गोंय विद्यापीठ
ताळगांव पठार
गोंय - ४०३ २०६
फोन: +९१-८६६९६०९०४८

Goa University
Taleigao Plateau, Goa - 403 206
Tel : +91-8669609048
Email : registrar@unigoa.ac.in
Website: www.unigoa.ac.in

(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/91/1 Date:31.05.2023

Ref : GU/Acad –PG/BoS -NEP/2022/339/17 dated 18.08.2022

CIRCULAR

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

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

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.05.31 11:05:33 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

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

Copy to:

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

Goa University

ANNEXURE I

M.Sc. Biotechnology

Preamble

The M.Sc. Biotechnology was started at Goa University in 2013 with the objective of developing manpower in the field of Biotechnology. The students are imparted training and skills and empowering them to undertake the challenges in the field of Biotechnology.

The eligibility for the program is B.Sc. Degree under 10+2+3 in any branch of Science such as Physical, Chemical Biological, Agricultural, Fisheries, Pharmaceutical Medicine Engineering, or Technology**,** and the admission is based on the GUART ranking test

M.Sc. Biotechnology Proposed Scheme

M.Sc. Biotechnology (effective from 2022 - 23)

SEMESTER I		
Course Codes	**Course Title**	**Credits**
Discipline Specific Core courses (16 credits)		
GBT-500	Microbiology	3
GBT-501	Lab I: Techniques in Microbiology.	3
GBT-502	Immunology	3
GBT-503	Lab II: Techniques in Immunology	2
GBT-504	Biophysical Principles & Analytical Techniques	2
GBT-505	LAB III: Biochemical and analytical techniques	3
Discipline Specific Elective courses (Any 4 credits)		
GBT-521	Concepts in Biochemistry	2
GBT-522	Biostatistics	2
GBT-523	Mathematics for Biologists	2
GBT-524	Biology of the Extremophilic Organisms	2
SEMESTER II		
Discipline Specific Core courses (16 credits)		
GBT-506	Environmental Biotechnology	3
GBT-507	Stem Cell Biology and regenerative medicine	1
GBT-508	Genetics and Molecular Biology	3
GBT-509	Lab IV: Genetics and Molecular Biology	2
GBT-510	Cell and Developmental Biology	3
GBT-511	Bioinformatics	2
GBT-512	Lab V: Plant and Animal Tissue Culture	2
Discipline-Specific Elective courses (Any 4 credits)		
GBT-525	Bio entrepreneurship	2
GBT-526	Lab VI: Lab in Bioinformatics	2
GBT-527	Nanotechnology	2
GBT-528	Vaccine Technology	2

SEMESTER III		
Research Specific Elective Courses (Any 8 credits)		
GBT-600	Recombinant DNA Technology	3
GBT-601	Lab VII: Recombinant DNA Technology	2
GBT-602	Bioprocess Technology	3
GBT-603	Lab VIII: Bioprocess technology	2
GBT-604	Lab IX : Environmental Biotechnology	2
Generic Elective Course (Any 12 credits)		
GBT-621	Solid Waste Management	3
MBT-621	IPR, Biosafety & Bioethics	3
GBT-622	Food Technology	2
GBT-623	Virology	2
GBT-624	Genomics & Proteomics	2
GBT-625	Emerging trends in wastewater treatment	2
GBT-652	Internship	2
SEMESTER IV		
Research-specific elective courses (Any 4 credits)		
GBT-605	Research Methodology	2
GBT-606	Synthetic Biology	2
GBT-607	Plant and Animal Biotechnology	2
MBT-602	Scuba Diving	2
GBT-608	Field trip	2
Discipline-specific dissertation		
GBT-651	Dissertation	16

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-500

Title of the Course: MICROBIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The objective of this course is to provide information about 1) the types of microbes, their growth characteristics. 2) their nutrition, general characteristics and classification.	
Content:	**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.	**No. of hours** 15
	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.	15

	MODULE III 1. Structure & classification. • Algae • Fungi • Cyanobacteria • Bacteria • Viruses • Viroids & prions 2. Specialized microorganisms: • Marine microbes. • Extremophiles: barophiles, psychrophiles, thermophiles, halophiles, acidophiles • Anaerobes	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. Atkins, de Paula. Physical Chemistry for the Life Sciences (2nd Edition). W.H. Freeman, 2011. 2. R.M. Atlas, Microbiology: Fundamentals and Applications. World Cat Publisher, 1989. 3. Collins, Granje J., Lyne, P. M. Falkenheim J. Microbiology Methods Hodder Arnold Publication, 2004. 4. T E. Ford, Aquatic Microbiology: An ecological approach. Blackwell Scientific Publication, 1993. 5. G. Reed, Prescott & Dunn. Industrial Microbiology CBS Publishers. 1987. 6. R.A. Harvey, C.N. Cornelisse, Lippincott Illustrated Reviews: Microbiology (Lippincott Illustrated Reviews Series) LWW publisher, 2012. 7. M. Madigan, K.M. Bender, D. Buckley, W. Sattley, D Stahl. Brock Biology of Microorganisms. Pearsons, 2018. 8. M. Madigan, Martinko & Parker, J. Rock's Biology of microorganisms. Pearson Prentice Hall, 2010. 9. M.J. Pelczar, E.C.S. Chan and Krige. Microbiology Tata Macgrw Hill, 2004. 10. G. Rheinhemer. Aquatic Microbiology Wiley and sons, 1980. 11. R.Y. Stanier, J.L. Ingraham General Microbiology. Palgrave Macmillan, 1999. 12. G. Tortora, B. Funke, C. Case. Microbiology: An Introduction. Pearson, 2018. 13. J. Willey, L. Sherwood, C.J. Woolverton. Prescott's Microbiology.	

	Mcgraw Hill, 2016.
Course Outcomes:	After completing this course, students would be able to 1. Distinguish different types of microorganisms. 2. Understand the morphology, nutrition and classification of various microbes. 3. Analyse the growth characteristics of different microorganisms. 4. Gain a basic understanding on the diversity of microorganisms in different extreme environments and their application.

(Back to top)

Programme: M. Sc. Biotechnology

Course Code: GBT-501

Title of the Course: Lab I: TECHNIQUES IN MICROBIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Prerequisites for the course:	No prerequisite is required.	
Course objective:	This course involves 1) learning techniques to culture microbes in the lab 2) understanding the application in microbiological research studies.	
Content:	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 characterization of bacteria. 9. a. Sugar utilization test (minimal medium + sugar) b. Sugar fermentation test c. IMViC d. Enzyme detection – Gelatinase, Catalase, Oxidase e. Oxidative-fermentative test	**No. of hours** 45

	10. Bacteriological tests for portability of water a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration) 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 test: 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	45
Pedagogy:	lectures/ tutorials assignments/practical	
References/Readings	1. W. Giltner, Laboratory Manual in General Microbiology. Creative Media Partners, LLC, 2017. 2. E.F. Harrigan, M.E. McCance. Laboratory Methods in Microbiology, Academic Press, 2014 3. A.S. Karwa, M.K. Rai, H.B. Singh. Handbook of Techniques in Microbiology: A Laboratory Guide to Microbes, 2012.	
Learning Outcomes	1. Key hands-on experience of converting and applying theoretical knowledge to laboratory. 2. Application of the varied interactions /reactions to be utilized in research. 3. Students become familiar with microbiology techniques that are used in many scientific disciplines as well as clinical medicine. 4. Hands-on experience with basic microbiological instruments to be used in future research studies.	

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-502

Title of the Course: IMMUNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	1. To provide basic knowledge and appreciate the components of the human immune response that work together to protect the host. 2. To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity. 3. To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immune-deficiencies. 4. To understand the principles of immunodiagnostic tests used in immune system related diseases.	
Content:	**MODULE I** **Concepts and Basics** • Introduction – History and scope of immunology • Innate immunity:- factors, features, processes • Acquired:- the Specificity, memory, recognition of self from non-self. • Cells of the immune system: Hematopoiesis and differentiation, Lymphoid and Myeloid lineage, lymphocyte trafficking, B lymphocytes, T lymphocytes, macrophages, dendritic cells, natural killer and lymphokine-activated killer cells, eosinophils and mast cells, lymphocyte subpopulations and CD markers. • Organization of lymphoid organs MALT, GALT, SALT • 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	**No. of hours** 15

	MODULE II **Defence Components: Constituents of immune system and response** • Theories of antibody formation and resolution of antibody structure • Humoral immunity: cells, antibody formation, primary and secondary response. • Immunoglobulins – structure, distribution and function. • Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics. • The basics of Immuno-diagnostics.	15
	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. • 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.I introduction to autoimmune diseases.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. D. R. Burton , P. J. Delves , S. J. Martin , I. M. Roitt. Roitt's Essential Immunology, Includes Desktop Edition. United Kingdom: Wiley, 2011. 2. J. Brostoff , D. K. Male, I. M. Roitt . Immunology. United Kingdom: Mosby, 2001. 3. M. Luttmann, K. Bratke, M. Kupper, & D. Myrtek, Immunology, 2006. 4. R.A. Goldsby, T.J. Kindt, B.A Osbrne and J. Kuby, Immunology, 2007.	
Course Outcomes:	1. The course will enable student to understand the fundamentals of basic immunological processes in human system 2. Application of the knowledge of immune system and processes to pursue research in field of immunology. 3. The mode of continuous assessment and formulation of tests enables	

	students to handle competitive entrance exams. 4. Knowledge of principles of immunodiagnostics would enable them to upskill effectively for research and development in the field. 5. The basic overview of Immunology strengthens their foundations for a career in Biotechnology.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT 503

Title of the Course: LAB II: TECHNIQUES IN IMMUNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	This course involves 1)learning techniques to understand the principles of antigen-antibody reactions 2) identifying immune reactions in the lab to form the basis for application in immunodiagnostics.	
Content:	**MODULE I** 1. Determination of Antibody titre using Double Immuno-diffusion assay. 2. Assessment of Similarity between antigens using Ouchterlony's Double Diffusion Test. 3. Estimation of Antigen Concentration using Radial Immuno Diffusion. 4. Quantitative Precipitation Assay	**No. of hours** 30
	MODULE II 5. DOT ELISA 6. Latex Agglutination 7. Immunoelectrophoresis 8. Rocket Immunoelectrophoresis 9. Slide / Tube agglutination Tests	30
Pedagogy:	Lectures/ tutorials-assignments/hands-on practical	
References/ Readings:	1. G.P. Talwar, S.K Gupta. A Handbook Of Practical And Clinical Immunology Vol I CBS Publishers, 2017. 2. K.R. Joshi, N.O. Osama, Immunology. 5th Edition, Agrobios Ltd, India, 2012. 3. F.C. Hay, O. M.R. Westwood, Practical Immunology, 4th edition, 2008. 4. B. Detrick, R.G. Hamilton, J.D. Folds, et al. eds. Manual of Molecular and Clinical Laboratory Immunology. 7th ed. Washington, DC: ASM Press, 2006. 5. C.A. Janeway, P. Travers, M. Walport, M. Shlomchik, Immunobiology: The Immune System in Health and Disease. Garland Publishing, USA, 2001.	

Course Outcomes:	1. Hands-on experience of applying theoretical knowledge to laboratory. 2. Application of the varied interactions /reactions to be utilized in research. 3. Students become familiar with immunologic techniques that are used in clinical medicine as well as immunology research laboratories. 4. Students will develop interest towards functionality of various immunodiagnostic kits and its application in health & disease related research.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-504

Title of the Course: BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The course is designed to provide a 1)broad exposure to basic techniques used in Modern Biology research. 2) to impart a basic conceptual understanding of the principles of these techniques and emphasize the biochemical utility of the same. 3) clear understanding of all analytical techniques such that the barrier to implementing the same is abated.	
Content:	**MODULE I** • Description of Macromolecular Structure, Intermolecular and Intramolecular forces in protein, DNA and other biomolecules. • Diffusion, Brownian motion and sedimentation, determination of molecular weight from sedimentation and diffusion. • Concept and application of Chemical and Physical equilibria in biological system • Nature and Role of Ionic, Covalent and Noncovalent Interaction in molecular confirmation, scaffolding and packaging of protein and DNA • Thermodynamics of protein folding: Protein folding kinetics, Misfolding and aggregation. • Physical biochemistry of cell: Chemical forces translation and rotation, diffusion, directed movements, biomolecules as machines, work, power and energy, thermal, chemical and mechanical switching of biomolecules, • Biochemical and biophysical characterizations of biomolecules: Fluorescence from GFP), UV-VIS absorption and emission spectra resulting from intrinsic Tryptophan and GFP chromophores, Fluorescence quenching and	**No. of hours** 15

	polarization studies, Unfolding and refolding studies using CD. protein 15 hours 11 diffusion, dynamics by fluorescence correlation spectroscopy.	15
	MODULE II • Spectroscopy: Electromagnetic radiations in spectroscopic techniques. Beer-Lambert law, UV/Visible spectroscopy, Fluorescence spectroscopy, Emission, excitation, Quenching, Quantum Yield. Nuclear magnetic resonance Spectroscopy. Electron spin resonance spectroscopy. • Centrifuge: Basic concepts of centrifugation. Calculation of g value from RPM. Types of rotors used, Differential centrifugation, Density gradient centrifugation. Rate-zonal centrifugation, Isopycnic centrifugation. • Microscopy: Abbey's law, Resolution, Magnification, Phase-contrast microscopy, Confocal microscopy, High resolution microscopy, • Nanoscopy: Atomic force Microscopy, Scanning tunneling Microscopy, Scanning electron microscopy, Transmission electron microscopy and Cryo-electron microscopy X-ray diffraction.	
Pedagogy:	Lectures/ tutorials/assignments.	
References/ Readings:	1. C.R. Cantor and P.R. Schimmel, Biophysical Chemistry, 2nd Edn., 1982. 2. M.A. Subramaniam, Biophysics: Principle & techniques. MJP Publishers, 2021. 3. K. Salman, and Z. Diaz, Principal and Techniques of Bioinstrumentation. Intelliz Publisher, 2016. 4. J. Frank, Three-Dimensional Electron Microscopy of Macromolecular Assemblies. Academic Press., 2006. 5. I. Tinoco, K. Sauer, J. Wang, and J. Puglisi, Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc. 2013 6. P. Atkins, Physical Chemistry for the Life Sciences (2nd Revised Edition), 2015. 7. A. Cooper, Biophysical Chemistry. Royal Society of Chemistry, 2011. 8. K. E. Van-Holde, C. Johnson, Principles of Physical Biochemistry, 3rd Edn. Prentice Hall, 2010.	
Course Outcomes:	1. Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell. 2. This course will offer them a broad idea of instruments/techniques used in biological science laboratories.	

	3. Students will achieve knowledge that will be helpful to use and handle research lab instruments. 4. After completion of this course students will have a clear idea of the industrial applications of bioinstrumentation that will be advantageous for their job /research prospects in Industries and academics.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-505

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

Number of Credits: 3

Effective from AY: 2022 - 23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	The objective of this laboratory course is to 1) introduce students to experimentation in Biochemistry. 2) teach the utility of these experimental methods in a problem-oriented manner.	
Content:	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	**No of hours** 45
	9. Column chromatographic techniques: ion exchange/Affinity/Gel filtration 10. Biochemical assays using ELISA plate reader. 11. Compound and Fluorescence microscopy demonstration 12. Analysis of a biological specimen by SEM 13. Fluorescence imaging of fixed stained and live cells 14. Demonstration of fluorescence spectroscopy. 15. Density gradient ultracentrifugation	45

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

	4. Students will be able to use the experimental methods to design biochemical experiments for the research purpose.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-521

Title of the Course: CONCEPTS IN BIOCHEMISTRY

Number of Credits: 2

Effective from AY: 2022-23

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

	MODULE II • Basic concepts and design of metabolism - glycolysis, gluconeogenesis • Pyruvate oxidation, Citric acid cycle • Oxidative phosphorylation; the importance of electron transfer in oxidative phosphorylation; F_1-F_0 ATP Synthase; shuttles across mitochondria; regulation of oxidative phosphorylation, inhibitors of electron transport chain. • Glyoxylate cycle • The pentose phosphate pathway • Fatty acid synthesis, β-oxidation; biosynthesis of membrane lipids and sterols with specific emphasis on cholesterol metabolism and the mevalonate pathway • Amino acid metabolism; nucleotide metabolism • Photosynthesis and photorespiration	15
Pedagogy:	Lectures, tutorials, assignments.	
References/ Readings:	1. E. E. Abali, S. D. Cline, D. S. Franklin, S. M. Viselli, Lippincott Illustrated Reviews: Biochemistry Wolters Kluwer publisher, 2021. 2. R. L . Miesfeld, M. M. McEvoy, Biochemistry. Worldwide publisher, 2020. 3. R.K. Murray, et al. Harper's Illustrated Biochemistry McGraw Hill publisher, 2022. 4. D.L. Nelson, Lehninger Principles of Biochemistry. W.H. Freeman & Co., 2017. 5. D. Papachristodoulou, A. Snape, W. H. Elliott, and D. C. Elliott, Biochemistry and Molecular Biology. Oxford University publisher, 2018. 6. L. Stryer, J. Berg, J. Tymoczko, G.Gatto. Biochemistry New York, Freeman publisher.,2019. 7. D. Voet, J.G. Voet, W.P.Charlotte, Principles of Biochemistry. Wiley publisher, 2012. 8. D. Voet, J.G. Voet, W.P.Charlotte, Fundamentals of Biochemistry. Life at the molecular level. Wiley publisher, 2018.	
	The students will be able to:	

Course Outcomes:	1. gain fundamental knowledge in biochemistry 2. draw molecules and reaction mechanisms perfectly. 3. acquire knowledge of biomolecules and their significance 4. understand the role of enzymes in the regulation of metabolic pathways.

(Back to top)

Name of the Programme: M.Sc. Biotechnology
Course Code: GBT-522
Title of the Course: BIOSTATISTICS
Number of Credits: 2
Effective from AY: 2022-23

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-523

Title of the Course: MATHEMATICS FOR BIOLOGISTS

Number of Credits: 2

Effective from AY: 2022-23

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-524

Title of the Course: BIOLOGY OF THE EXTREMOPHILIC ORGANISMS

Number of Credits: 2

Effective from AY: 2022-23

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

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

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

(Back to top)

SEMESTER II

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT–506

Title of the Course: ENVIRONMENTAL BIOTECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required	
Course Objectives:	The objective of this course is to 1) impart knowledge on Biotechnological applications. 2) Understand the steps to tackle environmental issues emerging due to industrialization and globalization.	
Content:	**MODULE I** ● 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.	**No. of hours** 15

	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).	15
	MODULE III ● Resource management and environment conservation: ● 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
Pedagogy:	Lectures, tutorials, assignments, demonstrations.	

References/ Readings:	1. A. K. Chatterjee, Introduction to environmental biotechnology. PHI, India, 2000. 2. M. Colin, Marine Microbiology: Ecology and applications. Second edition. Garland science, 2011. 3. R. B. King, J. K. Sheldon, and G. M. Long, Practical Environmental Bioremediation: The Field Guide, Lewis Publishers. CRC Press, 2019. 4. S. M. Meena, and M. M. Naik, Eds., Advances in Biological Science Research: a practical app. Elsevier, 2019. 5. H. J. Rehm, and G. Reed, Eds), Biotechnology, a comprehensive treatise, 1999. 6. T. Satyanarayana, B. Johri, and T. Anil, Eds., Microorganisms in Environmental Management. Springer Publishers, 2012. 7. A. Scragg, Environmental Biotechnology. Pearson Education Limited, Oxford University Press, 2005. 8. J. M. Willey, L. M. Sherwood, C. J. Woolverton, Prescott,s Microbiology. Mcgraw-Hill Education, 2017.
Course Outcomes:	1. Students will be able to apply their knowledge to analyse environmental pollution. 2. Student will be able to evaluate the environmental pollution and decide about treatment methods. 3. Students will be able to relate the apply the biotechnology knowledge to environmental issues. 4. Students will be able to apply their knowledge for the application of biotechnological processes and find solutions for betterment of environment and sustainable development of the society.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-507

Title of the Course: STEM CELL BIOLOGY AND REGENERATIVE MEDICINE

Number of Credits: 1

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic understanding of cell biology - cell types, growth media, cell division, cell growth, and cell differentiation.	
Course Objectives:	The aim of the course is 1) to bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells 2) to obtain a coherent picture of stem cell and their use in experimental and clinical context	
Content:	**MODULE I** • Definition, stem cell origins and plasticity, classification and source of stem cells; Stem cell differentiation; • Stem cells cryopreservation, iPS technology; microRNAs and stem cell regulation, Tumor stem cells, • Overview of embryonic and adult stem cells for therapy. Human stem cells research: • Ethical considerations; • Stem cell based therapies: Pre-clinical regulatory consideration and patient advocacy.	**No. of hours** 15
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings:	1. A.D. Hoffman, Stem Cell Transplantation Biology Process Therapy, Willy-VCH, 2006. 2. J. Collins, Stem cells: From basic to advanced principles, Hayle Medical, 2017. 3. R. Lanza, Essential of Stem Cell Biology, Academic Press, 2006. 4. R. Lanza, Essential stem cell methods, Elsevier, 2009. 5. R. Lanza, Principle of Tissue Engineering, AP publisher, 2011. 6. 6. R. Lanza, Essential of Stem cell Biology, Elsevier publisher, 2013.	

Course Outcomes:	1. Student will get theoretical and practical knowledge of stem cells. 2. This course will provide them knowledge and scope of emerging medical applications in regenerative medicine 3. Course will provide knowledge of scope of animal cell culture and animal models in medical industries 4. This course will offer student to think toward medical entrepreneurship.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-508

Title of the Course: GENETICS AND MOLECULAR BIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	The aim of this course is to 1) obtain and understand the fundamental knowledge of molecular and cellular processes such as RNA transcription, protein synthesis, mutation, epigenetic modification and gene regulation. 2) Understand the organization of the genome and gene transfers in prokaryotes	
Content:	**MODULE I** • Mendelian Genetics and Population genetics • Structure of DNA - A,B, Z and triplex DNA; • Organization of bacterial genome and eukaryotic chromosomes Heterochromatin and Euchromatin • DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis) Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects. • Structure and function of prokaryotic and eukaryotic mRNA, tRNA (including initiator tRNA), rRNA and ribosomes. Processing of eukaryotic hnRNA: 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of mRNA. • Gene transfer in bacteria-Conjugation, transformation and transduction. • DNA mutation and repair, Transposons	**No of hours** 15
	MODULE II • Prokaryotic and eukaryotic transcription -RNA	15

	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
Pedagogy:	Lectures/tutorials/assignments	
References/ Readings:	1. D. P. Clark, N. J. Pazdernik and M. R. McGehee, Molecular Biology (3rd) Elsevier Inc, 2019. 2. W. Klug, M. Cummings and C. Spencer, Concepts of Genetics (12ed), Pearson publishers, 2019. 3. E. S. Goldstein , T. Stephen, J. Kilpatrick and J. Krebs, Lewin's genes XII, Bartlett Publishers, 2017.	

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-509

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

Number of Credits: 2

Effective from AY: 2022-23

<table>
<tr><td>Pre-requisites for the Course:</td><td colspan="2">None</td></tr>
<tr><td>Course Objectives:</td><td colspan="2">The objective of this course is
1)to provide students with experimental knowledge of molecular biology and genetic engineering.
2) understand the concept of mutation and gene transfer processes</td></tr>
<tr><td rowspan="2">Content:</td><td>No. of hours</td><td></td></tr>
<tr><td>1. UV/Chemical mutagenesis and survival curve.
2. Isolation of amino acid auxotroph by replica plating.
3. Phage infection and burst size; types of plaque formation
4. Transduction
5. Genetic Transfer-Conjugation, gene mapping.
6. Genomic DNA isolation</td><td>30</td></tr>
<tr><td></td><td>7. DNA quantification and gel electrophoresis
8. RNA isolation
9. RNA denaturing gel electrophoresis.
10. Mitosis.
11. Meiosis</td><td>30</td></tr>
<tr><td>Pedagogy:</td><td colspan="2">Hands-on experiments in the laboratory, video, online data</td></tr>
<tr><td>References/ Readings:</td><td colspan="2">1. R.K. Sharma and S.P.S Sangha, Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press, 2020.
2. S. K. Gakhar, M. Miglani and A Kumar, Molecular Biology: A Laboratory Manual. Rupa Publications, 2019.
3. Hofmann, Wilson and Walkers Principles and Techniques Of Biochemistry And Molecular Biology, Cambridge University Press, 2018.
4. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set, 2012.
5. S. John Vennison, Laboratory Manual for Genetic Engineering 1st Edition, PHI Learning, 2009.</td></tr>
</table>

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT–510

Title of the Course: CELL AND DEVELOPMENTAL BIOLOGY

Number of Credits: 3

Effective from AY: 2022-23

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

	• 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 signalling • Cell fusion techniques • Molecular chaperones: types, characteristics, and functional significance • Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis.	15
	MODULE III • Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. • Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation, and formation of germ layers in marine animals. • Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of	15

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

	4. Students will be able to summarize the molecular and genetic background of animal developmental biology.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-511

Title of the Course: BIOINFORMATICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	The objectives of this course are 1) to provide students with theory and practical experience of the use of common computational tools and databases 2) To facilitate the investigation of molecular biology and evolution-related concepts.	
Content:	**MODULE I** • Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • Evolutionary basis of sequence alignment, optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, • Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle; Scoring matrices, Distance matrices. • Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; • Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL)	**No. of hours** 15

	recommendations, Barcode of Life Database (BOLD).	
	MODULE II • 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields *etc.* Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally similar proteins). • Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding *etc.*) Homology/comparative modeling, fold recognition, threading approaches, and ab initio structure prediction methods; CASP (Critical Assessment of protein Structure Prediction); Computational design of promoters, proteins & enzymes. • Chemical databases like NCI/PUBCHEM; Fundamentals of Receptor-ligand interactions; Structure-based drug design: Identification and Analysis of Binding sites and virtual screening; Ligand based drug design: Structure Activity Relationship– QSARs & Pharmacophore; *In silico* predictions of drug activity and ADMET. • Designing of oligo probes; Image processing and normalization; Microarray data variability (measurement ad quantification); Analysis of differentially expressed genes; Experimental designs.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. L. Arthur, Introduction to Bioinformatics. Oxford University Press, 2019. 2. A. D. Baxevanis, G. D. Bader and D. S. Wishart, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher, 2020.	

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-512

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

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	1) To gain a comprehensive understanding of the growth and development of plants in vitro. 2) To understand the fundamentals of animal cell culture, and the growth and maintenance of animal cells under aseptic conditions.	
Content:		**No. of hours**
	1. Preparation of starting material (Biosafety cabinet, solutions, media, cell sample etc.). 2. Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, contamination and precautions. 3. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell lines HEK293, COS-7 4. Transfection and co-transfection: Calcium-phosphate method and Lipofection 5. Cell fixation and staining: Immunolabeling, mounting, fluorescence imaging.	30
	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
Pedagogy:	Hands-on experiments in the laboratory, online videos, and demonstrations.	
References/ Readings:	1. I.R. Freshney and A. Capes-Davis, Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications,	

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-525

Title of the Course: BIOENTREPRENEURSHIP

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with an understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how t 1) to manage and develop life science companies and projects. 2) 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.	
Content:	**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;	**No. of hours** 15

	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 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 start-ups:** • 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.	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. D. J. Adams, & J. C. Sparrow, Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion, 2008. 2. A. J. Byrne, World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin, 2011. 3. Jordan, J. F. Routledge.., Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press, 2014. 4. V. Desai, The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House, 2009. 5. J. Lynn, The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur	

	Media Inc, 2007. 6. D. Ramsey, Entre Leadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard Books, 2011 7. C. D. Shimasaki, Biotechnology Entrepreneurship: Starting, Managing, 2014.
Course Outcomes:	1. Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation. 2. Students will be able to identify the scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. 3. The knowledge pertaining to management will help the students to be able to build up a strong network within the industry. 4. Students will be able to relate and develop entrepreneurship venture with biotechnological products they studied.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT–526

Title of the Course: LAB VI: LAB IN BIOINFORMATICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	NIL	
Course Objectives:	The aim is 1) to provide practical training in bioinformatics and statistical methods 2) learn to access and search the major public databases for data retrieval.	
Content:		**No. of hours**
	1. Using NCBI and Uniprot web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results. 5. Multiple sequence alignment using ClustalW. 6. Phylogenetic analysis of protein and nucleotide sequences. 7. Use of gene prediction methods (GRAIL/Genscan,/Glimmer). 8. Use of various primer designing and restriction site prediction tools.	30
	9. Use of different protein structure prediction databases (PDB, SCOP, CATH). 10. Construction and study of protein structures using RASMOL/Deepview/PyMol. 11. Homology modelling of proteins. 12. Whole-genome assembly from NGS raw data sequence 13. 16S rRNA sequence analysis and use of Bioedit 14. Molecular docking	30
Pedagogy:	Hands-on experiments in the laboratory, video, online data	
References/ Readings:	1. A.D. Baxevanis, G.D. Bader, D.S. Wishart, Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher, 2020. 2. S. Shui Qing, Bioinformatics: A Practical Approach (Chapman;	

	Hall/CRC Mathematical and Computational Biology), 2007. 3. W. Even, and G. Grant, Statistical methods in Bioinformatics: An introduction, 2005. 4. N.C. Jones, and P.A. Pevzner; Introduction to Bioinformatics Algorithms; Ane Books, India, 2004. 5. D.W. Mount, Bioinformatics: Sequence and Genome Analysis, Cold Spring Harbor Laboratory Press, 2001.
Course Outcomes:	On completion of this course, students should be able to: 1. describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyse and discuss results in the light of molecular biology knowledge; 2. explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming; 3. predict secondary and tertiary structures of protein sequences; 4. perform various statistical tools available to analyse the data.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-527

Title of the Course: NANOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	1) To provide a general and broad introduction to the multi-disciplinary field of nanotechnology. 2) To study the application of nanotechnology	
Content:	**MODULE I** • Introduction, concepts, historical perspective; • Different formats of nanomaterials and applications with examples for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis, and characterization of different nanomaterials. • Thin films; Colloidal nanostructures; Self-assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization. • Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages. • Strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.	**No. of hours** 15
	MODULE II • Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli-responsive nanoparticles, implications in cancer therapy,	15

	nanodevices for biosensor development. • Nanomaterials for catalysis, development, and characterization of nanobiocatalysts • Application of nano scaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. • Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment • Fate of nanomaterials in different strata of the environment; Ecotoxicity models and assays; Life cycle assessment, containment.	
Pedagogy:	Lectures/ video tutorials/assignment.	
References/ Readings:	1. K. Chittaranjan, D. S. Kumar, M. V. Khodakovskaya, Plant Nanotechnology Principles and Practices. Springer, 2016. 2. J. GeroDecher, B. Schlenoff., Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag, 2003. 3. D. S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley-Liss, 2004. 2. T. H. Grey, Bioconjugate Techniques, Elsevier, 2013. 3. M. Kuno, Introductory Nanoscience, Physical and Chemical Concepts. Garland Science, 2012. 4. N.H. Malsch, Biomedical Nanotechnology, CRC Press, 2005. 5. J.J. Ramsden, Nanotechnology: An Introduction. Elsevier Amsterdam,. 2012. 6. S. Sanmugam, Nanotechnology. MJP publisher, 2011.	
Course Outcomes:	1. Students will be able to describe the basic science behind the properties of materials at a nanometre scale. 2. Students will be able to use and apply knowledge gained to synthesize nanoparticles 3. Students will be able to analyse the properties of nanoparticles and decide on its application 4. Students will be able to understand the life cycle nanoparticles and their impact on environment.	

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-528

Title of the Course: VACCINE TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

	• Physical method of gene delivery: tattooing, gene gun, electroporation, ultrasound, and laser • Maternal Immunization	
	MODULE II • Vaccines with and without adjuvants. Different types of adjuvants: oil-based adjuvants such as Freunds, aluminum hydroxide, aluminum phosphate, [AS04] aluminum potassium sulfate monophosphoryl lipid A (MPL) + aluminum salt, [MF59] Oil in water emulsion composed of squalene. [AS01] Monophosphoryl lipid A (MPL) and QS-21, a natural compound extracted from the Chilean soapbark tree, combined in a liposomal formulation, [cpG1018] Cytosine phosphoguanine (CpG), a synthetic form of DNA that mimics bacterial and viral genetic material. • Vaccine delivery systems (e.g., emulsion (water- in-oil-in-water multiple emulsions, microemulsions, or nanoemulsions) microparticles, immune-stimulating complexes ISCOMs liposomes, nanoparticles, dendrimer and micellar) with examples such as PLGA, Chitosans, polyphosphazene, polyanyhydrides, polymethacrylic acid, liposomes, and their derivatives, virosomes, polymeric nanoparticle delivery system, • New emerging diseases and vaccine needs (Ebola, Zika). • Quality control and regulations in vaccine research	15
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. C. Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009. 2. R.W. Ellis, "New Vaccine Technologies", Landes Bioscience, 2001. 3. C. A. Janeway, Travers, P., Walport, M.; Shlomchik, M. J. Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub, 2005. 4. S. H. Kaufmann, Novel Vaccination Strategies. Weinheim: Wiley-VCH, 2004.	

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

(Back to top)

SEMESTER III

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-600

Title of the Course: RECOMBINANT DNA TECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	General concepts in genetics and molecular biology	
Course Objectives:	The students will understand the use of 1) various enzymes and techniques for manipulating DNA. 2) various DNA vectors and their use in creating recombinant DNA molecules 3) recombinant DNA modification techniques and heterologous gene expression used for creating applications for biological research and biotechnology industries.	
Content:	**MODULE I** ● Enzymes used in Molecular biology: restriction endonucleases and methylases; DNA ligase, Klenow enzyme, T4 DNA polymerase, polynucleotide kinase, alkaline phosphatase; nucleases, Topoisomerase, thermostable polymerase, Terminal deoxynucleotide polymerase and others. ● Cohesive and blunt end ligation; linkers; adaptors; ● Homopolymer tailing; labelling of DNA: nick translation, ● Random priming, radioactive and non-radioactive probes, ● Hybridization techniques: northern, southern, south-western and far-western and colony hybridization, fluorescence in situ hybridization. Plasmids; Bacteriophages; M13mp vectors; pUC19 and pBluescript vectors, phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Principles for maximizing gene expression vectors; pMal; GST; pET-based vectors; Protein purification; His-tag; GST-tag; MBP-tag etc.; Intein-based vectors;	**No. of hours** 15

	Inclusion bodies; methodologies to reduce formation of inclusion bodies; mammalian expression and replicating vectors; ● Baculovirus and Pichia vectors system, ● Plant based vectors, Ti and Ri as vectors, yeast vectors, shuttle vectors.	
	MODULE II ● Principles of PCR: primer design; fidelity of thermostable enzymes; DNA polymerases; types of PCR – multiplex, nested; real time PCR, touchdown PCR, hot start PCR, colony PCR, cloning of PCR products; T vectors; proofreading enzymes; ● PCR based site specific mutagenesis; PCR in molecular diagnostics; viral and bacterial detection; ● Sequencing methods; enzymatic DNA sequencing; chemical sequencing of DNA; automated DNA sequencing; RNA sequencing; chemical synthesis of oligonucleotides; mutation detection: SSCP, DGGE, RFLP. ● Insertion of foreign DNA into host cells; transformation, electroporation, transfection; ● construction of libraries; isolation of mRNA and total RNA; reverse transcriptase and cDNA synthesis; cDNA and genomic libraries; construction of microarrays – genomic arrays, cDNA arrays and oligo arrays; study of protein DNA interactions: electrophoretic mobility shift assay; ● DNase I footprinting; methyl interference assay, chromatin immunoprecipitation; protein-protein interactions using yeast two-hybrid system; phage display.	15
	MODULE III ● Gene silencing techniques; introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene silencing; gene knockouts and gene therapy; ● Development of transgenic plants; debate over GM crops; introduction to methods of genetic	**15**

	manipulation in different model systems e.g. fruit flies (Drosophila), worms (C. elegans),Frog (Xenopus sp), fish (zebra fish) and chick. ● Transgenics - gene replacement; gene targeting; creation of transgenic and knock-out mice; disease model; introduction to genome editing by CRISPR-CAS with specific emphasis on Chinese and American clinical trials; ● Cloning genomic targets into CRISPR/Cas9 plasmids; electroporation of Cas9 plasmids into cells; purification of DNA from Cas9 treated cells and evaluation of Cas9 gene editing; in vitro synthesis of single guide RNA (sgRNA); using Cas9/sgRNA complexes to test for activity on DNA substrates; evaluate Cas9 activity by T7E1 assays and DNA sequence analysis; Applications of CRISPR/Cas9 technology	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Wiley-Blackwell Publishers, 2016. 2. T. A Brown, Genomes, New York: Garland Science Publisher, 2017. 3. J. W. Dale, M. von Schantz and N. Plant, From Genes to Genomes: Concepts and Applications of DNA Technology, Wiley-Blackwell publisher, 2011. 4. H. K. Das, Textbook of Biotechnology, Wiley Publisher, 2017. 5. M. R. Green and J. Sambrook, Molecular Cloning: A Laboratory Manual.CSH Press, 2012. 6. V. Hunter and F. Strickland, Applications of Recombinant DNA Technology. ED-TECH Press, 2018. 7. A. J. Nair, Introduction to Biotechnology and Genetic Engineering. Laxmi Publications Pvt. Ltd, 2008. 8. S. Primrose and R. B. Twyman, Principles of Gene Manipulation and Genomics, Blackwell Publishing Limited, 2006. 9. M. K. Sarwar, I. A. Khan and D. Barp, Applied Molecular Biotechnology: The Next Generation of Genetic Engineering CRC Press, 2016. 10. V. Singh and P Dhar, Genome Engineering via CRISPR-Cas9 System, Elsevier Publisher, 2020.	
Course	The students will be able to	

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-601

Title of the Course: LAB VII: RECOMBINANT DNA TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-602

Title of the Course: BIOPROCESS TECHNOLOGY

Number of Credits: 3

Effective from AY: 2022-23

Pre-requisites for the Course:	None	
Course Objectives:	1) To educate students about fundamental concepts of Bioprocess technology 2) To study and understand related applications.	
Content:	**MODULE I** **Basic Principles of Biochemical Engineering and Fermentation Processes**: • Isolation, screening, and preservation of industrially important microbes • Bioreactor designs • Types of fermentors • Concepts of basic modes of fermentation: batch, fed-batch and continuous • Scale up fermentation processes • Media formulation • Air and media sterilization. • Aeration; agitation in bioprocess. • Measurement and control of bioprocess • parameters.	**No. of hours** 15
	MODULE II **Industrial production of chemicals:** • Strain improvement for increased field & other desirable characteristics • alcohol (beer) • organic acids (citric acid) • antibiotics (Penicillin) • amino acids (lysine) • Application of microbes in food processing:	15

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

	12. Trevan, M.D. Immobilized enzymes: An introduction & application in biotechnology, 1980.
Course Outcomes:	1. Students will gain knowledge regarding various concepts related to Biotechnological industrial aspects. 2. Students shall learn about the industrial production of Biotechnologically important products. 3. Students shall be aware of how an industry functions from a biotechnological perspective. 4. Students shall be prepared to meet the challenges of new and emerging areas of biotechnology industry.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-603

Title of the Course: LAB VIII: BIOPROCESS TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-604

Title of the Course: LAB IX: ENVIRONMENTAL BIOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	No prerequisite is required.	
Course Objectives:	1) To impart students with the hands-on experience in basic experimental analysis and the use of biological agents. 2) To understand emerging treatment processes carried out for the wastewater and organic solid waste analysis	
Content:	**MODULE I** **Analysis of Solid waste** 1. Estimation of Total solids and Volatile solids in organic waste 2. Biochemical methane potential assay 3. Analysis of Biogas using Gas Chromatography 4. Vermicomposting of organic waste	**No. of hours** 30
	MODULE II **Analysis of wastewater** 1. Chemical Oxygen demand of wastewater 2. Biological Oxygen demand of wastewater 3. Total Phosphorus analysis in wastewater 4. Total Kjeldahl Nitrogen analysis in wastewater 5. Struvite precipitation from wastewater and its analysis by XRD. 6. Microbiological analysis of wastewater	30
Pedagogy:	Hands-on experiments in the laboratory, online videos.	
References/ Readings:	1. APHA. "Standard Methods for Examination of Water and Wastewater", American Public Health Association WWA, Washington, D.C., 2005 2. Angelidaki I , Alves M, Bolzonella D, Borzacconi, L. Campos, J.L., Guwy, A.J., Kalyuzhnyi, S., Jenicek P., and Van Lier, J.B., Defining the Biomethane Potential (BMP) of Solid Organic Wastes and	

	Energy Crops: A Proposed Protocol for Batch Assays. Water Science & Technology, 2009.
Course Outcomes:	1. The students will be able to analyse municipal wastewater 2. The students will be able to analyse solid organic waste. 3. Students will understand the process of organic waste treatment. 4. Student will be able to relate the knowledge of Environmental Biotechnology with organic waste analysis.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-621

Title of the Course: SOLID WASTE MANAGEMENT

Number of Credits: 3

Effective from AY: 2022-23

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

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: MBT 621

Title of the Course: IPR, BIOSAFETY & BIOETHICS

Number of Credits: 3

Effective from AY: 2022-23

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

	Treaty (PCT) • International framework for the protection of IP • National Bio-diversity Authority (NBA) and other regulatory bodies, protection of new GMOs; • History of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; • Country-wise patent searches (USPTO, EPO, India); analysis and report formation. • International patenting-requirement, procedures and costs; financial assistance for patenting • Publication of patents-gazette of India, status in Europe and US; • Patent infringement- meaning, scope, litigation, case studies and examples; • Commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists-university/organizational rules in India and abroad, collaborative research - backward and forward IP; • Benefit/credit sharing among parties/community, commercial (financial) and non-commercial incentives.	
	MODULE II • Biosafety and Biosecurity - introduction; historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals; • Definition of GMOs & LMOs; principles of safety assessment of transgenic plants – sequential steps in risk assessment; concepts of familiarity and substantial equivalence; risk – environmental risk assessment and food and feed safety assessment; problem formulation – protection goals, compilation of relevant information, risk characterization and development of analysis plan;	15

	risk assessment of transgenic crops vs cisgenic plants or products derived from RNAi, genome editing tools. • International regulations – Cartagena protocol, OECD consensus documents and Codex Alimentarius; Indian regulations – EPA act and rules, guidance documents, regulatory framework – RCGM, GEAC, IBSC and other regulatory bodies; Draft bill of Biotechnology Regulatory authority of India - containments – biosafety levels and category of rDNA experiments; field trails – biosafety research trials – standard operating procedures - guidelines of state governments; GM labeling – Food Safety and Standards Authority of India (FSSAI).	
	MODULE III • Introduction, ethical conflicts in biological sciences - interference with nature Bioethics in health care - patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis genetic screening, gene therapy, transplantation. • Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare • Agricultural biotechnology - Genetically engineered food, environmental risk, labeling and public opinion. • Sharing benefits and protecting future generations • Protection of environment and biodiversity • Biopiracy	15
Pedagogy:	Lectures, tutorials, Case studies, assignments	
References/ Readings:	1. L. Bently and B. Sherman, Intellectual property law . Oxford University Press, 2008. 2. L. Bently, Intellectual property law Oxford University Press., 2008. 3. Complete Reference to Intellectual Property Rights	

4. T. M. Cook, A User's Guide to Patents Tottel Publishing., 2007.
5. W. Craig, M. Tepfer, G. Degrassi, & D. Ripandelli, An Overview of General divisions/csurv/geac/annex-5.pdf F, 2009.
6. Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9
7. D. O. Fleming, D. L. Hunt, Biological safety: principles and practices ASM Press., 2000.
8. P. Ganguli, Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub., 2001.
9. Grubb P. W. Grubb P. L. Thomsen, P. R., Patents for Chemicals, Pharmaceuticals and Biotechnology: Fundamentals of Global Law, Practice and Strategy Oxford University Press., 2010.
10. http://www.wipo.int
11. International Union for the Protection of New Varieties of Plants. http://www.upov.int
12. J. Rajmohan. Biosafety and bioethics Gyan Publishing House., 2006.
13. F Karen . Greif and Jon F. Merz, Current Controversies in the Biological Sciences – Case Studies of Policy Challenges from New Technologies, MIT Press
14. Keith F, CRC handbook of laboratory safety. A.CRC Press.,2000.
15. H. Kuhse, Bioethics: An Anthology. Malden, MA: Blackwell., 2010.
16. Laws. Snow White Publication Oct., 2007.
17. National Biodiversity Authority. http://www.nbaindia.org
18. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI.
19. National Portal of India.http://www.archive.india.gov.in
20. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Government of India. http://www.ipindia.nic.in/
21. Recombinant DNA Safety Guidelines, Department of Biotechnology, Ministry of Science and Technology, Govt. of India, 2017. Retrieved from https://dbtindia.gov.in/
22. K. Singh. Intellectual property rights in Biotechnology. A status report New Delhi Biotech Consortium, India, 1993.
23. N.S. Sreenivasulu, and C.B. Raju, Biotechnology and Patent laws: patenting living beings Manupatra Publishers, 2008.
24. Wegner H. Patent law in Biotechnology, chemicals & pharmaceuticals. Stockton Press, 1994.

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-622

Title of the Course: FOOD TECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge in Microbiology or Food Science.	
Course Objectives:	1) On completion of this course, students should be able to acquire knowledge and contribution of biotechnology in food industry. 2) To understand the safety standards in food industry	
Content:	**MODULE I** Industrial and Food Biotechnology; Introduction; Importance; Applications of biotechnology in food processing; Significant advances and Recent developments; Preservation and processing – chilling methods, phenomena of rigor mortis, spoilage changes – causative factors; Drying – conventional methods; Salt curing, pickling and smoking; Freezing and cold storage, Canning procedures; Role of preservatives in processing. Packing – handling fresh fish, frozen packs, individually quick frozen (IQF), layered and shatter packs; Fishery by-products, cannery waste, feeds, silage, fish gelatin, fish glue, chitin and chitosan, pearl essence, fertilizer	**No. of hours** 15
	MODULE II Seafood microbiology, factors influencing, microbial, growth and activity; food-borne pathogens: bacteria fungi, viruses; Spoilage factors; Toxins influencing food spoilage; Microbes as food single cell protein (SCP), microbial nutraceuticals; Quality management – concepts, planning, system, quality control, quality assurance, quality improvement; Certification standards – ISO and HACCP; Principles of quality related to food sanitation, contamination, pest control, human resource and occupational hazards; Novel product development, marketing and food export, government policies,	15

	economic importance, nutrition promotion, consumer studies qualitative and quantitative research methods.	
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings:	1. S. Omura, The search for bioactive compounds from microorganisms. Springer New York, 2011. 2. M. Fingerman, (Ed.), Recent Advances in Marine Biotechnology, Vol. 8: Bioremediation (1st ed.). CRC Press, 2003. 3. G. M. Evans, J.Furlong, G. G. Evans, Environmental Biotechnology: Theory and Application, United Kingdom: Wiley, 2011. 4. T. Fatma, Cyanobacterial and Algal Metabolism and Environmental Biotechnology. India: Narosa 1999. 5. A.S. Ninawe, K. Rathnakumar, Fish Processing Technology And Product Development. India: Narendra Publishing House, 2008. 6. P. Galvez Raul, Jean-Pascal Berge (Eds.) Utilization of Fish Waste. United Kingdom: CRC Press, 2013. 7. W.C .Frazier, D.C.Westhoff, V.M. Vanitha, Food Microbiology. 5th Edition. McGraw Hill Education, 2017. 8. G. M. Hall, Fish Processing Technology. United Kingdom: Springer US, 2012.	
Course Outcomes:	1. Students will gain knowledge about food preservation and safety. 2. Application of food technology in food related research, food industry and at national and international food organizations. 3. Understand the strategies for new product development, quality assurance, safety and marketing. 4. Impart knowledge to society regarding nutritional facts of food products and generate a healthier population. 5. Better understanding of marine - fish byproducts that will help them develop entrepreneur skills.	

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-623

Title of the Course: VIROLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

	● Astroviruses, Norwalk and Sapporo-like viruses and other enteroviral diseases. ● Polio; Non-polio Enteroviruses, hepatic viruses ● Biology of Measles, mumps, rubella, Parvovirus B-Chicken pox and other viral pox diseases ● Viral respiratory diseases Biology and pathogensis of SARS, ● Metapneumovirus, Human rhino virus and Corona virus etc. ● Viral Haemorrhagic Fevers Yellow Fever, Kyasanur forest, disease, Chikungunya, Rift Valley Fever, Crimean Congo.	
	MODULE II ● Haemorrhagic fever, Hanta, Marburg and Ebola, and Rickettsial fevers. ● Viral encephalitis: Japanese encephalitis and West Nile viral infection, endemic areas. ● Biology of HIV viruses. ● Vaccines and antivirals. ● Methods of culturing viruses ● Human Virome, assembly, composition and host interaction ● Marine Virome. Ecological role of viruses in marine ecosystem. ● Lysogeny strategy adopted by marine viruses ● Metagenomic methods to study the virome and the dark matter. ● Phage serotyping ● Phage therapy for combating diseases, Case studies	15
Pedagogy:	Lectures, tutorials, Case studies, Assignments	
References/ Readings:	1. R. Ananthanarayan, Ananthanarayan and Paniker's, Textbook of Microbiology. Universities Press, 2020. 2. J. Carter and V. A. Saunders, Virology: principles and applications, Wiley, 2007. 3. N. Dimmock, A. Easton and K. Leppard, Introduction to Modern Virology, John Wiley and Sons, 2006. 4. J. Flint, L W Enquist, V.R. Racaniello and A.M. Skalka, Principles	

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT 624

Title of the Course: GENOMICS AND PROTEOMICS

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge in Molecular Biology /Biochemistry.	
Course Objectives:	1) To develop required knowledge and skills in the students so that they are able to acquire the following competency in genomics and proteomics which aims to look into the genome and protein properties from a global perspective. 2) To provide basic knowledge about sample preparation, mass spectrometry workflow, different chromatography technologies and quantitative proteomics.	
Content:	**MODULE I** ● Brief overview of prokaryotic and eukaryotic genome organization; extra-chromosomal DNA: bacterial plasmids, mitochondria and chloroplast. ● Genetic and physical maps; markers for genetic mapping; methods and techniques used for gene mapping, physical mapping, linkage analysis, cytogenetic techniques, FISH technique in gene mapping, somatic cell hybridization, radiation hybrid maps, in situ hybridization, comparative gene mapping. ● Human Genome Project, genome sequencing projects for microbes, plants and animals, accessing and retrieving genome project information from the web. ● Identification and classification of organisms using molecular markers- 16S rRNA typing/sequencing, SNPs; ● Use of genomes to understand the evolution of eukaryotes ● Track emerging diseases and design new drugs; determining gene location in genome sequence.	**No. of hours** 15

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

	proteomics like 2D and MALDI and methods of protein separation, detection and quantitation. 3. evaluate various applications of genomics and proteomics in agriculture, human health and industry. 4. have the necessary learning to radically advance their understanding of life and transform medicine.

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-625

Title of the Course: EMERGING TRENDS IN WASTEWATER TREATMENT

Number of Credits: 2

Effective from AY: 2022-23

Pre-requisites for the Course:	Basic knowledge in Microbiology or Environmental Science or Environmental Technology	
Course Objectives:	The primary objectives of the course are as follows: 1) Reinforcing the basic tenets of microbial treatment of wastewaters and waterborne pathogens (source, fate and factors affecting their survival in the environment). 2) Understanding the advantages and disadvantages between centralized wastewater systems, decentralized systems and onsite systems and appropriate application of each of these systems. 3) Understanding of emerging and novel biological treatment technologies and how these technologies need to be modified to address site specific conditions. 4) Gain insights into the use of biological treatment processes used to recover valuable constituents or produce valuable products from wastewaters. 5) Understanding of microbial or molecular based technologies used to monitor for the presence, sources and types of contaminants discharged in complex wastewater mixtures.	
Content:	**MODULE I** **Global Water Crisis** Overall trends and challenges in the treatment of wastewaters and provide an overview of water demands from a Global and India centric perspective. Issues and questions: • Consumption v/s supply; how does the treatment of water help to ensure a renewable and sustainable water resource • The major wastewater impacts on ecosystem integrity and human health. • Areas requiring treatment in India. • Major sector treatment issues (industrial,	**No. of hours** 15

	agricultural, domestic) • Impact of increasing complexity in the composition of wastewater on treatment strategies • Challenges in treatment of wastewater **<u>Decentralized Wastewater Treatment Systems</u>** The major drivers for decentralized systems: • Economics of decentralized systems v/s centralized systems. • Logistical Challenges: Impacts relating to urban sprawl and difficulty in connecting newly developed areas to centralized systems • Complexity and Site Specific Treatment Needs: Flexibility of decentralized systems. • Difference between decentralized and on-site systems: in terms of size and the transport and treatment of wastewaters **<u>Conventional Biological Treatment Processes</u>** • Overview of conventional biological treatment processes and commonality amongst centralized and decentralized systems dealing with the treatment of wastewaters and solids. • The efficacy and challenges associated with the use of biological treatment for major classes of wastewater constituents. • Examination of common biological treatment strategies associated with different domestic, agricultural, industrial and manufacturing sector needs. • Treatment Platforms: Review of treatment processes that are generally incorporated within a technology (e.g., fixed film biological treatment incorporated into a technology like a rotating biological contactor) • Hybrid systems and different treatment platforms nested with a hybridized system in order to develop a customized treatment strategy designed to deal with a specific suite of	

	contaminants (e.g. a hybridized system that combines fixed biological films with phytoremediation to acquire polished effluent). • Overview of case studies demonstrating hybridized decentralized approaches. • Use of wetland for effective treatment of domestic wastewaters.	
	MODULE II Emerging technologies and integration of nanotechnology to enhance biological performance. • Microorganisms utilized: bacteria, fungi and algal groups. • Bioaugmentation techniques designed to improve the biodegradation of contaminated soils and waters through the actions of microorganisms: - Autochthonous bioaugmentation - Allochthonous bioaugmentation - Gene bioaugmentation • Techniques for the treatment of a wide range of pollutants ranging from polycyclic aromatic hydrocarbons, nitrophenols, polychlorinated biphenyls, chlorophenols, crude oil, diesel oil, textile dyes and several pesticides. • Hybridized treatment systems integrating emerging biological treatment technologies with emerging nanoparticle applications. Integration systems range from the use of nanotechnology in the oxidation or sequestering of wastewater constituents that could harm or impede the function of downstream biological treatment, to the incorporation of biocide nanoparticles into compound membranes to prevent biofouling of the membrane or to inactivate waterborne pathogens. • Standardized test protocols or standardized operating procedures of these technologies. • Modification required in these technologies to	15

address site specific conditions.

- Unique opportunities existing to address difficult or unusual treatment challenges.
- Seaweeds/macroalgal wastewater treatment
- Examining factors such as the maturity and reliability of the technology and a discussion of factors such as wastewater constituents, site conditions, cost factors and time that influence the applicability and suitability of the technology.

Resource Recovery from Wastewaters

- An overview of the use of biological treatment processes used to recover valuable constituents or produce valuable products from wastewaters
- The recovery of valued nutrients such as nitrogen and phosphorus, to valued elements and metals, to the generation of energy though microbial fuel cells or the generation of biogas.
- Integration of nutrient recovery steps such as Microbial Electrochemical Cell (MEC) to recover valuable nutrients in treatment technologies
- Novel composting methods such as *terra preta* of the sludge (biomass) generated after treatment for increasing soil fertility

Environmental Monitoring

- Review and discussion of microbial and molecular based technologies.
- Types of testing.
- Application of biomarkers; advantages and limitations.

Types of biomarkers used for environmental monitoring:

- Ames *Salmonella* mutagenicity assay
- Microtox using bioluminescent bacteria
- Vitellogenin
- DNA adducts
- Sister chromatid exchange
- Aryl hydrocarbon ethoxylase (AHH)
- Ethoxyresorufin – o – deethylase (EROD) assay
- Yeast based endocrine toxicity assays (YES)

	- Other ELISA based tests	
Pedagogy:	Lectures, tutorials, assignments	
References/ Readings:	1. A. K. Chaterjee, Introduction to environmental biotechnology. PHI, India, 2000. 2. M. Colin, Marine Microbiology: Ecology and applications. Second edition. Garland science, 2012. 3. T. Satyanarayana, B. Johri, and T. Anil, Microorganisms in Environmental Management, Springer Publishers, 2012. 4. M. J. Kennish, Practical Handbook of Estuarine and Marine Pollution. CRC Press, Francis and Taylor, 2019. 5. R. B. King, J. K. Sheldon, and G. M. Long, Practical Environmental Bioremediation: The Field Guide, Lewis Publishers, 1998. 6. S.M. Meena, and M.M. Naik, Advances in Biological Science Research: a practical approach. Elsevier, 2019. 7. M. Prabhu, Resource recovery from wastewaters for sustainable development. 2016.	
Course Outcomes:	At the end of this course, students will be 1. able to understand the basic tenets of biological wastewaters treatment, the advantages and disadvantages between centralized and decentralized systems. 2. able to gain insights into the processes to recover or produce valuable products from wastewater. 3. able to understand emerging treatment strategies that combine both conventional biological approaches with emerging technologies in hybridized systems 4. exposed to how biological monitoring can be integrated with water quality monitoring to enhance our understanding of how wastewaters are impacting ecosystem health.	

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT 652

Title of the Course: Internship

Number of Credits: 02

Effective from AY: 2022-23

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

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

(Back to top)

SEMESTER IV

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT 605

Title of the Course: RESEARCH METHODOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-606

Title of the Course: SYNTHETIC BIOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-607

Title of the Course: PLANT AND ANIMAL BIOTECHNOLOGY

Number of Credits: 2

Effective from AY: 2022-23

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

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

(Back to top)

Name of the Programme: M.Sc. Biotechnology

Course Code: MBT - 602

Title of the Course: SCUBA DIVING

Number of Credits: 2

Effective from AY: 2022-23

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

Name of the Programme: M.Sc. Biotechnology

Course Code: GBT-608

Title of the Course: Field trip

Number of Credits: 02

Effective from AY: 2022-23

Pre-requisites for the Course:	Knowledge of Microbiology/ Molecular Biology/ Biochemistry/ Bioprocess Technology/ Food Technology (Any one)	
Course Objectives:	The primary objectives of the group learning course are as follows: 1. To provide first hand experience, 2. To stimulate interest and motivation in science, 3. To add relevance to learning and inter-relationships, 4. To provide a potential impact to students' cognitive skills, knowledge, interests, and future career.	
Content:		**No of hours**
	• Visit to any two central science research and development institute or science laboratory.	10
	• Visit to any two pharmaceutical industry to learn about industrial manufacturing processes.	10
	• Visit to 3-4 Biotechnology industrial unit such as beverage production unit, dairy industry, fish processing unit, food processing unit, waste processing unit, etc.	15
	• Demonstration of sampling skills by visit to various ecological sites	10
	• Report preparation and Group discussion and individual presentation	15
Pedagogy:	Field visit	
Course Outcomes:	At the end of this course, the students will be able to: 1. connect between the field trip learning with prior experiences and knowledge from the classroom. 2. sharpen their skills of observation and perception. 3. understand experiential learning discussed during field trips. 4. learn to draft reports and share his experiences via presentation	

(Back to top)