GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

REVISED MINUTES

of the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

Saturday, 30th July, 2022

Time

10.00 a.m.

Council Hall
Goa University

	Council. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.29	**Minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022.** The Academic Council approved the minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022 with the following suggestions: 1. The Course Codes for the PG programme to be revised/Changed. 2. Minimum two optional courses to be offered. Four credits of optional courses shall be added in semester I and two credits in semester II. 3. Prerequisites for the Course to be added. 4. Course objectives to be included. 5. The Chairperson, Board of Studies was requested to resubmit the syllabus incorporating the suggestions and thereafter the Vice-Chancellor was authorized to approve the same on behalf of the Academic Council. 6. The proposed syllabus/Structure for M.Sc. Biotechnology and M.Sc. Marine Biotechnology of Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.30	**Minutes of the Board of Studies in Food Technology meeting held on 27.07.2022.** The Academic Council approved the minutes of the Board of Studies in Food Technology meeting held on 27.07.2022 with the following suggestions: 1. The word '&' used in the Course Code of the Programme to be removed/deleted. 2. The Course Codes for the Programme to be revised/Changed. 3. Programme structure to be changed. 4. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.31	**Minutes of the Board of Studies in Zoology meeting held on 26.07.2022.** The Academic Council approved the minutes of the Board of Studies in Zoology meeting held on 26.07.2022 with the following suggestions: 1. Number of credits for the course should be checked. 2. The Course codes and the Hours to be clearly mentioned/formatted. 3. The proposed syllabus/structure for Semester III and Semester IV was deferred by the house. **(Action: Assistant Registrar Academic – PG)**
D 3.32	**Minutes of the Board of Studies in PGDCG & MLT meeting held on 26.07.2022.** **(Item Withdrawn)** **(Action: Assistant Registrar Academic – PG)**
D 3.33	**Minutes of the Board of Studies in Marathi meeting held on 27.07.2022.** The Academic Council approved the minutes of the Board of Studies in Marathi meeting held on 27.07.2022 with the following suggestions: 1. The Chairperson, Board of Studies was requested not to indicate the titles of the

X AC- 9 (Special)
30.07.2022

GOA UNIVERSITY
Taleigao Plateau, Goa 403 206

F I N A L U P D A T E D A G E N D A

For the 9th Special Meeting of the

X ACADEMIC COUNCIL

Day & Date

30th July, 2022

Time

10.00 a.m.

Venue
Conference Hall
Administration Block

	1. **Upgradation of M. Sc Botany Syllabus from 64 to 80 credits and increasing the contact hours from 12 to 15 hours per credit.** 2. **Introduction of TWO new Discipline Specific Optional Courses for M. Sc. Botany Semester I & Semester II.** 3. **Updated the Course Codes of M.Sc. Botany programme.** 4. **Updated the master panel of the examiners of UG Botany programme.** 5. **Updated the model question paper marking scheme of paper BOC-109 Molecular Biology and Genetic Engineering.** ii. The declaration by the Chairman, that the minutes were read out by the Chairman at the meeting itself. Date: 27.07.2022 Sd/- Place: Goa University Signature of the Chairman **Part G**. The Remarks of the Dean of the Faculty i) The minutes are in order. ii) The minutes may be placed before the Academic Council with remarks if any. iii)May be recommended for approval of Academic Council. iv)Special remarks if any. Date: 27.07.2022 Sd/- Place Goa University Signature of the Dean **(Back to Index)**
D 3.29	**Minutes of the Board of Studies in Biotechnology meeting held on 20th May 2022.** **Part A.** **i.** Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level**: N.A.** **ii.** Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: **Reviewing the syllabus of M.Sc. Marine Biotechnology and M.Sc. Biotechnology for 80 credits.** **Part B** i. Scheme of Examinations at undergraduate level**: N.A.** ii. Panel of examiners for different examinations at the undergraduate level: **: N.A.** iii. Scheme of Examinations at postgraduate level: **: N.A.** iv. Panel of examiners for different examinations at post-graduate level: **N.A.** **Part C.** i. Recommendations regarding preparation and publication of selection of reading material in the subject or group of subjects and the names of the persons recommended for appointment to make the selection**: N.A.** **Part D** i. Recommendation regarding general academic requirements in the Departments of University or affiliated colleges. **: N.A.**

ii. Recommendations of the Academic Audit Committee and status thereof: **: N.A.**

Part E.

i. Recommendations of the text books for the course of study at undergraduate level: **: N.A.**

ii. Recommendations of the text books for the course of study at post graduate level: **Updated list of text books for First and Second Semester of M.Sc. Biotechnology and M.Sc .Marine Biotechnology proposed.**

Part F.

Important points for consideration/ approval of Academic Council

i) The important points/recommendations of BoS that require consideration/approval of Academic Council (points to be highlighted) as mentioned below

M.Sc. Zoology
Programme

1. **First and Second Semester courses (Theory and Practicals) for M.Sc. Biotechnology (Annexure-I 1023) and M.Sc. Marine Biotechnology (Annexure-II 1053) programs.**

2. **Scheme of courses for Third and Fourth Semester for M.Sc. Biotechnology (Annexure-I) and M.Sc. Marine Biotechnology (Annexure II) programs.**
   The declaration by the chairman that the minutes were readout by the Chairman at the meeting itself.

Date:27.07.2022
Place: Goa University

Sd/-
Signature of the Chairman

Part G. The Remarks of the Dean of School of Biological Sciences & Biotechnology

i) The minutes are in order.
ii) The minutes may be placed before the Academic Council with remarks if any.
iii) May be recommended for approval of Academic Council.
iv) Special remarks if any.

Date:27.07.2022
Place. Goa University.

Sd/-
Signature of the Dean

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D 3.30

Minutes of the Board of Studies in Food Technology meeting held on 27.07.2022.

Part A.

i. Recommendations regarding courses of study in the subject or group of subjects at the undergraduate level: NA

ii. Recommendations regarding courses of study in the subject or group of subjects at the postgraduate level: MSc. In Food Technology Syllabus attached as **Annexure I refer page no.1085**

Part B

i)Scheme of Examinations at undergraduate level: NA

ii)Panel of examiners for different examinations at the undergraduate level: NA

D 3.29 Minutes of the Board of studies in Biotechnology meeting held on 20th May 2022.

Annexure I

Proposed M.Sc. Biotechnology Proposed Scheme

M.Sc. Biotechnology 2022-23

Course Code	Courses		
SEMESTER I			
	Course Title	**Credits**	**Course Level**
GBC 181	Microbiology	3	100
GBO 182	Concepts in Biochemistry	2	100
GBC 183	Biophysical Principles & Analytical Techniques	2	100
GBC 184	Immunology	3	100
GBO 185	Biostatistics	2	100
GBC 186	Lab I: Techniques in Microbiology.	3	100
GBC 187	Lab II : Immunology	2	100
GBC188	LAB III: Biochemical and analytical techniques	3	100
	Total	20	
Semester II			
GBC 189	Environmental Biotechnology	3	100
GBC 190	Stem Cell Biology and regenerative medicine	1	
GBC 191	Genetics and Molecular Biology	3	100
GBC 192	Cell and Developmental Biology	3	100
GBO 193	Bioinformatics	2	200
GBO194	Bio entrepreneurship	2	100
GBC 195	Lab IV: Genetics and Molecular Biology	2	
GBC 196	Lab V: Plant and Animal Tissue Culture	2	100
GBO 197	Lab VI: Lab in Bioinformatics	2	100
Semester III			
GBRO 198	Recombinant DNA Technology	3	300
GBRO 199	Bioprocess Technology	3	300
GBOG 200	Waste Management	3	300
GBOG 201	IPR, Biosafety & Bioethics	3	100
GBOG 202	Food Technology	2	200
GBOG 203	Virology	2	200
GBOG 204	Lab in Bioprocess technology	2	300
GBRO 205	Lab VII: Lab in Recombinant DNA Technology	2	300
Semester IV			
GBOG 206	Research-based specialization	1	200
GBOG 207	Scuba Diving	2	200
GBSD 208	Dissertation	16	400

GBOG 209	Field trip	1	200
Optional Generic Course			
	Bio entrepreneurship	2	100
	Genomics & Proteomics	2	200
	Plant and Animal Biotechnology	2	300
	Emerging trends in wastewater treatment	1	200
	Solid waste Management	3	200
	Nanotechnology	2	100
	Lab in Environmental Biotechnology	3	100

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

GBC : Marine Biotechnology-specific core course.
GBO : Marine Biotechnology specific-optional course
GBOG: Marine Biotechnology-optional generic course
GBRO: Marine Biotechnology research-specific optional course
GBSD: Marine Biotechnology-specific dissertation

SEMESTER- I

Course Code: GBC-181
Title of the Course: Microbiology
Number of Credits: 3

Objective:	The objective of this course is to provide information about the types of microbes, nutrition, and general characteristics	
Learning Outcomes	After completing this course, students should be able to- 1. explain the principle features of marine ecosystems and the microbial diversity in oceans; 2. describe and discuss marine microbes in terms of physiological capability and their biogeochemical role.	
Contents:	**MODULE I** • A brief history of microbiology: discovery of the microbial world, controversy over spontaneous generation, the role of microorganisms in the causation of disease, development of pure enrichment culture methods. • Modern /contemporary microbiology in the 21st century • An overview of the organization and cell structure of Prokaryotes and Archaea: i) cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups. **MODULE II** ● 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. ● Microbial taxonomy: i) nomenclature ii) polyphasic identification, traditional & molecular, iii) Bergey's manual. **MODULE III** i) Structure & classification. ● Algae ● Fungi ● Cyanobacteria ● Bacteria	15 hours 15 hours 15 hours

	● Viruses ● Viroids & prions ii) Specialized microorganisms: • Marine microbes •Extremophiles: barophiles, psychrophiles, thermophiles, halophiles, acidophiles • Anaerobes	
References/Readings	1. Tortora, G., Funke B., Case, C., 2018 Microbiology: An Introduction. Pearson. 2. Madigan M., Bender K.M., Buckley D.,Sattley W., Stahl D (2018) Brock Biology of Microorganisms. Pearsons 3. Willey, J., Sherwood, L., Woolverton, C.J., (2016) Prescott's Microbiology. Mcgraw Hill. 4. Harvey, R.A., Cornelisse, C.N., (2012) Lippincott Illustrated Reviews: Microbiology (Lippincott Illustrated Reviews Series) LWW publisher 5. Madigan, M., Martinko & Parker, J (2010). Brock's Biology of microorganisms. Pearson Prentice Hall. 6. G. Reed, Prescott & Dunn , (2004) Industrial Microbiology CBS Publishers . 7. Pelczar M.J., Chan ECS and Krige (2004)Microbiology Tata Macgrw Hill 8. Stanier, R.Y., Ingraham, J.L., (1999) General Microbiology. Palgrave Macmillan 9. Ford T E (1993). Aquatic Microbiology:An ecological approach. Blackwell Scientific Publication. 10. Atlas, R.M. (1989). Microbiology: Fundamentals and Applications. World Cat Publisher 11. G Reed, (1987) Prescott & Dunns Industrial Microbiology. CBS Publishers. 12. Rheinhemer,G, (1980) Aquatic Microbiology Wiley and sons 13. Collins, Granje J., Lyne, P.. M. Falkenheim J., (2004) Microbiology Methods Hodder Arnold Publication.	

Course Code: GBO 182

Title of the course: CONCEPTS IN BIOCHEMISTRY

Number of 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	Gain fundamental knowledge in biochemistry and understand the role of

Outcomes	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 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. **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 15 hours

References/ Reading	1. Murray, R.K. et al (2022). Harper's Illustrated Biochemistry McGraw Hill publisher. 2. Abali E. E., Cline S. D., Franklin D. S., Viselli S. M., (2021) Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher 3. Miesfeld R. L., McEvoy M. M., (2020) Biochemistry. Worldwide publisher 4. Stryer L; Berg J., Tymoczko J., Gatto G. (2019). Biochemistry New York, Freeman publisher. 5. Voet, D., Voet, J.G., Charlotte W.P. (2018). Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher. 6. Papachristodoulou D., Snape A., Elliott W. H., and Elliott D. C. (2018). Biochemistry and Molecular Biology. Oxford University publisher. 7. Nelson D.L. (2017) Lehninger Principles of Biochemistry. W.H. Freeman & Co. 8. Voet, D., Voet, J.G., Charlotte W.P (2012). Principles of Biochemistry. Wiley publisher.	

Course Code: GBC 183

Title of the course: BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES

Number of the 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 basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same. Student is expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.

Learning Outcomes	Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.	
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 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 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,	15 hours 15 hours

	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**	
References/ Reading	1. Subramaniam, M. A (2021) Biophysics: Principle and techniques, MJP Publishers. 2. Bhavna P., Fulekar, M.H (2019), Bioinstrumentation, Wiley Int. 3. Rodney C., (2017). Biophysics: An IntroductionWiley Int. 4. Anders L. et al. (2016) Textbook of Structural Biology. World Scientific. 5. Salman K., and Diaz, Z., (2016) Principal And Techniques of Bioinstrumentation, Intelliz Publisher 6. 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 7. Atkins, de P. (2011) Physical Chemistry for the Life Sciences. W.H. Freeman. 8. Van Holde K. E., Johnson, C. Ho P. S. (2005) Principles of Physical Biochemistry. Prentice Hall. 9. Schulz GE and Schirmer RH, (1998) Principles of Protein Structure, Springer Verlag. 10. Branden C., and Tooze J., (1998) Introduction to Protein Structure, Garland Science. 11. Stout G.H., and Jensen L.H., (1989) X-ray Structure Determination: A practical guide. John Wiley and Sons Inc., New York.	

Course Code: GBC-184
Title of the Course: Immunology
Number of Credits: 3

Objective:	To provide a basic knowledge and to appreciate the components of the human immune response that work together to protect the host. 2) To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity 3) To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immune-deficiencies.

Learning Outcomes	The mode of continuous assessment and formulation of tests enables students to handle competitive entrance exams. The basic overview of Immunology strengthens their foundations for a career in Biotechnology.	
Contents:	**MODULE I – Concepts and Basics** • Introduction – History and scope of immunology • Innate immunity:- factors, features, processes • Acquired:- the Specificity, memory, recognition of self from non-self. • Cells of the immune system: Hematopoiesis and differentiation, Lymphoid and Myeloid lineage, lymphocyte trafficking, B lymphocytes, T lymphocytes, macrophages, dendritic cells, natural killer and lymphokine-activated killer cells, eosinophils and mast cells, lymphocyte subpopulations and CD markers. • Organization of lymphoid organs • MALT, GALT, SALT • Phagocytosis: oxygen-dependant/ 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 **MODULE II – Defence Components: Constituents of immune system and response** • Theories of antibody formation and res • olution of antibody structure • Humoral immunity: cells, antibody formation, primary and secondary response. • Immunoglobulins – structure, distribution and function. • Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics. • The basics of immuno-diagnostics **MODULE III – Defence Strategies and Pitfalls: Effector mechanisms of immune responses** • Complement system: mode of activation, classical, alternate and MBL pathways. Structures of key components.	15 hours 15 hours

	• 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 cytotoxicity. • Hybridoma technology and monoclonal antibodies. • Hypersensitivity: An introduction to the different types. • Introduction to autoimmune diseases.	15 hours
References/Readings	1. Kannan I (2021) Immunology. MJP Publishers. 2. Hardeep Kaur H., Toteja R., Makhija. S., (2021) Textbook of Immunology Wiley Publisher 3. Punt, J., Stranford, S., Jones, P., Owen, J.A., (2018) Kuby Immunology W.H. Freeman 4. Roitt I.M. Delves P.J. Martin S. J., Burton D R, Roitt I.M. (2017) Essential Immunology Wiley-Blackwell 5. Male D., Brostoff J., Roth D., Roitt I., (2013) Immunology. Elsevier Saunders publication. 6. Luttmann W., Bratke K., Kupper M., and Myrtek D (2009). Immunology. Academic Press.	

Course Code: GBO 185
Title of the course: BIOSTATISTICS

Number of Credits: 2

Course Objec	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 Outc	Upon completing this course, students should be able to - • 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.	
Contents:	**MODULE I** 1. Scope of Biostatistics 2. Brief description and tabulation of data and its graphical representation, and frequency distributions. 3. Measures of Central Tendency and dispersion: mean, median, mode, range, standard deviation, variance, coefficient of variation, skewness, kurtosis 4. Displaying data: Histograms, stem and leaf plots, box plots 5. Probability analysis: axiomatic definition, axioms of probability: addition theorem, multiplication rule, conditional probability, and applications in biology.	15 ho
	MODULE II 1. Counting and probability, Bernoulli trials, Binomial distribution, and its applications, 2. Poisson distribution 3. Normal distribution, z, t, and chi-square tests, levels of significance 4. Testing of hypotheses: null and alternative hypotheses, Type I and Type II errors 5. Simple linear regression and correlation 6. Analysis of variance	15 ho
References/ Reading	1. Mahajan B.K., (2018), Methods in Biostatistics: for Medical Students and Research Worker. Jaype Brothers, 2. Samuels, JA Witmer (2016) Statistics for the Life Sciences. Prentice Hall	

	3. Kothari, C. R.,(2013) Quantitative Techniques, Vikas Publishing House. 4. Rao K. Surya (2010), Biostatistics for Health and Life Sciences, Himalaya Publishing House. 5. Rastogi, V. B. (2009). Fundamentals of Biostatistics. Ane Books Pvt Ltd. 6. Arora P.N. and Malhan, P.K. (2006), Biostatistics. Himalaya Publishing House.

Course Code:GBC 186
Title of the Course: Lab I: Techniques in Microbiology
Number of Credits: 3

Objective:	This course involves learning techniques to culture microbes in the lab to form the basis for application in microbiological research studies.	
Learning Outcomes	Key hands-on experience of converting and applying theoretical knowledge to laboratory. Application of the varied interactions /reactions to be utilized in research. Students become familiar with microbiology techniques that are used in many scientific disciplines as well as clinical medicine.	
Contents:	1. Sterilization and disinfection. 2. Preparation of solid & liquid media: 3. Isolation and maintenance of organisms: Streaking, slants and stabs cultures, storage of microorganisms. 4. Differential and Selective media 5. Enumeration: serial dilution methods, plating. 6. Isolation of bacteria from seawater /sediments samples 7. Study of morphology and cultural characteristics 8. Biochemical tests for identification of bacteria. a. Sugar utilization test (minimal medium + sugar) b. Sugar fermentation test c. IMViC d. Enzyme detection – Gelatinase, Catalase, Oxidase e. Oxidative-fermentative test 9. Bacteriological tests for potability of water a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration)	30 hours

	11. Staining methods:- Gram staining, Endospore staining, Metachromatic granules, Cell wall staining 12. Motility in bacteria using: Hanging drop method and swarming growth method. 13. Antimicrobial sensitivity tests : Agar cup and Disc Diffusion methods 14. Drug resistance: comparative studies of different drugs/ disinfectants 15. Cultivation of fungi: a.Slide b. chunk c. coverslip techniques d. Wet mounts of fungal cultures	30 hours
References/Readings	1. Giltner W. (2017) Laboratory Manual in General Microbiology Creative Media Partners, LLC 2. Harrigan W. F., McCance M E (2014). Laboratory Methods in Microbiology Academic Press 3. Karwa A.S.. Rai M.K, Singh H.B (2012). Handbook of Techniques in Microbiology: A Laboratory Guide to Microbes Scientific Publishers	

Course Code: GBC 187
Title of the Course: Lab II: Techniques in Immunology
Number of Credits: 2

Objective:	This course involves learning techniques to culture microbes and to identify immune reactions in the lab to form the basis for application in immunodiagnostics.
Learning Outcomes	Key hands-on experience of converting and applying theoretical knowledge to laboratory. Application of the varied interactions /reactions to be utilized in research. Students become familiar with immunologic techniques that are used in clinical medicine as well as immunology research laboratories.

Contents:	• Determination of Antibody titer using Double Immuno-diffusion assay • Assessment of Similarity between antigens using Ouchterlony's Double diffusion Test • Estimation Of Antigen Concentration using Radial Immuno Diffusion • Quantitative Precipitation Assay	30 hours
	• DOT ELISA • Latex Agglutination • Immunoelectrophoresis • Rocket Immunoelectrophoresis • Slide / Tube agglutination Tests.	30 hrs
References/Readings	1. Talwar G.P Gupta S.K (2017) A Handbook of Practical And Clinical Immunology Vol I CBS Publishers 2. Detrick B., Hamilton R.G., Folds J.D. (2016) Manual of Molecular and Clinical Laboratory Immunology (2016) ASM Press. 3. Detrick B., Hamilton R.G.; Folds J.D. (2016) Manual of Molecular and Clinical Laboratory Immunology ASM Press. 4. Joshi, K.R., Osama, N.O. (2012) Immunology, Agrobios Ltd, India. 5. Hay, F.C &, O.M.R. Westwood. (2008) Practical Immunology Oxford University Press 6. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2001) Immunobiology: The 7. Hay F.C., Westwood. O.M.R., (2008) Practical Immunology (2008) Wiley BlackWell Publishers Immune System in Health and Disease, Garland Publishing, USA.	

Course code: GBC 188
Title of the course: LAB III - BIOCHEMICAL & ANALYTICAL TECHNIQUES
Number of credits: 3

Course Object	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 Outcc	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 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	30 hou 30 hrs

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

SEMESTER II

Title of the Course: Environmental Biotechnology
Course Code: GBC 189
Number of Credits: 03

Objective:	The objective of this course is to impart knowledge on biotechnological applications that can be used to tackle environmental issues emerging due to industrialization and globalization.	
Learning outcomes	At the end of this course, students will be able to apply their knowledge for the application of biotechnological processes for betterment of environment and sustainable development of the society.	
Contents:	**Module 1:**	

	Introduction to environmental biotechnology: Basic concept of environment and its components. Biotechnology for environment; definitions and facts. **Environment pollution:** Sources of pollution and their environmental impact. Hazardous wastes: Definition, sources and characteristics, categorization, generation, collection, transport, treatment and disposal. Municipal solid wastes: Collection, segregation and transport of solid wastes, handling and segregation of wastes at source. **Monitoring environmental pollution:** Air, water and soil sampling, Analyses of samples. Physical, chemical, biological and molecular methods for the measurement of pollution. Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, CRISPR–Cas technology, and cellular models). Nucleic acid based techniques for analyses of diversity, structure and dynamics of microbial community in wastewater treatment, Concept of biomarkers. Environmental impact assessment, Biodiversity and its conservation. **Module II** **Waste Water Treatment systems:** primary, secondary and tertiary treatments; Biological Treatment Processes, Biochemistry and Microbiology of Aerobic and Anaerobic Treatment, Bioreactors for waste water treatment, Disinfection and Disposal, Macrophytes in water treatment, treatment using constructed wetlands. **Treatment of Typical Industrial Effluents:** Dairy, Distillery, Sugar, and Antibiotic Industries. **Solid waste management:** Treatment of municipal, biomedical and agricultural solid waste. Biochemical processes and advanced methods: Methane generation by anaerobic digestion, composting, Vermicomposting, Biofertilizers. 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)). **Module III:** **Resource management and environment conservation:**	15 hours 15 hours

	Basic concept of saving of resources and energy through biotechnology; Prevention of eutrophication using macroalgae; biological control of mosquitos. **Bioresource technology for clean environment:** Integrated waste management: Biomass (wood waste, agricultural waste, municipal solid waste, manufacturing waste, and Sewage sludge) as source of energy and bio-fuels. Microalgae as a source for Biodiesel. Biodegradable plastic. **Environmental Pollution control**: concepts of bioremediation, bioaugmentation, biostimulation, biodegradation, biosorption, Bio-mineralization.	15 hours
References/ Readings	1. Meena, S. M. and Naik, M. M. (Ed.). (2019). Advances in Biological Science Research: a practical app. Elsevier. 2. King, R. B., Sheldon, J. K., and Long, G. M. (2019).Practical Environmental Bioremediation: The Field Guide, Lewis Publishers. CRC Press. 3. Willey, J. M., Sherwood, L. M., Woolverton, C. J. (2017). Prescott,s Microbiology. Mcgraw-Hill Education. 4. Satyanarayana, T. Johri, B. and Anil, T. (Ed.). (2012). Microorganisms in Environmental Management. Springer Publishers. 5. Colin, M. (2011). Marine Microbiology: Ecology and applications. Second edition. Garland science. 6. Scragg, A. (2005). Environmental Biotechnology. Pearson Education Limited, Oxford University Press. 7. Chaterjee, A. K. (2000). Introduction to environmental biotechnology. PHI, India, 8. Rehm, H. J. and Reed, G. (Eds.). (1999). Biotechnology, a comprehensive treatise.	

Title of the Course: Stem Cell Biology and Regenerative medicine
Course Code: GBC190
Number of Credits: 01

Prerequisites	Basic understanding of cell biology - cell types, growth media, cell division, cell growth, cell differentiation.
Objective:	The aim of the course is to bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells to a coherent picture in an experimental and clinical context.

Contents:	**MODULE I** Definition,stem cell origins and plasticity,classification and source of stem cells; Stem cell differentiation; Stem cells cryopreservation, iPS technology; microRNAs and stem cell regulation, Tumor stem cells, Overview of embryonic and adult stem cells for therapy. Human stem cells research: Ethical considerations; Stem cell based therapies: Pre-clinical regulatory consideration and patient advocacy.	15 hours
References/Readings	1. John Collins, (2017)Stem cells: From basic to advanced principles,. Hayle Medical 2. Robert lanza, (2013) Essential of Stem cell Biology, Elsevier publisher. 3. Robert lanza, (2011), Principle of Tissue Engineering, AP publisher 4. Robert Lanza (2009) Essential stem cell methods, Elsevier. 5. Robert Lanza (2006) Essential of Stem Cell Biology, Academic Press. 6. A.D. Ho. R. Hoffman, (2006) Stem Cell Transplantation Biology Process Therapy, Willy-VCH	
Learning Outcomes	On completion of the course, students should be aware of basics of stem cell function in the body and their usage in the medical context.	

Course Code: GBC 191
Title of the Course: Genetics and Molecular biology
Number of Credits: 3

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.	15 hours

	• 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 **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. **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 15 hours

References/Reading	1. Clark DP. Pazdernik, NJ., McGehee, MR. (2019) Molecular Biology (3 rd) Elsevier Inc 2. Klug, W., Cummings, M, Spencer.C . (2019) Concepts of Genetics (12ed). Pearson publishers 3. Goldstein ES. , Stephen T. Kilpatrick J Krebs J. (2017) Lewin's GENES XII . Bartlett Publishers 4. Lodish HF; Berk A ; Kaiser C ; Krieger M ; Bretscher A . (2016). Molecular Cell Biology (8 ed) Freeman MacMillan publisher 5. Russell PJ, iGenetics: A Molecular Approach. (2016) (3 ed) Pearson publisher. 6. Karp G.,Iwasa J., Marshall W., (2016) Karp's Cell and Molecular Biology: Concepts and Experiments, (8 ed) Wiley Publisher 7. Strickberger, M. (2015) Genetics, (3 ed) by Pearson publishers 8. Simmons M J., Snustad P. (2015). Principles of Genetics (7 ed). Wiley Student Edition. 9. Watson JD, Baker TA, Bell SP, Gann A, Levine M & Losick R (2014) Molecular Biology of the Gene, (7 ed), Cold Spring Harbor Laboratory Press, New York 10. Weaver RF (2012) Molecular Biology (5th ed) McGraw Hill Higher Education publisher.

Course Code: MBC 192
Title of the course: CELL AND DEVELOPMENTAL BIOLOGY
Number of 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,	15 hours

	metamorphosis; environmental regulation of normal development; sex determination.	
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:GBO-282
Title of the Course: Bioinformatics
Number of Credits:2

Objective:	The objectives of this course are to provide students with theory and practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts	
Learning Outcomes	Student should be able to: • develop an understanding of basic theory of these computational tools. • gain working knowledge of these computational tools and methods. • appreciate their relevance for investigating specific contemporary biological questions.	
Contents:	**MODULE I**	

	• Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • Evolutionary basis of sequence alignment, optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, • Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle; Scoring matrices, Distance matrices. • Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; • Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD). **MODULE II** • 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields *etc.* Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like 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	15 hours

	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
References/Readings	1. Perambur S Neelakanta (2020) A Textbook of Bioinformatics: Information-theoretic Perspectives of Bioengineering and Biological Complexes World Scientific Publisher. 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. Arthur L (2019) Introduction to Bioinformatics. Oxford University Press. 4. Jonathan Pevsner (2015) Bioinformatics and Functional Genomics. Wiley Blackwell Publication. 5. Ignacimuthus. S. (2013) Basic Bioinformatics Alpha Science International Ltd 6. Essential Bioinformatics Paperback – 2007 by Jin Xiong Cambridge University Press; First edition. 7. Bioinformatics databases and algorithms (2007) N. Gautham. 8. Xiong J. (2006). Essential Bioinformatics. Cambridge University Press 9. Bioinformatics: A modern approach . (2005) V.R. Srinivas. 10. Bioinformatics:concepts skills and applications (2004).S.C. Rastogi, N. Mendiratta and P. Rastogi. 11. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant.	

Title of the Course: Bioentrepreneurship

Course Code: **GBO194**

Number of Credits: 02

Objective:	Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with an understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.	
Learning outcomes	Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify the scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.	
Contents:	**Module I.** Fundamentals of Entrepreneurship. Mission, vision, entrepreneurial qualities. How to innovate, Design Thinking, Design-Driven Innovation, Systems thinking, Open innovation, How to start a start-up? Statutory and legal requirements for starting a company/venture (IPR, GST, Labor law), E business setup, management. Dos & Donts in entrepreneurship. **Business plan:** Making a business proposal/Plan for seeking loans from financial institution and Banks; Approach a bank for a loan; Sources of financial assistance; Funds from bank for capital expenditure and for working. Funding new ventures – bootstrapping, crowd sourcing, Angel investors, VCs, debt financing, and due diligence, Incubation and acceleration, Government incentives for entrepreneurship. Budget planning and cash flow management; Negotiations/Strategy With financiers, bankers etc.; Profit & Loss statement, Balance sheet, Cash flow, Cost-volume-profit & Bread-Even analysis, Capital budgeting. **Module II** **Marketing management:** Assessment of market demand for potential product(s) of interest; Market conditions, segments; Prediction of market changes; Identifying needs of customers including gaps in the	15 hours 15 hours

	market, packaging the product; Market linkages, branding issues; Developing distribution channels; Pricing/Policies/Competition; Promotion/ Advertising; Services Marketing Dispute resolution skills **Human Resource management in startups:** Human Resource Development (HRD) Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up. External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking.	
Reference Books	1. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing 2. Companies: Creating Value and Competitive Advantage with the Milestone Bridge.Routledge. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 3. Ramsey David (2011). Entre Leadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books 4. Byrne John A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin 5. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House. 6. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion. 7. Lynn Jacquelyn (2007). The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc.	

Title of the Course: Lab IV Genetics and Molecular Biology
Course Code: GBC 195

Number of Credits: 02

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.	30 hours

	3. Phage infection and burst size; types of plaque formation 4. Transduction 5. Genetic Transfer-Conjugation, gene mapping. 6. Genomic DNA isolation 7. DNA quantification and gel electrophoresis 8. RNA isolation 9. RNA denaturing gel electrophoresis. 10. Mitosis. 11. Meiosis	30 hours
References/Readings	1. Sharma R.K., Sangha S.P.S (2020) Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press. 2. Gakhar S.K., Miglani M., Kumar A., (2019) Molecular Biology: A Laboratory Manual. Rupa Publications. 3. Hofmann A. (2018) Wilson and Walkers Principles And Techniques Of Biochemistry And Molecular Biology. Cambridge University Press 4. Green R. , Sambrook J. (2012) Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set 5. Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN Vennison PHI Learning	

Course Code: GBC-196

Title of the Course: Lab V-Plant and Animal Tissue Culture

Number of 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.): Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, contamination and precautions 2. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell lines HEK293, COS-7 3. Transfection and co-transfection: Calcium-phosphate method and Lipofection 4. 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
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: GBO-197
Title of the Course: Lab VI- Bioinformatics
Number of 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 analyse various statistical tools available to analyse the data.	
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. 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 and annotation 13. 16S rRNA sequence analysis and use of BioEdit 14. Molecular docking	30 hours 30 hours
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. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins, John Wiley and Sons. 3. D.W. Mount, (2001), Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press. 4. Jones & Peuzner, (2004); Introduction to Bioinformatics Algorithms; Ane Books, India. 5. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant 6. Bioinformatics: A Practical Approach 2007 Shui Qing (Chapman & Hall/CRC Mathematical and Computational Biology)	

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Annexure II

Proposed Scheme For

M.Sc. Marine Biotechnology

(Applicable from 2022-23)

Course Codes	Courses		
SEMESTER I			
	Course Titles	**Credits**	**Course Level**

MBC 181	Marine Microbiology & Ecology	3	100
MBO 182	Concepts in Biochemistry	2	100
MBC 183	Biophysical Principles & Analytical Techniques	2	100
MBC 184	Immunology and Marine pathogenesis	3	100
MBO 185	Biostatistics	2	100
MBC 186	Lab I: Techniques in Microbiology and Marine Biology and Chemistry	3	100
MBC 187	Lab II : Immunology & Marine Pathogenesis	2	100
MBC188	LAB III: Biochemistry and analytical techniques	3	100
	Total	20	
Semester II			
MBC 189	Oceanography and Marine Bioresources	3	100
MBC 190	Aquaculture Technology	3	200
MBC 191	Genetics and Molecular Biology	3	100
MBC 192	Cell and Developmental Biology	3	100
MBO 193	Bioinformatics	2	200
MBC 195	Lab IV: Genetics and Molecular Biology	2	200
MBC 196	Lab V: Plant and Animal Tissue Culture	2	100
MBO 197	Lab VI: Lab in Bioinformatics	2	200
Semester III			
MBRO 198	Recombinant DNA Technology	3	300
MBR0 199	Bioprocess Technology and Marine Bioprocessing	3	300
MBOG 200	Potential of Marine Biotechnology	3	300
MBOG 201	IPR, Biosafety & Bioethics	3	100
MBOG 202	Marine Food Technology	2	200
MBOG 203	Virology	2	200
MBOG 204	Lab in Bioprocess technology and marine bioprocessing	2	300
MBRO 204	Lab VII: Lab in Recombinant DNA Technology	2	300
Semester IV			
MBOG 206	Research-based specialization	1	200
MBOG 207	Scuba Diving	2	200
MBSD 208	Dissertation	16	400
MROG 209	Summer/ Winter Training Assessment	1	200
Optional Generic Course			
	Bio entrepreneurship	2	100
	Stem Cell Biology	1	200
	Genomics & Proteomics	2	200
	Plant and Animal Biotechnology	2	300
	Emerging trends in wastewater treatment	2	200
	Solid waste Management	2	200
	Nanotechnology	2	200

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

MBC : Marine Biotechnology-specific core course.
MBO : Marine Biotechnology specific-optional course
MBOG: Marine Biotechnology-optional generic course
MBRO: Marine Biotechnology research-specific optional course
MBSD: Marine Biotechnology-specific dissertation

SEMESTER- I

Course Code: MBC 181

Title of the Course: MARINE MICROBIOLOGY & ECOLOGY

Number of 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 principle features of marine ecosystems and the microbial diversity in oceans; • Describe and discuss marine microbes in terms of physiological capability and their biogeochemical role.

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
References/	1. Munn, C.B., (2020) Marine Microbiology: Ecology and Applications. CRC	

Reading	Press 2. Kirchman, D.L, Gasol, J.M., (2018), Microbial ecology of the Oceans. Wiley-Blackwell, New York. 3. Paul, J., (2001) Methods in Microbiology: Marine microbiology, Academic Press. 4. Gram, L., (2009) Microbial Spoilage of Fish and Seafood, Springer 5. Pelczar M.J. Jr., Chan E.C.S. and Kreig N.R. (2001) Microbiology. CBS Publishers. 6. Surajit D., Hirak Ranjan D., (2018) Microbial Diversity in the Genomic Era, Elsevier 7. Horikoshi K., Antranikian G., Bull A. T, Robb F. T. and Stetter, K. O., (2011) Extremophiles handbook, Springer 8. Madigan. M.T., Buckley, D.H., Sattley, W.M., Stahl, D.A.(2021) Brock Biology of Microorganisms, Pearson Publisher.

Course Code: MBO 182

Title of the course: CONCEPTS IN BIOCHEMISTRY

Number of 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
References/ Reading	1. Murray, R.K. et al (2022). Harper's Illustrated Biochemistry McGraw Hill publisher. 2. Abali E. E., Cline S. D., Franklin D. S., Viselli S. M., (2021) Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher 3. Miesfeld R. L., McEvoy M. M., (2020) Biochemistry. Worldwide publisher 4. Stryer L; Berg J., Tymoczko J., Gatto G. (2019). Biochemistry New York, Freeman publisher. 5. Voet, D., Voet, J.G., Charlotte W.P. (2018). Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher. 6. Papachristodoulou D., Snape A., Elliott W. H., and Elliott D. C. (2018).	

	Biochemistry and Molecular Biology. Oxford University publisher. 7. Nelson D.L. (2017) Lehninger Principles of Biochemistry. W.H. Freeman & Co. 8. Voet, D., Voet, J.G., Charlotte W.P (2012). Principles of Biochemistry. Wiley publisher.

Course Code: MBC 183
Title of the course: BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES
Number of the 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, • Biochemical and biophysical characterizations of biomolecules: Fluorescence from GFP), UV-VIS absorption and emission spectra resulting from	15 hours

	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
References/ Reading	1. Subramaniam, M. A (2021) Biophysics: Principle and techniques, MJP Publishers. 2. Bhavna P., Fulekar, M.H (2019), Bioinstrumentation, Wiley Int. 3. Rodney C., (2017). Biophysics: An IntroductionWiley Int. 4. Anders L. et al. (2016) Textbook of Structural Biology. World Scientific. 5. Salman K., and Diaz, Z., (2016) Principal And Techniques of Bioinstrumentation, Intelliz Publisher 6. 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 7. Atkins, de P. (2011) Physical Chemistry for the Life Sciences. W.H. Freeman. 8. Van Holde K. E., Johnson, C. Ho P. S. (2005) Principles of Physical Biochemistry. Prentice Hall. 9. Schulz GE and Schirmer RH, (1998) Principles of Protein Structure, Springer Verlag. 10. Branden C., and Tooze J., (1998) Introduction to Protein Structure,	

	Garland Science. 11. Stout G.H., and Jensen L.H., (1989) X-ray Structure Determination: A practical guide. John Wiley and Sons Inc., New York.

Course Code: MBC-184
Title of the Course: Immunology & Marine Pathogenesis
Number of Credits: 3

Course Objectives:	1) To provide a 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 disorder and immune deficiencies. 4) 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.	
Content:	**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 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 **MODULE II – Defence Components: Constituents of immune system and effector mechanisms of immune responses**	15 hours

	• 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. **MODULE III – 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 hours 15 hours
References/ Readings	1. Parthiban F., Felix S. (2018) Microbiology of Fish and Fishery Products, Daya Publishing House. 2. Punt, J., Stranford, S., Jones, P., Owen, J.A.,(2018) Kuby Immunology W.H. Freeman 3. Roitt I.M. Delves P.J. Martin S. J., Burton D R, Roitt I.M. (2017) Essential Immunology Wiley-Blackwell 4. Male D., Brostoff J., Roth D., Roitt I., (2013) Immunology. Elsevier Saunders publication 5. Ward, D.R. and Hackney, C.A., (2012). Microbiology of marine food products. Springer Science 6. Woo, P. T. K., Bruno, D. W (2011). Fish diseases and disorders. Volume 3: viral, bacterial and fungal infections. CABI	

	Publishing. 7. Luttmann W., Bratke K., Kupper M., and Myrtek D (2009). Immunology. Academic Press

Course Code: MBO 185
Title of the course: BIOSTATISTICS

Number of Credits: 2

Course Obj	The objective of this course is to introduce students to statistical methods and to understand principles, as well as practical guidelines of "how to do it" and "how to interpret it" statistical data.	
Learning Ou	Upon completing this course, students should be able to – • 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.	
Conte	**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. **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 hypotheses, Type I and Type II errors • Simple linear regression and correlation • Analysis of variance	15 ho 15 ho
References / Reading	1. Mahajan B.K., (2018), Methods in Biostatistics: for Medical Students and Research Worker. Jaype Brothers, 2. Samuels, JA Witmer (2016) Statistics for the Life Sciences. Prentice Hall 3. Kothari, C. R.,(2013) Quantitative Techniques, Vikas Publishing	

	House. 4. Rao K. Surya (2010), Biostatistics for Health and Life Sciences, Himalaya Publishing House. 5. Rastogi, V. B. (2009). Fundamentals of Biostatistics. Ane Books Pvt Ltd. 6. Arora P.N. and Malhan, P.K. (2006), Biostatistics. Himalaya Publishing House.

Course Code: MBC 187

Title: LAB I -TECHNIQUES IN MICROBIOLOGY, MARINE BIOLOGY AND CHEMISTRY

Number of Credits: 3

Course Obj	To introduce the students to methods to isolate and culture bacteria using different medium, le sampling methods and measure the physical and chemical parameters of the marine aquatic system.	
Learning Ou	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 sea water	
Conter	• Preparation of solid & liquid media, Differential and Selective media: Isolation of bacteria from seawater /sediments samples, Enumeration: serial dilution methods, plating. • Maintenance of organisms: Streaking, slants and stabs cultures • Study of morphology and cultural characteristics. • Gram staining. • Motility • Antimicrobial sensitivity test and demo of drug resistance. • Cultivation of fungi: Slide, chunk and coverslip techniques. • 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.	30 hour 30 hour

References/	1. Sastry, A. (2021). Essentials of Practical Microbiology. India: Jaypee Brothers Medical Publishers Pvt. Limited.Yuncong Li, Kati M., (2019) Water Quality Concepts, Sampling, and Analyses. CRC Press LLC. 2. Sattley, W., Madigan, M., Bender, K., Stahl, D., Buckley, D. (2017). Brock Biology of Microorganism. Pearson Education. 3. Baird R., Eaton A. D., Rice E. W., Bridgewater L. (2017) Standard methods for the examination of water and wastewater. American Public Health Association 4. McCance, M. E., Harrigan, W. F. (2014). Laboratory Methods in Microbiology. Elsevier Science. 5. Leo M.L. Nollet, Leen S. P. Gelder De (2013) Handbook of Water Analysis. CRC Press. 6. Grasshoff K., Kremling K.,Ehrhardt, M., (2009) Methods of Seawater Analysis, Wiley Publisher . 7. Vasanthakumari R., (2009) Practical Microbiology. (2009). India: B.I. Publications Pvt. Limited. 8. Bakus, G. J., Bakus, G. J. (2007). Quantitative Analysis of Marine Biological Communities: Field Biology and Environment. Wiley publisher. 9. Eleftheriou A, and McIntyre A., (2005) Methods for the Study of Marine Benthos.Wiley Publisher. 10. Omori, M., Ikeda, T. (1992). Methods in Marine Zooplankton Ecology. Krieger Publisher

Course Code: MBC 187

Title of the course : LAB VII - IMMUNOLOGY & MARINE PATHOGENESIS

Number of credits: 2

Course Object	This course involves learning techniques to identify reactions in the lab that form the ba application in immunodiagnostics and also to gain an insight into the evaluation mar	
Learning Outcc	Key hands-on experience of converting and applying theoretical knowledge to the laborator become familiar with techniques involved in immunology as well as in the study of marine	
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 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 h 30 h
References/ Re	1. Talwar G.P ., Gupta S.K (2017) A Handbook Of Practical And Clinical Immunology Vol I CBS Publishers. 2. Thanwal. R., (2014) A Handbook of Diseases, Astha Publishers & Distributors. 3. Bullock, G.L.,(2014) Diseases of Fisheries . Narendra Publishing House . 4. Joshi, K.R., Osama, N.O. (2012) Immunology, 5th Edition, Agrobios Ltd, India. 5. Edward J. Noga, (2010). Fish Disease: Diagnosis and treatment, Wiley Blackwell. 6. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2001) Immunobiology: The Immune System in Health and Disease, Garland Publishing, USA. 7. Freshney. I.R., (1998). Culture of Animal Cells. Wiley-Blackwell 8. Inglis, V.,(2013) Bacterial Diseases of Fish , Wiley Publications	

Course code: MBC 188
Title of the course: LAB III - BIOCHEMICAL & ANALYTICAL TECHNIQUES
Number of credits: 3

Course Object	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 Outcc	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:	16. UV-Visible spectroscopic analysis. 17. Estimation of proteins by the Lowry/Bradford's method 18. Estimation of reducing sugars 19. Enzyme assay 20. Ammonium sulfate precipitation and dialysis 21. Specific activity, fold purification, percentage yield of enzyme 22. Protein subunit molecular weight determination by SDS-PAGE. 23. Thin-layer chromatography. 24. Column chromatographic techniques: ion exchange/Affinity/Gel filtration 25. Biochemical assays using ELISA plate reader. 26. Compound and Fluorescence microscopy demonstration 27. Analysis of a biological specimen by SEM 28. Fluorescence imaging of fixed stained and live cells 29. Demonstration of fluorescence spectroscopy. 30. Density gradient ultracentrifugation	30 hou 30 hou

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

SEMESTER II

Title of the Course: Oceanography and Marine Bioresources
Course Code: MBC 189.
Number of Credits: 03

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: 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.	
Contents:	**Module 1: (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 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.	15 hours
	Module 2: (Physical Oceanography) •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	15 hours

	• Plate tectonics, Mid-oceanic ridge spreading and convection **Module 3: (Chemical Oceanography)** • Seawater composition and its properties • 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	15 hours
References/ Readings	1. Beer, T. (2017). Environmental Oceanography. CRC Press Heywood V.H. (1995) Global Biodiversity Assessment. UNEP, Cambridge University Press 2. Trujillo A. P., and Thurman H. V., (2017) Essentials of Oceanography. Pearson Publisher 3. Knauss, J. A., & Garfield, N. (2016). Introduction to physical oceanography. Waveland Press. 4. Pickard, G. L., & Emery, W. J. (2016). Descriptive physical oceanography: an introduction. Elsevier. 5. Bertness, M. D., Bruno, J. F., Silliman, B. R., & Stachowicz, J. J. (Eds.). (2014). Marine community ecology and conservation. Sinauer Associates, Incorporated. 6. Chambers, R. C., & Trippel, E. A. (Eds.). (2012). Early life history and recruitment in fish populations (Vol. 21). Springer Science & Business Media 7. Kortzinger, (2004). The Ocean takes a Breath, Science 306(5700):1337 8. Jeffrey S. Levinton, C. D., (2001). Marine Biology: Function, Biodiversity , Ecology . OUP, USA publication 9. Naskar K. and Mandal R., (1999) Ecology and Biodiversity of Indian Mangroves. Daya Publishers 10. Agarwalk et. al., (1996) Biodiversity and Environment. APH Publishing Corporation,	

Course Code: MBC 190:
Title of the course: AQUACULTURE TECHNOLOGY
Number of Credits: 3

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. 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	15 hours 15 hours

	Breeding: Hypophysation, cryopreservation technique, genetic basis of determination of sex; chromosome manipulation: ploidy induction, sex reversal; gynogenesis and androgenesis; Broodstock management; Application of cross breeding in aquaculture; Selective breeding: qualitative and quantitative traits for selection, methods of selection; Inbreeding and heterosis in various economic characters; hormone induced ovulation; Synthetic hormones for induced breeding- GnRH analogue structure and function. **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 hours
References/ Reading	1. Stickney R.R., Gatlin D., (2022) Aquaculture: An Introductory Text CABI Publishing 2. Krishnaveni, G., and Veeranjaneyulu, K., (2016) RECENT TECHNOLOGIES IN FISH AND FISHERIES Rigi Publications 3. Se-kwon Kim , (2015) Handbook of Marine Biotechnology, Springer 4. Patel, A., and Pathak S.N., (2010) Textbook of Aquaculture. Pacific Book Internationals. 5. Felix,S,(2010) Handbook of Marine and Aquaculture Biotechnology AGROBIOS INDIA. 6. Gautam, N,C, (2007) Aquaculture Biotechnology, Shree Publishers and Distributors 7. Kutty, M.N., and Pillay T.V., (2005) Aquaculture: Principles and Practices (Wiley Blackwell) 8. Stickney, R.R., (2000) Encyclopedia of Aquaculture Wiley InterScience	

Course Code: GBC 191
Title of the Course: Genetics and Molecular biology
Number of 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 **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. **MODULE III**	15 hours 15 hours

	• 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
References/Reading	1. Clark DP. Pazdernik, NJ., McGehee, MR. (2019) Molecular Biology (3 rd) Elsevier Inc 2. Klug, W., Cummings, M, Spencer.C . (2019) Concepts of Genetics (12ed). Pearson publishers 3. Goldstein ES. , Stephen T. Kilpatrick J Krebs J. (2017) Lewin's GENES XII . Bartlett Publishers 4. Lodish HF; Berk A ; Kaiser C ; Krieger M ; Bretscher A . (2016). Molecular Cell Biology (8 ed) Freeman MacMillan publisher 5. Russell PJ, iGenetics: A Molecular Approach. (2016) (3 ed) Pearson publisher. 6. Karp G.,Iwasa J., Marshall W., (2016) Karp's Cell and Molecular Biology: Concepts and Experiments, (8 ed) Wiley Publisher 7. Strickberger, M. (2015) Genetics, (3 ed) by Pearson publishers 8. Simmons M J., Snustad P. (2015). Principles of Genetics (7 ed). Wiley Student Edition. 9. Watson JD, Baker TA, Bell SP, Gann A, Levine M & Losick R (2014) Molecular Biology of the Gene, (7 ed), Cold Spring Harbor Laboratory Press, New York 10. Weaver RF (2012) Molecular Biology (5th ed) McGraw Hill Higher Education publisher.	

Course Code: MBC 192
Title of the course: CELL AND DEVELOPMENTAL BIOLOGY
Number of 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. **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-	15 hours 15 hours

	oncogenes, tumor suppressor genes, metastasis. **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
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:GBO-282 **Title of the Course:** Bioinformatics

Number of Credits:2

Objective:	The objectives of this course are to provide students with theory and practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts	
Learning Outcomes	Students should be able to: • develop an understanding of basic theory of these computational tools. • gain working knowledge of these computational tools and methods. • appreciate their relevance for investigating specific contemporary biological questions	
Contents:	**MODULE I** • Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • Evolutionary basis of sequence alignment, optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, • Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle; Scoring matrices, Distance matrices. • Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; • Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD). **MODULE II**	15 hours

	• 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
References/Readings	1. Perambur S Neelakanta (2020) A Textbook of Bioinformatics: Information-theoretic Perspectives of Bioengineering and Biological Complexes World Scientific Publisher. 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. Arthur L (2019) Introduction to Bioinformatics. Oxford University Press.	

	4. Jonathan Pevsner (2015) Bioinformatics and Functional Genomics. Wiley Blackwell Publication. 5. Ignacimuthus. S. (2013) Basic Bioinformatics Alpha Science International Ltd 6. Essential Bioinformatics Paperback – 2007 by Jin Xiong Cambridge University Press; First edition. 7. Bioinformatics databases and algorithms (2007) N. Gautham. 8. Xiong J. (2006). Essential Bioinformatics. Cambridge University Press 9. Bioinformatics: A modern approach . (2005) V.R. Srinivas. 10. Bioinformatics:concepts skills and applications (2004).S.C. Rastogi, N. Mendiratta and P. Rastogi. 11. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant.	

Title of the Course: Lab IV Genetics and Molecular Biology
Course Code: MBC 194

Number of Credits: 02

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.	
Content:	7. UV/Chemical mutagenesis and survival curve. 8. Isolation of amino acid auxotroph by replica plating. 9. Phage infection and burst size; types of plaque formation 10. Transduction 11. Genetic Transfer-Conjugation, gene mapping. 12. Genomic DNA isolation 13. DNA quantification and gel electrophoresis 14. RNA isolation 15. RNA denaturing gel electrophoresis. 16. Mitosis. 17. Meiosis	30 hrs 30 hrs
References/Readings	1. Sharma R.K., Sangha S.P.S (2020) Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press. 2. Gakhar S.K., Miglani M., Kumar A., (2019) Molecular Biology: A Laboratory Manual. Rupa Publications.	

	3. Hofmann A. (2018) Wilson and Walkers Principles And Techniques Of Biochemistry And Molecular Biology. Cambridge University Press 4. Green R. , Sambrook J. (2012) Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set 5. Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN Vennison PHI Learning	

Course Code: MBC-195

Title of the Course: Lab V Cell and Tissue Culture

Number of 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

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: MBO-196
Title of the Course: Lab VI- Bioinformatics
Number of 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 analyse various statistical tools available to analyse the data.	
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. 9. Use of different protein structure prediction databases (PDB, SCOP, CATH). 10. Construction and study of protein structures using RASMOL/Deepview/PyMol.	30 hrs

	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
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. A.D. Baxevanis and B.F.F. Ouellette (Eds). (2002), *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*, John Wiley and Sons. 3. D.W. Mount, (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press. 4. Jones & Peuzner, (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India. 5. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant 6. Bioinformatics: A Practical Approach 2007 Shui Qing (Chapman & Hall/CRC Mathematical and Computational Biology)	

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