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 Sciences such as Physical, Chemical Biological, Agricultural, Fisheries, Pharmaceutical Medicine Engineering or Technology and the admission is based on GUART ranking test

Proposed M.Sc. Biotechnology Proposed Scheme

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

SEMESTER I			
Course Codes	**Course Title**	**Credits**	**Course Level**
Discipline Specific Core courses (16 credits)			
GBTC-401	Microbiology	3	100
GBPC-401	Lab I: Techniques in Microbiology.	3	100
GBTC-402	Immunology	3	100
GBPC- 402	Lab II: Techniques in Immunology	2	100
GBTC-403	Biophysical Principles & Analytical Techniques	2	100
GBPC-404	LAB III: Biochemical and analytical techniques	3	100
Discipline Specific Elective courses (Any 4 credits)			
GBTE-401	Concepts in Biochemistry	2	100
GBTE-402	Biostatistics	2	100
GBTE-403	Mathematics for Biologists	2	100
GBTE-404	Biology of the Extremophilic Organisms	2	100
Semester II			
Discipline Specific Core courses (16 credits)			
GBTC-405	Environmental Biotechnology	3	100
GBTC-406	Stem Cell Biology and regenerative medicine	1	100
GBTC-407	Genetics and Molecular Biology	3	100
GBPC-407	Lab IV: Genetics and Molecular Biology	2	200
GBTC-408	Cell and Developmental Biology	3	100
GBTC-409	Bioinformatics	2	200
GBPC-410	Lab V: Plant and Animal Tissue Culture	2	100
Discipline-Specific Elective courses (Any 4 credits)			
GBTE-405	Bio entrepreneurship	2	100
GBPE-409	Lab VI: Lab in Bioinformatics	2	200
GBTE-406	Nanotechnology	2	100
GBTE-407	Vaccine Technology	2	200
Semester III			
Research Specific Elective Courses (Any 8 credits)			
GBTR-501	Recombinant DNA Technology	3	300
GBPR-501	Lab VII: Recombinant DNA Technology	2	300
GBTR-502	Bioprocess Technology	3	300
GBPR-502	Lab VIII: Bioprocess technology	2	300
GBPR-503	Lab IX : Environmental Biotechnology	2	100
Elective Generic Course (Any 12 credits)			

GBTG-501	Solid Waste Management	3	300
GBTG-502	IPR, Biosafety & Bioethics	3	100
GBTG-503	Food Technology	2	200
GBTG-506	Virology	2	200
GBTG-507	Genomics & Proteomics	2	200
GBTG-508	Emerging trends in wastewater treatment	2	200
GBIG-501	Internship	2	200
Semester IV			
Research specific elective courses (Any 4 credits)			
GBTR-504	Research Methodology	2	200
GBTR-505	Synthetic Biology	2	300
GBTR-506	Plant and Animal Biotechnology	2	300
GBSR-501	Scuba Diving	2	200
GBFR- 501	Field trip	2	200
Discipline-specific dissertation			
GBPD-501	Dissertation	16	400

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

SEMESTER- I

Course Code:	GBTC-401	
Title of the Course	MICROBIOLOGY	
Credits	3	
Objective:	The objective of this course is to provide information about the types of microbes, nutrition, and general characteristics	
Learning Outcomes	After completing this course, students should be able to- • explain the principle features of marine ecosystems and the microbial diversity in oceans; • describe and discuss marine microbes in terms of physiological capability and their biogeochemical role.	
Contents:	**MODULE I** • A brief history of microbiology: discovery of the microbial world, controversy over spontaneous generation, the role of microorganisms in the causation of disease, development of pure enrichment culture methods. • Modern /contemporary microbiology in the 21st century • An overview of the organization and cell structure of Prokaryotes and Archaea: i) cell wall ii) outer membrane iii) cytoplasmic membrane iv) flagella & specialized movements in microbes v) cell inclusions iv) differences among the groups. **MODULE II**	15 hours
	● Microbial nutrition: i) autotrophic & heterotrophic modes, ii) defining culture media to support growth, iii) Selective and differential culture media. ● Bacterial growth kinetics: i) growth curve, the mathematical expression of growth & measurement of growth ii) synchronous growth iii) factors affecting growth iv) chemostat & turbidostat. ● Microbial taxonomy: i) nomenclature ii) polyphasic identification, traditional & molecular, iii) Bergey's manual.	15 hours
	MODULE III	

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

	13. Willey, J., Sherwood, L., Woolverton, C.J., (2016) Prescott's Microbiology. Mcgraw Hill.

Course Code	GBPC-401	
Title of the Course	LAB I: TECHNIQUES IN MICROBIOLOGY	
Credits	3	
Objective:	This course involves learning techniques to culture microbes in the lab to form the basis for application in microbiological research studies.	
Learning Outcomes	• Key hands-on experience of converting and applying theoretical knowledge to laboratory. Application of the varied interactions /reactions to be utilized in research. Students become familiar with microbiology techniques that are used in many scientific disciplines as well as clinical medicine.	
Contents:	1. Sterilization and disinfection. 2. Preparation of solid & liquid media: 3. Isolation and maintenance of organisms: Streaking, slants and stabs cultures, storage of microorganisms. 4. Differential and Selective media 5. Enumeration: serial dilution methods, plating. 6. Isolation of bacteria from seawater /sediments samples 7. Study of morphology and cultural characteristics 8. Biochemical tests for identification of bacteria. a. Sugar utilization test (minimal medium + sugar) b. Sugar fermentation test c. IMViC d. Enzyme detection – Gelatinase, Catalase, Oxidase e. Oxidative-fermentative test 9. Bacteriological tests for potability of water a. MPN, Confirmed and Completed test. b. Membrane filter technique (Demonstration)	45 hours

	11. Staining methods: Gram staining, Endospore staining, Metachromatic granules, Cell wall staining 12. Motility in bacteria using: Hanging drop method and swarming growth method. 13. Antimicrobial sensitivity tests : Agar cup and Disc Diffusion methods 14. Drug resistance: comparative studies of different drugs/ disinfectants 15. Cultivation of fungi: a.Slide b. chunk c. coverslip techniques d. Wet mounts of fungal cultures	45 hours
Pedagogy	Hands-on experiments in the laboratory, video, online data.	
References/Readings	1. Giltner W. (2017) Laboratory Manual in General Microbiology Creative Media Partners, LLC 2. Harrigan W. F., McCance M E (2014). Laboratory Methods in Microbiology Academic Press 3. Karwa A.S.. Rai M.K, Singh H.B (2012). Handbook of Techniques in Microbiology: A Laboratory Guide to Microbes Scientific Publishers	

Course Code	GBTC-402	
Title of the Course	IMMUNOLOGY	
Credits	3	
Objective:	To provide a basic knowledge and to appreciate the components of the human immune response that work together to protect the host. 2) To understand the concept of immune-based diseases as either a deficiency of components or excess activity as hypersensitivity 3) To gain an insight into the mechanisms that lead to beneficial immune responses, immune disorders, and immune-deficiencies.	
Learning Outcomes	The mode of continuous assessment and formulation of tests enables students to handle competitive entrance exams. The basic overview of Immunology strengthens their foundations for a career in Biotechnology.	
Contents:	**MODULE I – Concepts and Basics** • Introduction – History and scope of immunology • Innate immunity:- factors, features, processes	

	• Acquired:- the Specificity, memory, recognition of self from non-self. • Cells of the immune system: Hematopoiesis and differentiation, Lymphoid and Myeloid lineage, lymphocyte trafficking, B lymphocytes, T lymphocytes, macrophages, dendritic cells, natural killer and lymphokine-activated killer cells, eosinophils and mast cells, lymphocyte subpopulations and CD markers. • Organization of lymphoid organs • MALT, GALT, SALT • Phagocytosis: oxygen-dependant/ independent killing intracellularly. • Major histocompatibility complex…Structure of MHC molecules, basic organization of MHC in human , haplotype-restricted killing. • Nature and biology of antigens and superantigens: haptens, adjuvants, carriers, epitopes, T dependant and T independent antigens	15 hours
	MODULE II – Defence Components: Constituents of immune system and response • Theories of antibody formation and res • olution of antibody structure • Humoral immunity: cells, antibody formation, primary and secondary response. • Immunoglobulins – structure, distribution and function. • Antigen – Antibody interactions: forces, affinity, avidity, valency and kinetics. • The basics of immuno-diagnostics	15 hours
	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 cytotoxicity. • Hybridoma technology and monoclonal antibodies. • Hypersensitivity: An introduction to the different types. • Introduction to autoimmune diseases.	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Hardeep Kaur H., Toteja R., Makhija. S., (2021) Textbook of Immunology Wiley Publisher 2. Kannan I (2021) Immunology. MJP Publishers. 3. Luttmann W., Bratke K., Kupper M., and Myrtek D (2009). Immunology. Academic Press. 4. Male D., Brostoff J., Roth D., Roitt I., (2013) Immunology. Elsevier Saunders publication. 5. Punt, J., Stranford, S., Jones, P., Owen, J.A., (2018) Kuby Immunology W.H. Freeman 6. Roitt I.M. Delves P.J. Martin S. J., Burton D R, Roitt I.M. (2017) Essential Immunology Wiley-Blackwell	

Course Code	GBPC-402
Title of the Course:	LAB II: TECHNIQUES IN IMMUNOLOGY
Credits	2
Objective:	This course involves learning techniques to culture microbes and to identify immune reactions in the lab to form the basis for application in immunodiagnostics.
Learning Outcomes	Key hands-on experience of converting and applying theoretical knowledge to laboratory. Application of the varied interactions /reactions to be utilized in research. Students become familiar with immunologic techniques that are used in clinical medicine as well as immunology research laboratories.

Contents:	• Determination of Antibody titer using Double Immuno-diffusion assay • Assessment of Similarity between antigens using Ouchterlony's Double diffusion Test • Estimation Of Antigen Concentration using Radial Immuno Diffusion • Quantitative Precipitation Assay	30 hours
	• DOT ELISA • Latex Agglutination • Immunoelectrophoresis • Rocket Immunoelectrophoresis • Slide / Tube agglutination Tests.	30 hrs
References/Readings	1. Detrick B., Hamilton R.G., Folds J.D. (2016) Manual of Molecular and Clinical Laboratory Immunology (2016) ASM Press. 2. Detrick B., Hamilton R.G.; Folds J.D. (2016) Manual of Molecular and Clinical Laboratory 3. Hay F.C., Westwood. O.M.R., (2008) Practical Immunology (2008) Wiley BlackWell Publishers 4. Hay, F.C &, O.M.R. Westwood. (2008) Practical Immunology Oxford University Press 5. Janeway CA Jr, Travers P, Walport M, et al. (2001) Immune System in Health and Disease, Garland Publishing, USA. Immunology ASM Press. 6. Janeway, C.A., Travers, P., Walport, M. and Shlomchik, M.J. (2001) Immunobiology: The 7. Joshi, K.R., Osama, N.O. (2012) Immunology, Agrobios Ltd, India. 8. Talwar G.P Gupta S.K (2017) A Handbook of Practical And Clinical Immunology Vol I CBS Publishers	

Course Code	GBTC-403	
Title of the course	BIOPHYSICAL PRINCIPLES & ANALYTICAL TECHNIQUES	
Credits	2	
Course Objectives	The course is designed to provide a broad exposure to basic techniques used in Modern Biology research. The goal is to impart basic conceptual understanding of principles of these techniques and emphasize biochemical utility of the same. Student is expected to have a clear understanding of all analytical techniques such that the barrier to implement the same is abated to a great extent.	
Learning Outcomes	Students will learn to combine previously acquired knowledge of physics and chemistry to understand the biochemical processes in the cell.	
Contents:	**MODULE I** • Description of Macromolecular Structure, Intermolecular and Intramolecular forces in protein, DNA and other biomolecules. • Diffusion, Brownian motion and sedimentation, determination of molecular weight from sedimentation and diffusion. • Concept and application of Chemical and Physical equilibria in biological system • Nature and Role of Ionic, Covalent and Non-covalent Interaction in molecular confirmation, scaffolding and packaging of protein and DNA • Thermodynamics of protein folding: Protein folding kinetics, Misfolding and aggregation. • Physical biochemistry of cell: Chemical forces translation and rotation, diffusion, directed movements, biomolecules as machines, work, power and energy, thermal, chemical and mechanical switching of biomolecules, • Biochemical and biophysical characterizations of biomolecules: Fluorescence from GFP), UV-VIS absorption and emission spectra resulting from intrinsic Tryptophan and GFP chromophores, Fluorescence quenching and polarization studies, Unfolding and refolding studies using CD. protein	15 hours

	diffusion, dynamics by fluorescence correlation spectroscopy. **MODULE II** **Spectroscopy:** Electromagnetic radiations in spectroscopic techniques. Beer-Lambert law, UV/Visible spectroscopy, Fluorescence spectroscopy, Emission, excitation, Quenching, Quantum Yield. Nuclear magnetic resonance Spectroscopy. Electron spin resonance spectroscopy. **Centrifuge:** Basic concepts of centrifugation. Calculation of g value from RPM. Types of rotors used, Differential centrifugation, Density gradient centrifugation. Rate-zonal centrifugation, Isopycnic centrifugation. **Microscopy:** Abbey's law, Resolution, Magnification, Phase-contrast microscopy, Confocal microscopy, High resolution microscopy, **Nanoscopy:** Atomic force Microscopy, Scanning-tunneling Microscopy, Scanning electron microscopy, Transmission electron microscopy and Cryo-electron microscopy **X-ray diffraction**	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Anders L. et al. (2016) Textbook of Structural Biology. World Scientific. 2. Atkins, de P. (2011) Physical Chemistry for the Life Sciences. W.H. Freeman. 3. Bhavna P., Fulekar, M.H (2019), Bioinstrumentation, Wiley Int. 4. Branden C., and Tooze J., (1998) Introduction to Protein Structure, Garland Science. 5. Rodney C., (2017). Biophysics: An IntroductionWiley Int. 6. Salman K., and Diaz, Z., (2016) Principal And Techniques of Bioinstrumentation, Intelliz Publisher 7. Schulz GE and Schirmer RH, (1998) Principles of Protein Structure, Springer Verlag. 8. Stout G.H., and Jensen L.H., (1989) X-ray Structure Determination: A practical guide. John Wiley and Sons Inc., New York. 9. Subramaniam, M. A (2021) Biophysics: Principle and techniques, MJP Publishers.	

	10. Tinoco Jr. I. Sauer K., Wang J.C., Puglisi J. D., Harbison G., Rovnyak D. (2013) Physical Chemistry: Principles and Applications in Biological Sciences Pearson Publishers 11. Van Holde K. E., Johnson, C. Ho P. S. (2005) Principles of Physical Biochemistry. Prentice Hall.

Course code	GBPC-404	
Title of the course	LAB III – BIOCHEMICAL AND ANALYTICAL TECHNIQUES	
Credits	3	
Course Objectives	The objective of this laboratory course is to introduce students to experimentation in biochemistry. The course is designed to teach the utility of these experimental methods in a problem-oriented manner.	
Learning Outcomes	Students should be able to: • Elaborate concepts of biochemistry with easy-to-run experiments. • Familiarize with basic laboratory instruments and understand principles underlying measurements using those instruments for experiments in biochemistry.	
Contents:	1. UV-Visible spectroscopic analysis. 2. Estimation of proteins by the Lowry/Bradford's method 3. Estimation of reducing sugars 4. Enzyme assay 5. Ammonium sulfate precipitation and dialysis 6. Specific activity, fold purification, percentage yield of enzyme 7. Protein subunit molecular weight determination by SDS-PAGE 8. Thin-layer chromatography	45 hours

	9. Column chromatographic techniques: ion exchange/Affinity/Gel filtration 10. Biochemical assays using ELISA plate reader. 11. Compound and Fluorescence microscopy demonstration 12. Analysis of a biological specimen by SEM 13. Fluorescence imaging of fixed stained and live cells 14. Demonstration of fluorescence spectroscopy. 15. Density gradient ultracentrifugation	45 hrs
Pedagogy	Hands-on experiments in the laboratory, online videos.	
References/ Reading	1. Atkins, de Paula. (2011) Physical Chemistry for the Life Sciences (2nd Edition). W.H. Freeman. 2. Atkins, de Paula. (2015), Physical Chemistry for the Life Sciences (2nd Edition). W. H. Freeman 3. Boyer, R. (2000). Modern experimental biochemistry. Pearson Education India. 4. Friedrich L., Engels, J. W. (2018) Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology. Wiley-VCH publisher 5. James J.F. (2017), An Introduction to practical laboratory optics, Cambridge University press. 6. Jayaraman, J. (2011). Laboratory Manual of Biochemistry. New Age International Private Limited 7. John G., (2020), Biological Centrifugation CRC Press. 8. K. E. van Holde, C. Johnson, P. S. Ho (2005) Principles of Physical Biochemistry, 2nd Edn., Prentice Hall. 9. Mu, P., & Plummer, D. T. (2001). Introduction to practical biochemistry. Tata McGraw-Hill Education. 10. Prakash S. Bisen, (2014), Laboratory Protocols in Applied Life Sciences., Taylor and Francis Publisher 11. Tinoco, Sauer,Wang, and Puglisi. (2013) Physical Chemistry: Principles and Applications in the Biological Sciences. Prentice Hall, Inc.	

	12. Ulrich K., (2017) Fluorescence microscopy: From Principle to application, Wiley Int. 13. Wilson, K., Walker, J. (Eds.). (2010). Principles and techniques of biochemistry and molecular biology. Cambridge university press.

Course Code:	GBTE-401	
Title of the course	CONCEPTS IN BIOCHEMISTRY	
Credits:	2	
Course Objectives	The major objective of this course is to build upon the knowledge of basic biochemical principles with emphasis on different metabolic pathways and their integration. Attention is drawn to the structure-function relationships of biomolecules.	
Learning Outcomes	Gain fundamental knowledge in biochemistry and understand the role of enzymes in the regulation of metabolic pathways.	
Contents:	**MODULE I** • Biochemistry: the molecular logic of life. • Amino acids, proteins, nucleic acids, carbohydrates, and lipids. • Vitamins and hormones. • Forces that stabilize biomolecules: electrostatic and 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.	15 hours

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

Course Code	GBTE-402	
Title of the course	BIOSTATISTICS	
Credits	2	
Course Objectives	The objective of this course is to introduce students to statistical methods and to understand underlying principles, as well as practical guidelines of "how to do it" and "how to interpret it" statistical data.	
Learning Outcomes	Upon completing this course, students should be able to - • understand how to summarize statistical data; • apply appropriate statistical tests based on an understanding of the study question, type of study, and type of data; • Interpret results of statistical tests.	
Contents:	**MODULE I** • 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.	15 hours
	MODULE II • Counting and probability, Bernoulli trials, Binomial distribution, and its applications, • Poisson distribution • Normal distribution, z, t, and chi-square tests, levels of significance • Testing of hypotheses: null and alternative hypotheses, Type I and Type II errors	15 hours

	• Simple linear regression and correlation • Analysis of variance	
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Arora P.N. and Malhan, P.K. (2006), Biostatistics. Himalaya Publishing House. 2. Kothari, C. R.,(2013) Quantitative Techniques, Vikas Publishing House. 3. Mahajan B.K., (2018), Methods in Biostatistics: for Medical Students and Research Worker. Jaype Brothers, 4. Rao K. Surya (2010), Biostatistics for Health and Life Sciences, Himalaya Publishing House. 5. Rastogi, V. B. (2009). Fundamentals of Biostatistics. Ane Books Pvt Ltd. 6. Samuels, JA Witmer (2016) Statistics for the Life Sciences. Prentice Hall	

Course Code	GBTE-403	
Title	MATHEMATICS FOR BIOLOGISTS	
Credits	2	
Prerequisite	None	
Objectives	• To give conceptual exposure to essential contents of mathematics • To enable them to perform quantitative analysis in biology.	
Learning outcomes	• Gain a broad understanding of mathematics • Recognize the importance and value of mathematical thinking, understand the use of mathematics to describe biological processes and their use in problem-solving, and understand the diverse phenomena that exist in biological systems.	
Contents	<u>Module I</u> • Linear equations, functions: slopes-intercepts, forms of two-variable linear equations; • Constructing linear models in biological systems. • Quadratic equations (solving, graphing, features of, interpreting quadratic models, etc.) • Introduction to polynomials, graphs of binomials and polynomials; Symmetry of polynomial functions, • Basics of trigonometric functions, Pythagorean theory.	15 hours

	• Graphing and constructing sinusoidal functions, imaginary numbers, complex numbers, adding-subtracting-multiplying complex numbers, • Basics of vectors, introduction to matrices.	
	Module II • Images as 2D/3D Functions, Functions and its derivatives, Computing Derivatives of Curves, Rules for Calculating Derivatives. • Curvature and Second Derivative Plotting Curves Numerical Calculation of Derivatives., Function, Derivatives and Series Expansion Differential calculus (limits, derivatives), integral calculus (integrals, sequences, and series, *etc*.). • Population dynamics; oscillations, circadian rhythms, developmental patterns, • Symmetry in biological systems, fractal geometries, size limits & scaling in biology, • Modelling chemical reaction networks and metabolic networks	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/Reading	1) Aggarwal, S.K., (2008) Bio Mathematics. Alps Book Publishers. 2) Aitken, M., Broadhursts, B., & Haldky, S. (2009) Mathematics for biological scientists. Garland Science. 3) Bairagi N., (2021) Introductory Mathematical Biology. U. N. Dhur and Sons Private Limited Publisher 4) Foster, P.C. (1999) Easy mathematics for biologists. Taylor and Francis 5) Robeva R (2013) Mathematical concepts and methods in modern biology using Modern Discrete Models. Academic Press 6) Stroud, K. A., & Booth, D. J. (2009). Foundation Mathematics. Palgrave Macmillan.	

Course Code	GBTE-404	
Title	BIOLOGY OF THE EXTREMOPHILIC ORGANISMS	
Credits	2	
Prerequisite	None	
Objectives	• To obtain knowledge regarding the existence of extreme habitats. • To understand how the strategies are adopted to overcome extreme conditions.	
Learning outcomes	• Understands the mechanisms of adaptation adopted by different organisms in extreme habitats. • Bioprospecting of the extremophiles for biotechnological applications	
Contents	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 mine drainages from coal and metal mining waste] or Alkaline (Soda lakes and soda deserts). • Low oxygen: Low or depleted oxygen level in water bodies (anthropogenic activities, pollution, eutrophication, algal growth) • Methane: Natural wetlands, freshwater lakes, streams, rivers, estuarine and coastal areas, termite, and wild ruminant guts, terrestrial and marine seeps, volcanoes, geothermal vents, gas hydrates, and	15 hours

	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.	
	<u>Module II</u> • Homeostasis, enantiosis (physiological/biochemical) • Thermogenesis, exothermic, endothermy molecular mechanisms (stability of proteins, catalytic rates) Stress proteins: heat shock, chaperonins, SAPKs • Freeze avoidance/tolerance: antifreeze proteins, ice nucleation, frost (cold) hardiness, Membrane structures, and temperature. • Life under pressure: barophilic bacteria, metazoan, Deep diving penguins, mammals • Energy metabolism – the role of oxygen (normoxia, hypoxia, anoxia) physiological adaptations (hibernation, torpor, estivation) • Photosynthesis - physiological and biochemical adaptations to extreme light and temperature • Ionizing radiation - mechanism of radiation resistance • Life with limited water - arthropods, reptiles • Hot, dry environments - mammalian physiological adaptations • Mechanisms to avoid osmotic stress acid and alkaline environments • Overcoming heavy metal and toxin tolerances, • Biotechnological application of extremophiles	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/Reading	1) Anitori, R.P., (2012) Extremophiles: Microbiology and	

	Biotechnology. Caister Academic Press. 2) Durvasula, R.V., and Subba Rao.D.V. (2018). Extremophiles: From Biology to Biotechnology. CRC Press. 3) Elster J., Prisco, G.di, Huiskes, A.H.L, Edwards, H.G.M., (2020) Life in Extreme Environments., Insights in Biological Capability. Cambridge University Press. 4) Gunde-Cimerman N, Oren, A., Plemenitaš a.,(Ed) (2005)Adaptation to Life at High Salt Concentrations in Archaea, Bacteria, and Eukarya. Springer Publisher. 5) Richa, S. and Vivek S., (2020) Physiological and Biotechnological Aspects of Extremophiles. Academic Press. 6) Singh Om V.(2012) Extremophiles: Sustainable Blackwell 7) Wharton D.A., (2002) Life at the Limits: Organisms in Extreme Environments Cambridge Press.

SEMESTER II

Course Code:	GBTC-405
Title of the Course	ENVIRONMENTAL BIOTECHNOLOGY
Credits	3
Objective:	The objective of this course is to impart knowledge on biotechnological applications that can be used to tackle environmental issues emerging due to industrialization and globalization.
Learning outcomes	At the end of this course, students will be able to apply their knowledge for the application of biotechnological processes for betterment of environment and sustainable development of the society.
Contents:	**Module 1:** • Introduction to environmental biotechnology: • Basic concept of environment and its components. Biotechnology for environment; definitions and facts. • Environment pollution**:** Sources of pollution and their

	environmental impact. Hazardous wastes: Definition, sources and characteristics, categorization, generation, collection, transport, treatment and disposal. Municipal solid wastes: Collection, segregation and transport of solid wastes, handling and segregation of wastes at source. • Monitoring environmental pollution**:** Air, water and soil sampling, Analyses of samples. Physical, chemical, biological and molecular methods for the measurement of pollution. Robust techniques and innovative new concepts for identifying and screening of toxins and pathogens in the environment (genetic and biochemical kits and reagents, CRISPR–Cas technology, and cellular models). • Nucleic acid based techniques for analyses of diversity, structure and dynamics of microbial community in wastewater treatment, Concept of biomarkers. • Environmental impact assessment, Biodiversity and its conservation.	15 hours
	<u>Module II</u> • 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	15 hours

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

Course Code	GBTC-406	
Title of the Course	STEM CELL BIOLOGY AND REGENERATIVE MEDICINE	
Credits	1	
Prerequisites	Basic understanding of cell biology - cell types, growth media, cell division, cell growth, cell differentiation.	
Objective:	The aim of the course is to bring together cellular, biochemical, anatomical, histological, physiological and evolutionary medical views of stem cells to a coherent picture in an experimental and clinical context.	
Contents:	**MODULE I** • Definition,stem cell origins and plasticity,classification and source of stem cells; Stem cell differentiation; • Stem cells cryopreservation, iPS technology; microRNAs and stem cell regulation, Tumor stem cells, • Overview of embryonic and adult stem cells for therapy. Human stem cells research: • Ethical considerations; • Stem cell based therapies: Pre-clinical regulatory consideration and patient advocacy.	15 hours
Pedagogy	Lectures/tutorials/assignments	
References/Readings	1. Hoffman A.D. Ho. R., (2006) Stem Cell Transplantation Biology Process Therapy, Willy-VCH 2. John Collins, (2017)Stem cells: From basic to advanced principles,. Hayle Medical 3. Robert Lanza (2006) Essential of Stem Cell Biology, Academic Press. 4. Robert Lanza (2009) Essential stem cell methods, Elsevier. 5. Robert lanza, (2011), Principle of Tissue Engineering, AP publisher 6. Robert lanza, (2013) Essential of Stem cell Biology, Elsevier publisher.	

Course Code	GBTC-407	
Title of the Course	GENETICS AND MOLECULAR BIOLOGY	
Credits	3	
Objective:	The aim of this course is to obtain and understand the fundamental knowledge of molecular and cellular processes such as RNA transcription, protein synthesis, mutation, epigenetic modification and gene regulation.	
Learning Outcomes	The students should be able to explain and summarize the scientific principles of the molecular biology of DNA, RNA and understand the role played in overall functioning of the cell.	
Contents:	**MODULE I** • Mendelian Genetics and Population genetics • Structure of DNA - A,B, Z and triplex DNA; • Organization of bacterial genome and eukaryotic chromosomes Heterochromatin and Euchromatin • DNA melting and buoyant density; Tm; DNA reassociation kinetics (Cot curve analysis) Repetitive and unique sequences; Satellite DNA; DNase I hypersensitive regions; DNA methylation & epigenetic effects. • Structure and function of prokaryotic and eukaryotic mRNA, tRNA (including initiator tRNA), rRNA and ribosomes. Processing of eukaryotic hnRNA: 5'-Cap formation; 3'-end processing of RNAs and polyadenylation; loop model of translation; Splicing of mRNA. • Gene transfer in bacteria-Conjugation, transformation and transduction. • DNA mutation and repair, Transposons	15 hours
	MODULE II	

	• Prokaryotic and eukaryotic transcription -RNA polymerase/s and sigma factors, • Transcription unit, Prokaryotic and eukaryotic promoters, Promoter recognition, Initiation, Elongation and Termination (intrinsic, Rho and Mfd dependent) • Gene regulation: Repressors, activators, positive and negative regulation, Constitutive and Inducible, small molecule regulators, operon concept: *lac, trp*operons, attenuation, anti-termination, stringent control, translational control. • Eukaryotic transcription - RNA polymerase I, II and III mediated, General eukaryotic transcription factors; TATA binding proteins (TBP) and TBP associated factors (TAF); assembly of pre-initiation complex for nuclear enzymes, interaction of transcription factors with the basal transcription machinery and with other regulatory proteins, mediator, TAFs. ; Silencers, insulators, enhancers, mechanism of silencing and activation.	15 hours
	MODULE III • Translation in prokaryotes and eukaryotes, • Regulatory RNA and RNA interference mechanisms, miRNA, non-coding RNA; • Families of DNA binding transcription factors: Helix-turn-helix, helix-loop-helix, homeodomain; 2C 2H zinc finger, multi cysteine zinc finger, basic DNA binding domains (leucine zipper, helix-loop-helix), nuclear receptors. • Interaction of regulatory transcription factors with DNA: properties and mechanism of activation and repression including Ligand-mediated transcription regulation by nuclear receptors.	15 hours

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

Course code	GBPC-407	
Title of the Course	LAB IV: GENETICS AND MOLECULAR BIOLOGY	
Credits	2	
Objective:	The objective of this course is to provide students with experimental knowledge of molecular biology and genetic engineering.	
Learning Outcomes	Students should be able to gain hands-on experience on gene cloning, protein expression and purification. This experience would enable them to begin a career in industry.	
<u>Contents:</u>	1. UV/Chemical mutagenesis and survival curve. 2. Isolation of amino acid auxotroph by replica plating. 3. Phage infection and burst size; types of plaque formation 4. Transduction 5. Genetic Transfer-Conjugation, gene mapping. 6. Genomic DNA isolation	30 hours
	7. DNA quantification and gel electrophoresis	30 hours

	8. RNA isolation 9. RNA denaturing gel electrophoresis. 10. Mitosis. 11. Meiosis	
Pedagogy	Hands-on experiments in the laboratory, online videos.	
References/Readings	1. Sharma R.K., Sangha S.P.S (2020) Basic Techniques in Biochemistry and Molecular Biology Dream Tech Press. 2. Gakhar S.K., Miglani M., Kumar A., (2019) Molecular Biology: A Laboratory Manual. Rupa Publications. 3. Hofmann A. (2018) Wilson and Walkers Principles And Techniques Of Biochemistry And Molecular Biology. Cambridge University Press 4. Green R. , Sambrook J. (2012) Molecular Cloning: A Laboratory Manual (Fourth Edition): Three-volume set 5. Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN Vennison PHI Learning	

Course Code	GBTC-408	
Title of the course	CELL AND DEVELOPMENTAL BIOLOGY	
Credits	3	
Course Objectives	The cells being "the fundamental building blocks of all organisms", a comprehensive understanding of the cell and cellular function is essential for all biologists. This course will hence provide a conceptual overview of a cellular system and its functioning in animals and plants. The course will also highlight a conceptual overview of how developmental patterns arise. Using examples from different model systems regulatory networks involved are highlighted, aiming to project the molecular basis of developmental patterns.	
Learning Outcomes	Understanding major concepts in cell and Developmental biology with an awareness of experimental approaches and how they are applied in cell biology research.	
Contents:	**MODULE I** Biochemical organization of the cell; diversity of cell size and shape; cell theory, and the emergence of modern Cell Biology. Principles underlying microscopic techniques for the study of	

	cells. Structure and diversity of biological membranes; mechanisms of membrane transport. Self-assembly of lipids, micelle, bio membrane organization - sidedness and function; membrane assembly. • The plant cell wall; extracellular matrix in plants and animals • Cell lysis and subcellular fractionation • Structural organization and functions of cell organelles: nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, lysosomes, Chloroplast, peroxisomes, vacuoles. Cytoskeletons structure and motility function • Cellular communication: General principles of cell communication, cell adhesion and roles of different adhesion molecules, tight junctions, communicating junctions, integrins, neurotransmission, and its regulation. **MODULE II** • Protein localization – synthesis of secretory and membrane proteins, import into nucleus, mitochondria, chloroplast, and peroxisomes, receptor-mediated endocytosis. • Proteasomes; structure and function • Cell division and cell cycle: Mitosis and meiosis, their regulation, Cell cycle, and its regulation, Apoptosis, Necrosis, and Autophagy. • Cell signaling • Cell fusion techniques • Molecular chaperones: types, characteristics, and functional significance • Cell transformation and cancer, oncogenes and proto-oncogenes, tumor suppressor genes, metastasis.	15 hours 15 hours
	MODULE III • Potency, commitment, specification, induction, competence, determination and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence	

	and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. • Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation, and formation of germ layers in marine animals. • Cell aggregation and differentiation in *Dictyostelium*; axes and pattern formation in *Drosophila*, amphibia; organogenesis – vulva formation in *Caenorhabditis elegans*, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post-embryonic development- larval formation, metamorphosis; environmental regulation of normal development; sex determination.	15 hours
Pedagogy	Lectures, tutorials, assignments	
References/ Reading	1. Amon, A., Krieger, M., Lodish, H., Bretscher, A., Kaiser, C. A., Berk, A., Martin, K. C., Ploegh, H. (2016). Molecular Cell Biology. United Kingdom: W. H. Freeman. 2. C. Smith & E. Wood (2005) Cell Biology, Chapman Hall . 3. Cooper, G. M., Hausman, R. E. (2013). The Cell: A Molecular Approach. United States: Sinauer Associates. 4. Gilbert, S. F. (2010). Developmental biology. Sinauer Associates, Inc. 5. J.D. Watson, M.,Levine, T. A. Baker, A. Gann, S. P. Bell, R.L. Watson (2014) Molecular Biology of the Gene, Pearson Education. 6. Karp, G., Iwasa, J., Marshall, W. (2018). Cell Biology Global Edition. United States: Wiley. 7. Kilpatrick, S. T., Krebs, J. E., Goldstein, E. S. (2017). Lewin GENES XII. Japan: Jones; Bartlett Learning. 8. Lodish et al., (2000) Molecular Cell Biology, W.H.Freeman & Company 9. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J, Johnson, G. (2016). Cell biology E-book. Elsevier Health Sciences. 10. Slack, J. M. W. (2009). Essential Developmental Biology. Germany: Wiley. 11. Smith & Wood (2005) Cell Biology, Chapman & Hall London 12. Subramanian, M. A. (2022). Developmental Biology. India: MJP Publisher. 13. Turner, B. M. (2008). Chromatin and gene regulation: molecular mechanisms in epigenetics. John Wiley & Sons.	

	14. Wolpert, L. (2011). Developmental Biology: A Very Short Introduction. OUP Oxford.

Course Code	GBTC-409	
Title of the Course	BIOINFORMATICS	
Credits	2	
Objective:	The objectives of this course are to provide students with theory and practical experience of use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts	
Learning Outcomes	Student should be able to: • develop an understanding of basic theory of these computational tools. • gain working knowledge of these computational tools and methods. • appreciate their relevance for investigating specific contemporary biological questions.	
Prerequisite	GBTC-407	
Contents:	**MODULE I** • Introduction, Primary & Secondary database, Sequence file formats, Introduction to structures, Protein Data Bank (PDb), Molecular Modelling Database (MMDb), Structure file formats, Collection of sequences, sequence annotation, sequence description. • Evolutionary basis of sequence alignment, optimal alignment methods, Substitution scores & gap penalties, Statistical significance of alignments, • Database similarity searching, FASTA, BLAST, Low complexity regions, Repetitive elements, Multiple Sequence Alignment: Progressive alignment methods, Motifs and patterns, Clustal, Muscle; Scoring matrices, Distance matrices. • Alignment, tree building and tree evaluation, Comparison and application of Unweighted Pair Group	15 hours

	Method with Arithmetic Mean (UPGMA), Neighbour Joining (NJ), Maximum Parsimony (MP), Maximum Likelihood (ML) methods, Bootstrapping, Jackknife; • Software for Phylogenetic analysis. DNA barcoding: Methods tools and databases for barcoding across all species, Applications and limitations of barcoding, Consortium for Barcode of Life (CBOL) recommendations, Barcode of Life Database (BOLD).	
	MODULE II • 3-D structure visualization and simulation, Basic concepts in molecular modeling: different types of computer representations of molecules; External coordinates and Internal Coordinates, Molecular Mechanics, Force fields *etc*. Secondary structure elucidation using Peptide bond, phi, psi and chi torsion angles, Ramachandran map, anatomy of proteins – Hierarchical organization of protein structure –like CATH (class, architecture, topology, homology), SCOP (Structural Classification of Proteins), FSSP (families of structurally similar proteins). • Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target 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–	15 hours

	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.	
Pedagogy	Lectures, tutorials, assignments	
References/Readings	1. Arthur L (2019) Introduction to Bioinformatics. Oxford University Press. 2. Baxevanis A. D., Bader,G.D., Wishart D.S. (2020) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher. 3. Bioinformatics databases and algorithms (2007) N. Gautham. 4. Bioinformatics: A modern approach . (2005) V.R. Srinivas. 5. Bioinformatics:concepts skills and applications (2004).S.C. Rastogi, N. Mendiratta and P. Rastogi. 6. Essential Bioinformatics Paperback – 2007 by Jin Xiong Cambridge University Press; First edition. 7. Ignacimuthus. S. (2013) Basic Bioinformatics Alpha Science International Ltd 8. Jonathan Pevsner (2015) Bioinformatics and Functional Genomics. Wiley Blackwell Publication. 9. Perambur S Neelakanta (2020) A Textbook of Bioinformatics: Information-theoretic Perspectives of Bioengineering and Biological Complexes World Scientific Publisher. 10. Statistical methods in Bioinformatics: An introduction. (2005). W. Even and G. Grant. 11. Xiong J. (2006). Essential Bioinformatics. Cambridge University Press	

Course Code	GBPC-410
Title of the Course	LAB V-PLANT AND ANIMAL TISSUE CULTURE
Credits	2
Objective:	• A comprehensive understanding of the cell and cellular

	functions;plant and animal tissue culture.	
Learning Outcomes	• To carry out and interpret experiments in Plant and animal tissue culture.	
Contents:	1. Preparation of starting material (Biosafety cabinet, solutions, media, cell sample etc.): Cell stock preparation (glycerol stock), storage, freezing, thaw and subculture, contamination and precautions 2. Animal cell culture: Secondary cell culture HeLa and non-cancerous cell lines HEK293, COS-7 3. Transfection and co-transfection: Calcium-phosphate method and Lipofection 4. Cell fixation and staining: Immunolabeling, mounting, fluorescence imaging.	30 hours
	1. Tissue culture medium preparation, contamination and precautions in plant tissue culture 2. Callus induction from different explants such as rice and carrot 3. plantlet regeneration. 4. Somatic embryogenesis 5. Single cell suspension. 6. Protoplast isolation	30 hrs
Pedagogy	Hands-on experiments in the laboratory, online video.	
References/Readings	1. Freshney I.R. and Capes-Davis A., (2021) Freshney's Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. Wiley Blackwell Publisher 2. Freshney R.I and Masters. J.R.W. (2000) Animal cell culture (2000) – A Practical Approach Oxford University Press	

	3. Sherathiya, H., (2013) Practical manual for Plant Tissue Culture: Basic Techniques of Plant Tissue Culture and Molecular Biology. Grin Verlag 4. Smith R. (2012) Plant tissue culture Techniques and experiment. Academic Press.

Course Code:	GBTE-405	
Title of the Course:	BIOENTREPRENEURSHIP	
Credits	2	
Objective**:**	Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with an understanding of science & technology. Bio-entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects. The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.	
Learning outcomes	Students should be able to gain entrepreneurial skills, understand the various operations involved in venture creation, identify the scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centers and various agencies. The knowledge pertaining to management should also help students to be able to build up a strong network within the industry.	
Contents:	• **<u>Module I.</u>** • 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;	15 hours

	Sources of financial assistance; Funds from bank for capital expenditure and for working. • Funding new ventures – bootstrapping, crowd sourcing, Angel investors, VCs, debt financing, and due diligence, Incubation and acceleration, Government incentives for entrepreneurship. • Budget planning and cash flow management; Negotiations/Strategy With financiers, bankers etc.; Profit & Loss statement, Balance sheet, Cash flow, Cost-volume-profit & Bread-Even analysis, Capital budgeting. • **<u>Module II</u>** • **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 startups:** • Human Resource Development (HRD) Leadership skills; Managerial skills; Organization structure, pros & cons of different structures; Team building, teamwork; Appraisal; Rewards in small scale set up. External environment/changes; Crisis/ Avoiding/Managing; Broader vision–Global thinking.	15 hours
Pedagogy	Lectures, tutorials,,assignments	
Reference Books	1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion. 2. Byrne John A. (2011). World Changers: 25 Entrepreneurs Who Changed Business as We Knew it. New York: Penguin 3. Companies: Creating Value and Competitive Advantage with the Milestone Bridge.Routledge. Jordan, J. F. (2014). Innovation, Commercialization, and Start-Ups in Life Sciences. London: CRC Press. 4. Desai, V. (2009). The Dynamics of Entrepreneurial Development and Management. New Delhi: Himalaya Pub. House. 5. Lynn Jacquelyn (2007). The Entrepreneur's Almanac: Fascinating Figures, Fundamentals and Facts at your Fingertips. Canada: Entrepreneur Media Inc. 6. Ramsey David (2011). Entre Leadership: 20 Years of Practical Business Wisdom from the Trenches. New York: Howard	

	Books 7. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing	

Course Code	GBPE-409	
Title of the course	LAB VI: LAB IN BIOINFORMATICS	
Credits	2	
Prerequisites	GBTC-409	
Objective:	• The aim is to provide practical training in bioinformatics and statistical methods including accessing major public sequence databases.	
Learning Outcomes	On completion of this course, students should be able to: ▪ describe contents and properties of important bioinformatics databases, perform text- and sequence-based searches, analyse and discuss results in the light of molecular biology knowledge; • explain major steps in pairwise and multiple sequence alignment, explain its principles and execute pairwise sequence alignment by dynamic programming; • predict secondary and tertiary structures of protein sequences; • perform and analyse various statistical tools available to analyse the data.	
Contents:	1. Using NCBI and UniProt web resources. 2. Introduction and use of various genome databases. 3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/ TrEMBL, UniProt. 4. Similarity searches using tools like BLAST and interpretation of results.	30 hours

	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 hours
	9. Use of different protein structure prediction databases (PDB, SCOP, CATH). 10. Construction and study of protein structures using RASMOL/Deepview/PyMol. 11. Homology modelling of proteins. 12. Whole-genome assembly from NGS raw data sequence and annotation 13. 16S rRNA sequence analysis and use of BioEdit 14. 14. Molecular docking	
References/Readings	1. Baxevanis A. D., Bader,G.D., Wishart D.S. (2020) Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins Wiley Publisher. 2. Even W., and Grant G., (2005) Statistical methods in Bioinformatics: An introduction. (2005). 3. Jones, N.C., and Pevzner, P.A., (2004); *Introduction to Bioinformatics Algorithms*; Ane Books, India. 4. Mount D.W., (2001), *Bioinformatics: Sequence and Genome Analysis*, Cold Spring Harbor Laboratory Press. 5. Shui Qing S., (2007) Bioinformatics: A Practical Approach (Chapman & Hall/CRC Mathematical and Computational Biology)	

Course Code	GBTE-406
Title of the course	NANOBIOTECHNOLOGY
Credits	2

Objective:	• Providing a general and broad introduction to the multi-disciplinary field of nanotechnology.	
Learning Outcomes	• Students should be able to describe the basic science behind the properties of materials at a nanometre scale.	
Contents:	**MODULE I** • Introduction, concepts, historical perspective; • Different formats of nanomaterials and applications with examples for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis, and characterization of different nanomaterials. • Thin films; Colloidal nanostructures; Self-assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterization. • Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, • Strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.	15 hours
	MODULE II • Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli-responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development. • Nanomaterials for catalysis, development, and characterization of nanobiocatalysts, • Application of nano scaffolds in synthesis, applications of nanobiocatalysis in the production of drugs and drug intermediates. • Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; • Fate of nanomaterials in different strata of the	15 hours

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

Course Code	GBTE-407	
Title	VACCINE TECHNOLOGY	
Credits	2	
Prerequisite	GBTC-402	
Objectives	• To understand the conventional to the latest technology in vaccine production. • To understand the immunological effect and strategies for vaccine design.	
Learning outcomes	• Understanding of vaccine design and strategies for vaccine delivery. • Understand the significance of adjuvant, immunogens, and other ingredients for developing an effective vaccine	
Contents	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:	15 hours

	role of CD4+ and CD8+ T cells; • Memory responses: Memory and effector T and B cells, Generation and Maintenance of memory T and B cells Correlates of protection. • Epitopes, linear and conformational epitopes, characterization and location of APC, MHC, and immunogenicity • History of vaccines, Conventional vaccines; Vaccination and immune response; • Different types of Vaccines: Inactivated Vaccine, Attenuated Vaccine, Toxoid Vaccine, Subunit Vaccine, Conjugate Vaccine, Valence Vaccine, Heterotypic Vaccine, mRNA vaccine with examples • Vaccines based on routes of administration: oral, intranasal, intramuscular. Subcutaneous, intravenous. Case examples of injectable vaccines, and combination vaccines. • Physical method of gene delivery: tattooing, gene gun, electroporation, ultrasound, and laser • Maternal Immunization	
	<u>Module II</u> • Vaccines with and without adjuvants. different types of adjuvants:oil-based adjuvants such as Freunds, aluminum hydroxide, aluminum phosphate, [AS04] aluminum potassium sulfate monophosphoryl lipid A (MPL) + aluminum salt, [MF59] Oil in water emulsion composed of squalene. [AS01] Monophosphoryl lipid A (MPL) and QS-21, a natural compound extracted from the Chilean soapbark tree, combined in a liposomal formulation, [cpG1018]Cytosine phosphoguanine (CpG), a synthetic form of DNA that mimics bacterial and viral genetic material. • Vaccine delivery systems (e.g., emulsion (water-in-oil-in-water multiple emulsions,	15 hours

	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	
Pedagogy	Lectures, tutorials, assignments	
References/Reading	1) Cheryl Barton, "Advances in Vaccine Technology and Delivery", Espicom Business Intelligence, 2009. 2) Ellis R.W.,(2001) "New Vaccine Technologies", Landes Bioscience. 3) Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub. 4) Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH. 5) Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH. 6) Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman. 7) Male, David, et al., (2007) "Immunology", Mosby Publication.	