell and cellular function is essential for all biologists. This course will hence provide a conceptual overview of a cellular system and its functioning in animals and plants. The course will also highlight a conceptual overview of how developmental patterns arise. Using examples from different model systems regulatory networks involved are highlighted, aiming to project the molecular basis of developmental patterns.	
Learning Outcomes	Understanding major concepts in cell and Developmental biology with an awareness of experimental approaches and how they are applied in cell biology research.	
Contents:	**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, bio membrane 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 communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, integrins, neurotransmission, and its regulation.	15 hours

	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 hours
	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 formation, metamorphosis; environmental regulation of normal development; sex determination.	15 hours
Pedagogy	Lectures/tutorials/assignments	
References/ Reading	1. Amon, A., Krieger, M., Lodish, H., Bretscher, A., Kaiser, C. A., Berk, A.,	

	Martin, K. C., Ploegh, H. (2016). Molecular Cell Biology. United Kingdom: W. H. Freeman. 2. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J, Johnson, G. (2016). Cell biology E-book. Elsevier Health Sciences. 3. Karp, G., Iwasa, J., Marshall, W. (2018). Cell Biology Global Edition. United States: Wiley. 4. J.D. Watson, M.,Levine, T. A. Baker, A. Gann, S. P. Bell, R.L. Watson (2014) Molecular Biology of the Gene, Pearson Education. 5. Turner, B. M. (2008). Chromatin and gene regulation: molecular mechanisms in epigenetics. John Wiley & Sons. 6. Kilpatrick, S. T., Krebs, J. E., Goldstein, E. S. (2017). Lewin GENES XII. Japan: Jones; Bartlett Learning. 7. Gilbert, S. F. (2010). Developmental biology. Sinauer Associates, Inc. 8. Subramanian, M. A. (2022). Developmental Biology. India: MJP Publisher. 9. Cooper, G. M., Hausman, R. E. (2013). The Cell: A Molecular Approach. United States: Sinauer Associates. 10. C. Smith & E. Wood (2005) Cell Biology, Chapman Hall . 11. Wolpert, L. (2011). Developmental Biology: A Very Short Introduction. OUP Oxford. 12. Slack, J. M. W. (2009). Essential Developmental Biology. Germany: Wiley. 13. Lodish et al., (2000) Molecular Cell Biology, W.H.Freeman & Company 14. Smith & Wood (2005) Cell Biology, Chapman & Hall London

Course Code	MBPC-409
Title of the Course	LAB V: PLANT AND ANIMAL TISSUE CULTURE
Credits	2
Objective:	• A comprehensive understanding of the cell and cellular functions; plant and animal tissue culture.
Learning Outcomes	• To carry out and interpret experiments in Plant and animal tissue culture.

Contents:	1. Preparation of starting material (Biosafety cabinet, solutions, media, cell sample etc.): 2. Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, 3. contamination and precautions 4. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell like 5. HEK293, COS-7 6. Transfection and co-transfection: Calcium-phosphate method and Lipofection 7. Cell fixation and staining: Immunolabeling, mounting, fluorescence imaging	30 hours
	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	30 hrs
Pedagogy	Hands-on experiments in the laboratory, video, online data	
References/Readings	1. Freshney I.R. and Capes-Davis A., (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley Blackwell Publisher 2. Freshney R.I and Masters. J.R.W. (2000) Animal cell culture (2000) – A Practical Approach Oxford University Press 3. Sherathiya, H., (2013) Practical manual for Plant Tissue Culture: Basic Techniques of Plant Tissue Culture and Molecular Biology. Grin Verlag 4. Smith R. (2012) Plant tissue culture Techniques and experiment. Academic Press.	

Course Code	MBTE-405	
Title of the Course	BIOINFORMATICS	
Credit	2	
Prerequisite	MBTC-407	
Objective:	The objectives of this course are to provide students with theory and practical experience of the use of common computational tools and databases which facilitates the investigation of molecular biology and evolution-related concepts	
Learning Outcomes	Students should be able to: • develop an understanding of the basic theory of these computational tools. • gain working knowledge of these computational tools and methods. • appreciate their relevance for investigating specific contemporary biological questions	
Contents:	**MODULE I** • Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • Evolutionary basis of sequence alignment, optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, • Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle; Scoring matrices, Distance matrices. • Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; • Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).	15 hours
	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 hours
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Arthur L (2019) Introduction to Bioinformatics. Oxford University Press. 2. Baxevanis A. D., Bader,G.D., Wishart D.S. (2020) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher. 3. Bioinformatics databases and algorithms (2007) N. Gautham. 4. Bioinformatics: A modern approach . (2005) V.R. Srinivas. 5. Bioinformatics:concepts skills and applications (2004).S.C. Rastogi, N. Mendiratta and P. Rastogi. 6. Essential Bioinformatics Paperback – 2007 by Jin Xiong Cambridge University Press; First edition. 7. Ignacimuthus. S. (2013) Basic Bioinformatics Alpha Science International Ltd	

	8. Jonathan Pevsner (2015) Bioinformatics and Functional Genomics. Wiley Blackwell Publication. 9. Perambur S Neelakanta (2020) A Textbook of Bioinformatics: Information-theoretic Perspectives of Bioengineering and Biological Complexes World Scientific Publisher. 10. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant. 11. Xiong J. (2006). Essential Bioinformatics. Cambridge University Press

Course Code	MBPE- 405	
Title of the Course	LAB VI: BIOINFORMATICS	
Credits	2	
Objective:	• The aim is to provide practical training in bioinformatics and statistical methods including accessing major public sequence databases.	
Learning Outcomes	On completion of this course, students should be able to: • describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyse and discuss results in the light of molecular biology knowledge; ▪ explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming; ▪ predict secondary and tertiary structures of protein sequences; • perform and analyze various statistical tools available to analyze the data.	
Prerequisite	MBE 417	
Contents:	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.	30 hrs
	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 hours
Pedagogy	Hands-on experiments in the laboratory, video, online data	
References/Readings	1. Baxevanis A. D., Bader,G.D., Wishart D.S. (2020) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher. 2. Even W., and Grant G., (2005) Statistical methods in Bioinformatics: An introduction. (2005). 3. Jones, N.C., and Pevzner, P.A., (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India. 4. Mount D.W., (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press. 5. Shui Qing S., (2007) Bioinformatics: A Practical Approach (Chapman & Hall/CRC Mathematical and Computational Biology)	

Course code	MBTE-406

Title of the course	NANOBIOTECHNOLOGY	
Credits	2	
Objective:	• Providing a general and broad introduction to the multi-disciplinary field of nanotechnology.	
Learning Outcomes	• Students should be able to describe the basic science behind the properties of materials at a nanometre scale.	
Contents:	**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.	15 hours

	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 hours
Pedagogy:	Lectures/ tutorials/assignments	
References/Readings	1. Chittaranjan K., Kumar, D. S., Khodakovskaya, M. V (2016) Plant Nanotechnology Principles and Practices. Springer 2. GeroDecher, J., Schlenoff. B., (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag 3. Goodsell D. S., (2004); Bionanotechnology: Lessons from Nature, Wiley-Liss 4. Grey T. H., (2013); Bioconjugate Techniques, Elsevier 5. Kuno, M., (2012) Introductory Nanoscience, Physical and Chemical Concepts. Garland Science 6. Malsch, N.H. (2005). Biomedical Nanotechnology, CRC Press 7. Ramsden.J.J., (2012) Nanotechnology. An Introduction. Elsevier Amsterdam. 8. Sanmugam, S., (2011). Nanotechnology. MJP publisher	

Course Code	MBTE-407
Title	VACCINE TECHNOLOGY
Credits	2
Prerequisite	MBTC-402
Objectives	• To understand the conventional to the latest technology in vaccine production.

	• To understand the immunological effect and strategies for vaccine design.	
Learning outcomes	• Understanding of vaccine design and strategies for vaccine delivery. • Understand the significance of adjuvant, immunogens, and other ingredients for developing an effective vaccine	
Contents	<u>Module I</u> • 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. • Physical method of gene delivery: tattooing, gene gun, electroporation, ultrasound, and laser • Maternal Immunization	15 hours
	<u>Module II</u>	

	• 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 hours
Pedagogy	Lectures/tutorials/assignments	
References/Reading	1) Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009. 2) Ellis R.W.,(2001) "New Vaccine Technologies", Landes Bioscience. 3) Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub. 4) Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.	

	5) Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH. 6) Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman. 7) Male, David, et al., (2007) “Immunology”, Mosby Publication.